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Westinghouse Astronuclear Laboratory

Digital Programs for Obtaining the
System Frequency Responses from Time
Responses for Impulse, Step or
Arbitrary Inputs (U)

MASLEN

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DATE: July, 1966

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DIGITAL PROGRAMS FOR OBTAINING
THE SYSTEM FREQUENCY RESPONSES
FROM TIME RESPONSES FOR IMPULSE
STEP OR ARBITRARY INPUTS

The Programs

The Los Alamos Scientific Laboratory has developed digital computer programs "IMPULSE", "STEP-4C", and "ARBIT" for computing system frequency responses from time responses for impulse, step or arbitrary inputs respectively; the first pages of the appendix give these FORTRAN programs with the input and output statements modified to fit the WANL digital computer.

The programs mentioned have been modified at WANL in order to derive:

- a) the closed loop frequency response with unity feedback when the original transient response measurements were performed for an open loop system, and
- b) the open loop frequency response assuming unity feedback when the original transient response was measured for a closed loop system.

These modified frequency response programs have been given the names "IMPULSE-TF", "STEP-TF" and "ARBIT-TF"; the FORTRAN programs for

them are to be found in the appendix. The modifications in the new programs have been kept to a minimum; however, for a given response, the gain and phase shift values (and perhaps other values) obtained using one of the original programs may differ slightly from those values derived using the modified version of the same program--these differences will be found to be negligible.

Data Card Preparation

A complete description on how to prepare data cards is as follows--an abbreviated description in tabular form is contained in Appendix B.

1. The first card in each data card set is a title or comment card; this card is for identification purposes and must be used. The comment or title used is punched in columns 1-72 inclusive and will be printed, following the program name, at the top of the page containing the printout of the time response values.
2. The second card in each data card set is punched using FORTRAN format 24 I3. In the first card field, columns 1--3, for the programs "ARBIT" and "ARBIT-TF" the number N_R (maximum value=200) of equally spaced input values of the system transient time response is punched. In the

second card field (col. 4--6), for the programs "ARBIT" and "ARBIT-TF" the number N_C (maximum value = 200) of equally spaced output values of the system transient time response is punched.

For the programs other than "ARBIT" and "ARBIT-TF" the value N_R is not pertinent; the number N_C , however, is pertinent and is punched in the first card field (col. 1--3) of the second data card when using these other programs.

The card field following the N_C field contains the number N_F (maximum value = 36) of frequency values for which the computation of the system frequency response is desired.

The field following N_F contains the value for L_F ; this value should be "0" if the frequencies for which the system response is to be computed are to be given in radians per second -- L_F should be "1" if these frequencies are to be given in cycles per second.

The next card field contains the value for "FREQ" or "TFREQ". This value should be "0" if no new frequency cards for the data set under discussion are to be read,

i.e., the frequencies at which the system frequency response is to be computed are the same as in the previous set of data. The value should be "1" if new frequency cards for the data set under discussion are given and should be read.

The following field "1 PLOT" determines whether or not the computed frequency response data is also to be plotted. This function is not included in the WANL digital program; although not necessary, this field should be left blank.¹

In the programs "IMPULSE-TF", "STEP-TF", and "ARBIT-TF" the next card field will contain the value for the FORTRAN symbol "LOOP"; this value should be "0" if the original transient time response of the system is measured for a closed loop system; this value should be "1" if the original transient time response of the system is measured for an open loop system.

When punching the second card, it should be kept in mind that the FORTRAN format is 24I3, i.e., the fixed point format, and all the numbers must be right adjusted within each field (all empty spaces to the right of a fixed point number within its field are assumed to be zeros). The contents of this second card are listed about two rows below the contents of the first card in the computer printout.

¹Presently installed in the Digital Computation Facility is a Cal Comp 566 Digital Incremental Plotter; refer to WANL-IL-027 for instructions in the use of this device.

3. The FORTRAN format of the third data card is floating point (12 E 6.2). For the programs "ARBIT" and "ARBIT-TF" the first field, columns 1--6, contains the value of the constant time increment T_R between input points in seconds. The value of the constant time increment T_C between the corresponding transient time response points is to be punched in the second field, columns 7--12, for the "ARBIT" and "ARBIT-TF" programs; for the remaining programs, the value T_R is not pertinent but the value of T_C is pertinent and is punched in columns 1--6.

The card field following the T_C field contains the value of the scale factor SF_R of the input variable and the following field the value of the scale factor SF_C of the output variable. These scale factors are the numerical constants by which the values of the recorded input and output variables R and C respectively are multiplied to obtain the numerical values of the corresponding actual input and output variables V_R and V_C :

$$V_R = SF_R \times R$$

$$V_C = SF_C \times C$$

The gain of the recorder on which the input variable is recorded (volts/division) is punched in the following card field, and into the next card field is punched the gain of the recorder on which the output variable is recorded (volts/division).

The following card field contains the value of the strength of the input impulse in the programs "IMPULSE" and "IMPULSE-TF", and contains the magnitude of the step in the programs "STEP-4C" and "STEP-TF". For the programs "ARBIT" and "ARBIT-TF" this information is not pertinent and thus not required.

The fourth, fifth, and sixth cards or card groups all have the same floating point format (12 E 6.2) in columns 1--72, as did the third card. The fourth card or card group lists the values of the input variable (200 max.) taken at equal consecutive time intervals starting at time $T = 0$ (the constant time increment was specified in the third card). The fifth card or card group lists the values of the output variable (200 max.) taken at equal consecutive time intervals starting at time $T = 0$ (the constant time increment was specified in the third card). The fourth card or card group is used only with the "ARBIT" and "ARBIT-TF" programs; only the magnitude of the step for the "STEP-TF" program or the strength of the impulse signal for the "IMPULSE-TF" program need be specified and this is already done in card three.

It should be noted here that the interpolation between the time increments is performed by assuming a

parabolic curve between three consecutive data points. Also, if the system transfer function has no pure $\frac{1}{s^n}$ - term as a multiplier, the last two points of the system time response to a step input should be made exactly equal and the last two points of the system time response to an impulse input should be made exactly equal to the value the output had at time $T = 0$.

It should also be noted that because of the discrete numerical data, the sampling theorem is applicable. Also, we should not expect to obtain any lower frequency information from the transient data than that which has the same period as the total record length. Thus, assuming noiseless transient data, the maximum useful bandwidth of the obtained frequency response is:

$$\frac{1}{2T} \leq f < \frac{1}{T}$$

where T = the constant time increment between the data points (the longer constant time increment of the input or output data).

The sixth card or card group contains the frequency values (36 values max.) in columns 1--72 in radians or cycles per second as specified in the second card. If several computations are performed consecutively, the same frequency values can be used in all the computations if the FORTRAN symbol "I FREQ" is given the value "0" in each data card set excepting the first data set in which "I FREQ" is "1".

Any number of independent transient responses to the same type input disturbance can be computed in series by stacking the different data card sets one after the other; only one FORTRAN "**DATA" card is needed for the entire series and is placed at the beginning of the first data card set.

Test Runs

A few trials were run with ideal data taken from the computed transient responses of the transfer function

$$G(s) = \frac{1}{1 + s + s^2}$$

The computer runs are presented in Appendix C and listed as follows:

<u>Computer Program</u>	<u>Data</u>
IMPULSE-TF	<ul style="list-style-type: none"> a) Original data assumed to be obtained from an open loop system. b) Original data assumed to be obtained from a closed loop system.
STEP-TF	<ul style="list-style-type: none"> a) Original data assumed to be obtained from an open loop system. b) Original data assumed to be obtained from a closed loop system.
STEP-4C	Rounded data - compare the results with the frequency response computed for the original system using STEP-TF program.
STEP-TF	"PCV-41 Step Response"-experimental data reduced using STEP-TF program.
ARBIT-TF	<ul style="list-style-type: none"> a) Original data assumed to be obtained from an open loop system. b) Original data assumed to be obtained from a closed loop system.

In the accompanying graphs describing the frequency responses in App. C the computed values have been marked as dots and triangles and the theoretical frequency response of $G(s) = \frac{1}{1 + s + s^2}$ has been drawn as a reference with a solid line. Also, in these graphs there are two vertical dash lines between which the reliable data, if any, should exist. The computer has been asked purposely to try to calculate the values of the frequency response at frequencies with periods longer than the total recording time of the transient response of the system. The only reason why this information also looks quite good is that by setting the last two values of the step response equal and the last two values of the impulse response equal to zero the computer program assumes that the response has completely settled down. However, the error caused by this type of truncation is reflected in the scattering of the highest frequency data. Of course, this high frequency scattering will occur any time we do not continue the data record until it has completely settled down with or without making the last two data points artificially equal. The other reasons for high frequency scattering can be the inaccuracies of the original data, and noise or non-linearities in the system.

A sanborn record of a step response was processed using the STEP-T_p code and assuming that the data was for a closed loop unity

feedback system. The original data and corresponding computed frequency response and derived open loop frequency response are given in tabular form -- Bode diagrams and a Nichols chart diagram are included. The frequency response measured directly using sinusoidal input into the same system is also given in the same Nichols chart. The deviations seem to be fairly small and, in fact, it might be that the computed frequency response is more accurate.

APPENDIX A

FORTRAN PROGRAMS

'IMPLSE

```

2000 FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,0PF10.2)
2003 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/10H    RAD/SEC)
2004 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/6H    CPS)
2005 FORMAT(12A6)
2006 FORMAT(1P12E14.4)
2007 FORMAT(11H1 IMPULSE 12A6)
2008 FORMAT(1H0,24I5)
2009 FORMAT(1H 12F10.4)
      DIMENSIONWI(36),P(200),W(36),COM(12),DB(36),PH(36),WL(36)
10 READ INPUT TAPE 5,2005,(COM(L),L=1,12)
   READ INPUT TAPE 5,2000,NI,NF,LF,IFREQ,IPL0T
   READ INPUT TAPE 5,2001,T,SF1,SF2,G1,G2,ST1
   READ INPUT TAPE 5,2001,(P(I),I=1,NI)
   IF(IFREQ)14,14,20
20 READ INPUT TAPE 5,2001,(WI(N),N=1,NF)
14 WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
   WRITE OUTPUT TAPE 6,2008,NI,NF,LF,IFREQ,IPL0T
   WRITE OUTPUT TAPE 6,2006,T,SF1,SF2,G1,G2,ST1
   WRITE OUTPUT TAPE 6,2009,(P(I),I=1,NI)
   IF(LF)11,11,12
11 DO 21 N=1,NF
21 W(N)=WI(N)
   WRITE OUTPUT TAPE 6,2003
   GO TO 13
12 DO 22 N=1,NF
22 W(N)=6.283184*WI(N)
   WRITE OUTPUT TAPE 6,2004
13 D = (SF1*G1*ST1)/(SF2*G2)
   DO 15 N=1,NF
15 WL(N)=LOG10F(W(N))
   DO 100 N=1,NF
   REX=P(2)-P(1)
   CMX=0.
   DO 50 J=3,NI
   X=P(J)-2.*P(J-1)+P(J-2)
   RE=X*COSF(W(N)*T*FLOATF(J-2))
   CM=-X*SINF(W(N)*T*FLOATF(J-2))
   REX=RE+REX

```

IMPLSE

```
50 CMX=CM+CMX
   CMZ=-CMX/(T*D*W(N)**2)
   REZ=-REX/(T*D*W(N)**2)
   CALL BAZFAZ (REZ,CMZ,ABS,DB(N),PH(N))
100 WRITE OUTPUT TAPE 6,2002,WI(N),REZ,CMZ,ABS,DB(N),PH(N)
   GO TO 10
   END
```

```

2000 FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,OPF10.2)
2003 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1      DECIBELS      PHASE/10H      RAD/SEC)
2004 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1      DECIBELS      PHASE/6H      CPS)
2005 FORMAT(12A6)
2006 FORMAT(1P12E14.4)
2007 FORMAT(13H1 IMPULSE-TF 12A6)
2008 FORMAT(1H0,24I5)
2009 FORMAT(1H 12F10.4)
201 FORMAT(1H ,28HOPEN LOOP FREQUENCY RESPONSE)
202 FORMAT(1H ,23HASSUMING UNITY FEEDBACK)
203 FORMAT(1H ,30HCLOSED LOOP FREQUENCY RESPONSE)
204 FORMAT(1H ,19HWITH UNITY FEEDBACK)
205 FORMAT (1H1,8HORIGINAL)
206 FORMAT (1H1,7HDERIVED)
      DIMENSIONWI(36),P(200),W(36),COM(12),DB(36),PH(36),WL(36)
      DIMENSION ABS(36),ABSM(36),DBM(36),PHM(36),REM(36),CMZ(36),REZ(36)
1,CMM(36)
10 READ INPUT TAPE 5,2005,(COM(L),L=1,12)
   READ INPUT TAPE 5,2000,NI,NF,LF,IFREQ,IPLOT,LOOP
   READ INPUT TAPE 5,2001,T,SF1,SF2,G1,G2,ST1
   READ INPUT TAPE 5,2001,(P(I),I=1,NI)
   IF(IFREQ)14,14,20
20 READ INPUT TAPE 5,2001,(WI(N),N=1,NF)
14 WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
   WRITE OUTPUT TAPE 6,2008,NI,NF,LF,IFREQ,IPLOT,LOOP
   WRITE OUTPUT TAPE 6,2006,T,SF1,SF2,G1,G2,ST1
   WRITE OUTPUT TAPE 6,2009,(P(I),I=1,NI)
   WRITE OUTPUT TAPE 6,205
   IF(LOOP) 303,303,301
301 WRITE OUTPUT TAPE 6,201
   GO TO 60
303 WRITE OUTPUT TAPE 6,203
304 WRITE OUTPUT TAPE 6,204
60 IF(LF)11,11,12
11 DO 21 N=1,NF
21 W(N)=WI(N)
   WRITE OUTPUT TAPE 6,2003
   GO TO 13

```

```
12 DO 22 N=1,NF
22 W(N)=6.283184*W1(N)
   WRITE OUTPUT TAPE 6,2004
13 D = (SF1*G1*ST1)/(SF2*G2)
   DO 15 N=1,NF
15 WL(N)=LOG10F(W(N))
   DO 100 N=1,NF
   REX=P(2)-P(1)
   CMX=0.
   DO 50 J=3,NI
   X=P(J)-2.*P(J-1)+P(J-2)
   RE=X*COSF(W(N)*T*FLOATF(J-2))
   CM=-X*SINF(W(N)*T*FLOATF(J-2))
   REX=RE+REX
50 CMX=CM+CMX
   CMZ(N)=-CMX/(T*D*W(N)**2)
   REZ(N)=-REX/(T*D*W(N)**2)
   CALL BAZFAZ (REZ(N),CMZ(N),ABS(N),DB(N),PH(N))
100 WRITE OUTPUT TAPE 6,2002,W1(N),REZ(N),CMZ(N),ABS(N),DB(N),PH(N)
   WRITE OUTPUT TAPE 6,206
   IF(LOOP) 500,500,400
400 WRITE OUTPUT TAPE 6,203
   WRITE OUTPUT TAPE 6,204
   IF(LF) 410,410,420
410 WRITE OUTPUT TAPE 6,2003
   GO TO 401
420 WRITE OUTPUT TAPE 6,2004
401 DO 402 N=1,NF
   REZS =1.+REZ(N)
   ABSM(N)=ABS(N)/(SQRTF(REZS**2+CMZ(N)**2))
   PHM(N)=PH(N)-ARTNF(CMZ(N),REZS)*57.29578
   REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
   CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
   DBM(N)=8.68589*LOGF(ABSM(N))
402 WRITE OUTPUT TAPE 6,2002,W1(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
   GO TO 10
500 WRITE OUTPUT TAPE 6,201
   WRITE OUTPUT TAPE 6,202
   IF(LF) 510,510,520
510 WRITE OUTPUT TAPE 6,2003
   GO TO 501
520 WRITE OUTPUT TAPE 6,2004
501 DO 502 N=1,NF
```

```
REZS =1.-REZ(N)
ABSM(N)=ABS(N)/(SQRTF(REZS**2+CMZ(N)**2))
PHM(N)=PH(N)-ARTNF(-CMZ(N),REZS)*57.29578
REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
DBM(N)=8.68589*LOGF(ABSM(N))
502 WRITE OUTPUT TAPE 6,2002,WI(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
GO TO 10
END
```

IMPULSE-TF

```
SUBROUTINE BAZFAZ (REAL,COMP,AMAG,DB,PHASE)

SUBROUTINE BAZFAZ (REAL,COMP,AMAG,DB,PHASE)
AMAG=SQRTF(REAL**2+COMP**2)
DB=8.68588964*LOGF(AMAG)
IF(REAL)1,4,2
1 PHASE=57.29578*ATANF(COMP/REAL)-180.
GO TO 3
2 PHASE=57.29578*ATANF(COMP/REAL)
GO TO 3
4 IF(COMP)6,7,8
6 PHASE= -90.
GO TO 3
7 PHASE= 0.
GO TO 3
8 PHASE= 90.
3 RETURN
END
```

STEP- 4C

```
200J FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,0PF10.2)
2003 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/10H  RAD/SEC)
2004 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/6H   CPS)
2005 FORMAT(12A6)
2006 FORMAT(1P12E14.4)
2007 FORMAT(11H1 STEP 4A  12A6)
2008 FORMAT(1H0,24I5)
2009 FORMAT(1H 12F10.4)
      DIMENSIONWI(96),P(200),W(96),COM(12),DB(96),PH(96),WL(96)
10 READ INPUT TAPE  5,2005,(COM(L),L=1,12)
   READ INPUT TAPE  5,2000,NI,NF,LF,IFREQ,IPL0T
   READ INPUT TAPE  5,2001,T,SF1,SF2,G1,G2,ST1
   READ INPUT TAPE  5,2001,(P(I),I=1,NI)
   IF(IFREQ)14,14,20
20 READ INPUT TAPE  5,2001,(WI(N),N=1,NF)
14 WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
   WRITE OUTPUT TAPE 6,2008,NI,NF,LF,IFREQ,IPL0T
   WRITE OUTPUT TAPE 6,2006,T,SF1,SF2,G1,G2,ST1
   WRITE OUTPUT TAPE 6,2009,(P(I),I=1,NI)
   IF(LF)11,11,12
11 DO 21 N=1,NF
21 W(N)=WI(N)
   WRITE OUTPUT TAPE 6,2003
   GO TO 13
12 DO 22 N=1,NF
22 W(N)=6.283184*WI(N)
   WRITE OUTPUT TAPE 6,2004
13 D = (SF1*G1*ST1)/(SF2*G2)
   DO 15 N=1,NF
15 WL(N)=LOG10F(W(N))
   DO 100 N=1,NF
   REX=P(2)-P(1)
   CMX=0.
   DO 50 J=3,NI
   X=P(J)-2.*P(J-1)+P(J-2)
   RE=X*COSF(W(N)*T*FLOATF(J-2))
   CM=-X*SINF(W(N)*T*FLOATF(J-2))
   REX=RE+REX
```


STEP-4C

```
50 CMX=CM+CMX
   CMZ=-REX/(W(N)*(T*D))
   REZ=CMX/(W(N)*(T*D))
   CALL BAZFAZ (REZ,CMZ,ABS,DB(N),PH(N))
100 WRITE OUTPUT TAPE 6,2002,WI(N),REZ,CMZ,ABS,DB(N),PH(N)
   GO TO 10
END
```

STEP-TF

```

2000 FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,0PF10.2)
2003 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
      1      DECIBELS      PHASE/10H      RAD/SEC)
2004 FORMAT(80H0 FREQUENCY      REAL      IMAGINARY      MAGNITUDE
      1      DECIBELS      PHASE/6H      CPS)
2005 FORMAT(12A6)
2006 FORMAT(1P12E14.4)
2007 FORMAT(11H1 STEP-TF 12A6)
2008 FORMAT(1H0,24I5)
2009 FORMAT(1H 12F10.4)
      201 FORMAT(1H ,28HOPEN LOOP FREQUENCY RESPONSE)
      202 FORMAT(1H ,23HASSUMING UNITY FEEDBACK)
      203 FORMAT(1H ,30HCLOSED LOOP FREQUENCY RESPONSE)
      204 FORMAT(1H ,19HWITH UNITY FEEDBACK)
      205 FORMAT (1H1,8HORIGINAL)
      206 FORMAT (1H1,7HDERIVED)
      DIMENSION WI(96),P(200),W(96),COM(12),DB(96),PH(96),WL(96)
      DIMENSION ABS(36),ABSM(36),DBM(36),PHM(36),REM(36),CMZ(36),REZ(36)
      1,CMM(36)
      10 READ INPUT TAPE 5,2005,(COM(L),L=1,12)
      READ INPUT TAPE 5,2000,NI,NF,LF,IFREQ,IPL0T,LOOP
      READ INPUT TAPE 5,2001,T,SF1,SF2,G1,G2,ST1
      READ INPUT TAPE 5,2001,(P(I),I=1,NI)
      IF(IFREQ)14,14,20
      20 READ INPUT TAPE 5,2001,(WI(N),N=1,NF)
      14 WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
      WRITE OUTPUT TAPE 6,2008,NI,NF,LF,IFREQ,IPL0T,LOOP
      WRITE OUTPUT TAPE 6,2006,T,SF1,SF2,G1,G2,ST1
      WRITE OUTPUT TAPE 6,2009,(P(I),I=1,NI)
      WRITE OUTPUT TAPE 6,205
      IF(LOOP) 303,303,301
      301 WRITE OUTPUT TAPE 6,201
      GO TO 60
      303 WRITE OUTPUT TAPE 6,203
      304 WRITE OUTPUT TAPE 6,204
      60 IF(LF) 11,11,12
      11 DO 21 N=1,NF
      21 W(N)=WI(N)
      WRITE OUTPUT TAPE 6,2033
      GO TO 13

```

STEP - T F

```

12 DO 22 N=1,NF
22 W(N)=6.283184*W1(N)
   WRITE OUTPUT TAPE 6,2004
13 D = (SF1*G1*ST1)/(SF2*G2)
   DO 15 N=1,NF
15 WL(N)=LOG10F(W(N))
   DO 100 N=1,NF
   REX=P(2)-P(1)
   CMX=0.
   DO 50 J=3,NI
   X=P(J)-2.*P(J-1)+P(J-2)
   RE=X*COSF(W(N)*T*FLOATF(J-2))
   CM=-X*SINF(W(N)*T*FLOATF(J-2))
   REX=RE+REX
50 CMX=CM+CMX
   CMZ(N)=-REX/(W(N)*(T*D))
   REZ(N)=CMX/(W(N)*(T*D))
   CALL BAZFAZ (REZ(N),CMZ(N),ABS(N),DB(N),PH(N))
100 WRITE OUTPUT TAPE 6,2002,W1(N),REZ(N),CMZ(N),ABS(N),DB(N),PH(N)
   WRITE OUTPUT TAPE 6,206
   IF(LOOP) 500,500,400
400 WRITE OUTPUT TAPE 6,203
   WRITE OUTPUT TAPE 6,204
   IF(LF) 410,410,420
410 WRITE OUTPUT TAPE 6,2003
   GO TO 401
420 WRITE OUTPUT TAPE 6,2004
401 DO 402 N=1,NF
   REZS =1.+REZ(N)
   ABSM(N)=ABS(N)/(SQRTF(REZS**2+CMZ(N)**2))
   PHM(N)=PH(N)-ARTNF(CMZ(N),REZS)*57.29578
   REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
   CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
   DBM(N)=8.68589*LOGF(ABSM(N))
402 WRITE OUTPUT TAPE 6,2002,W1(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
   GO TO 10
500 WRITE OUTPUT TAPE 6,201
   WRITE OUTPUT TAPE 6,202
   IF(LF) 510,510,520
510 WRITE OUTPUT TAPE 6,2003
   GO TO 501
520 WRITE OUTPUT TAPE 6,2004
501 DO 502 N=1,NF

```

STEP-TF

```
REZS =1.-REZ(N)
ABSM(N)=ABS(N)/(SQRTF(REZS**2+CMZ(N)**2))
PHM(N)=PH(N)-ARTNF(-CMZ(N),REZS)*57.29578
REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
DBM(N)=8.68589*LOGF(ABSM(N))
502 WRITE OUTPUT TAPE 6,2002,WI(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
GO TO 10
END
```

ROUTINE BAZFAZ (REAL,COMP,AMAG,DB,PHASE

STEP-TF

```
SUBROUTINE BAZFAZ (REAL,COMP,AMAG,DB,PHASE)
AMAG=SQRTF(REAL**2+COMP**2)
DB=8.68588964*LOGF(AMAG)
IF(REAL)1,4,2
1 PHASE=57.29578*ATANF(COMP/REAL)-180.
  GO TO 3
2 PHASE=57.29578*ATANF(COMP/REAL)
  GO TO 3
4 IF(COMP)6,7,8
6 PHASE= -90.
  GO TO 3
7 PHASE= 0.
  GO TO 3
8 PHASE= 90.
3 RETURN
END
```

ARBIT

```

2000 FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,0PF10.2)
2003 FORMAT(80H0 FREQUENCY      REAL          IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/10H    RAD/SEC)
2004 FORMAT(80H0 FREQUENCY      REAL          IMAGINARY      MAGNITUDE
1    DECIBELS      PHASE/6H     CPS)
2005 FORMAT(12A6)
2006 FORMAT(1H 1P12E14.4)
2007 FORMAT(10H1 ARBIT      12A6)
2008 FORMAT(1H0,24I5)
2009 FORMAT(12F10.4)
      DIMENSION WI(36),R(200),C(200),COM(12),W(36),HR(36),FI(36),
1ABS(36),PH(36),WL(36),DB(36)
10 READ INPUT TAPE  5,2005,(COM(L),L=1,12)
   READ INPUT TAPE  5,2000,NR,NC,NF,LF,IFREQ,IPL0T
   READ INPUT TAPE  5,2001,TR,TC,SFR,SFC,GR,GC
   READ INPUT TAPE  5,2001,(R(I),I=1,NR)
   READ INPUT TAPE  5,2001,(C(I),I=1,NC)
   IF(IFREQ)14,14,20
20 READ INPUT TAPE  5,2001,(WI(N),N=1,NF)
14 WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
   WRITE OUTPUT TAPE 6,2008,NR,NC,NF,LF,IFREQ,IPL0T
   WRITE OUTPUT TAPE 6,2006,TR,TC,SFR,SFC,GR,GC
   WRITE OUTPUT TAPE 6,2009,(R(I),I=1,NR)
   WRITE OUTPUT TAPE 6,2009,(C(I),I=1,NC)
   IF(LF)11,11,12
11 DO 21 N=1,NF
21 W(N)=WI(N)
   WRITE OUTPUT TAPE 6,2003
   GO TO 13
12 DO 22 N=1,NF
22 W(N)=6.283184*WI(N)
   WRITE OUTPUT TAPE 6,2004
   DO 15 N=1,NF
15 WL(N)=LOG10F(W(N))
13 DO 100 N=1,NF
   RRA=R(2)-R(1)
   RIA=0.
   DO 50 J=3,NR
   X=R(J)-2.*R(J-1)+R(J-2)
   RRB=X*COSF(W(N)*TR*FLOATF(J-2))

```

ARBIT

```
RIB=-X*SINF(W(N)*TR*FLOATF(J-2))
RRA=RRA+RRB
50 RIA=RIA+RIB
RR=(RRA/TR)*SFR*GR
RI=(RIA/TR)*SFR*GR
CRA=C(2)-C(1)
CIA=0.
DO 75 J=3,NC
X=C(J)-2.*C(J-1)+C(J-2)
CRB=X*COSF(W(N)*TC*FLOATF(J-2))
CIB=-X*SINF(W(N)*TC*FLOATF(J-2))
CRA=CRA+CRB
75 CIA=CIA+CIB
CR=(CRA/TC)*SFC*GC
CI=(CIA/TC)*SFC*GC
HR(N)=(CR*RR+CI*RI)/(RR**2+RI**2)
HI(N)=(CI*RR-CR*RI)/(RR**2+RI**2)
100 CALL BAZFAZ(HR(N),HI(N),ABS(N),DB(N),PH(N))
WRITE OUTPUT TAPE 6,2002,(WI(N),HR(N),HI(N),ABS(N),DB(N),PH(N),
IN=1,NF)
GO TO 10
END
```

ARBIT-TF

```

2000 FORMAT(24I3)
2001 FORMAT(12E6.2)
2002 FORMAT(F10.4,1P4E15.4,OPF10.2)
2003 FORMAT(8CHO FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1      DECIBELS      PHASE/10H      RAD/SEC)
2004 FCRMAT(8CHO FREQUENCY      REAL      IMAGINARY      MAGNITUDE
1      DECIBELS      PHASE/6H      CPS)
2005 FCRMAT(12A6)
2006 FORMAT(1H 1P12E14.4)
2007 FCRMAT(12H1 ARBIT-TF 12A6)
2008 FORMAT(1F0,24I5)
2009 FORMAT(12F10.4)
201  FORMAT(1F ,28HOPEN LOOP FREQUENCY RESPONSE)
202  FCRMAT(1F ,23HASSUMING UNITY FEEDBACK)
203  FCRMAT(1F ,3CHCLOSED LOOP FREQUENCY RESPONSE)
204  FCRMAT(1F ,15HWITH UNITY FEEDBACK)
205  FORMAT (1H1,8HORIGINAL)
206  FCRMAT (1H1,7HDERIVED)
      DIMENSION WI(36),R(200),C(200),COM(12),w(36),HR(36),HI(36),
1ABS(36),PH(36),WL(36),DB(36)
      DIMENSION CMM(36),ABSM(36),DBM(36),PHM(36),REM(36)
10  READ INPUT TAPE 5,2005,(COM(L),L=1,12)
      READ INPUT TAPE 5,2000,NR,NC,NF,LF,IFREQ,IPLOT,LCOP
      READ INPUT TAPE 5,2001,TR,TC,SFR,SFC,GR,GC
      READ INPUT TAPE 5,2001,(R(I),I=1,NR)
      READ INPUT TAPE 5,2001,(C(I),I=1,NC)
      IF(IFREQ)14,14,20
20  READ INPUT TAPE 5,2001,(WI(N),N=1,NF)
14  WRITE OUTPUT TAPE 6,2007,(COM(L),L=1,12)
      WRITE OUTPUT TAPE 6,2008,NR,NC,NF,LF,IFREQ,IPLOT,LOOP
      WRITE OUTPUT TAPE 6,2006,TR,TC,SFR,SFC,GR,GC
      WRITE OUTPUT TAPE 6,2009,(R(I),I=1,NR)
      WRITE OUTPUT TAPE 6,2009,(C(I),I=1,NC)
      WRITE OUTPUT TAPE 6,205
      IF(LCOP) 303,303,301
301  WRITE OUTPUT TAPE 6,201
      GO TO 60
303  WRITE OUTPUT TAPE 6,203
304  WRITE OUTPUT TAPE 6,204
60  IF(LF) 11,11,12
11  DO 21 N=1,NF
21  W(N)=WI(N)

```

```
WRITE OUTPUT TAPE 6,2003
GO TC 13
12 DO 22 N=1,NF
22 W(N)=6.283184*W1(N)
WRITE OUTPUT TAPE 6,2004
DO 15 N=1,NF
15 WL(N)=LCG10F(W(N))
13 DO 100 N=1,NF
  RRA=R(2)-R(1)
  RIA=C.
  DO 50 J=3,NR
    X=R(J)-2.*R(J-1)+R(J-2)
    RRB=X*COSF(W(N)*TR*FLOATF(J-2))
    RIB=-X*SINF(W(N)*TR*FLOATF(J-2))
    RRA=RRA+RRB
50  RIA=RIA+RIB
    RR=(RRA/TR)*SFR*GR
    RI=(RIA/TR)*SFR*GR
    CRA=C(2)-C(1)
    CIA=C.
    DO 75 J=3,NC
      X=C(J)-2.*C(J-1)+C(J-2)
      CRB=X*COSF(W(N)*TC*FLOATF(J-2))
      CIB=-X*SINF(W(N)*TC*FLOATF(J-2))
      CRA=CRA+CRB
75  CIA=CIA+CIB
    CR=(CRA/TC)*SFC*GC
    CI=(CIA/TC)*SFC*GC
    HR(N)=(CR*RR+CI*RI)/(RR**2+RI**2)
    HI(N)=(CI*RR-CR*RI)/(RR**2+RI**2)
100 CALL BAZFAZ(HR(N),HI(N),ABS(N),DB(N),PH(N))
  WRITE OUTPUT TAPE 6,2002,(W1(N),HR(N),HI(N),ABS(N),DB(N),PH(N),
  1N=1,NF)
  WRITE OUTPUT TAPE 6,2006
  IF(LCOP) 500,500,400
400 WRITE OUTPUT TAPE 6,203
  WRITE OUTPUT TAPE 6,204
  IF(LF) 410,410,420
410 WRITE OUTPUT TAPE 6,2003
  GO TC 401
420 WRITE OUTPUT TAPE 6,2004
401 DO 402 N=1,NF
  REZS =1.+HR(N)
```

ARBIT-TF

```
      ABSM(N)=ABS(N)/(SQRTF(REZS**2+ HI(N)**2))
      PHM(N)=PH(N)-ARTNF( HI(N),REZS)*57.29578
      REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
      CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
      DBM(N)=8.68589*LOGF(ABSM(N))
402  WRITE OUTPUT TAPE 6,2002,WI(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
      GO TC 10
500  WRITE OUTPUT TAPE 6,201
      WRITE OUTPUT TAPE 6,202
      IF(LF) 510,510,520
510  WRITE OUTPUT TAPE 6,2003
      GO TC 501
520  WRITE OUTPUT TAPE 6,2004
501  CO 502 N=1,NF
      REZS=1.-HR(N)
      ABSM(N)=ABS(N)/(SQRTF(REZS**2+ HI(N)**2))
      PHM(N)=PH(N)-ARTNF(- HI(N),REZS)*57.29578
      REM(N)=ABSM(N)*COSF(PHM(N)/57.29578)
      CMM(N)=ABSM(N)*SINF(PHM(N)/57.29578)
      DBM(N)=8.68589*LOGF(ABSM(N))
502  WRITE OUTPUT TAPE 6,2002,WI(N),REM(N),CMM(N),ABSM(N),DBM(N),PHM(N)
      GO TC 10
      END
```

ARBIT-TF

```
JUBRCUTINE BAZFAZ (REAL,CCMP,AMAG,DB,PHASE)

SUBRCUTINE BAZFAZ (REAL,CCMP,AMAG,DB,PHASE)
AMAG=SQRTF(REAL**2+COMP**2)
DB=8.68588964*LOGF(AMAG)
IF(REAL)1,4,2
1 PHASE=57.29578*ATANF(COMP/REAL)-180.
GO TC 3
2 PHASE=57.29578*ATANF(COMP/REAL)
GO TC 3
4 IF(CCMP)6,7,8
6 PHASE= -90.
GO TC 3
7 PHASE= 0.
GO TC 3
8 PHASE= 90.
3 RETURN
END
```

APPENDIX B

"DATA CARDS" - TABLE FOR PUNCHING DATA CARDS

DATA CARDS

WAPL-TTE-1338

Card Number	Data Format	Parameter or Variable	FORTRAN Symbol	Card Columns		
				IMPULSE-TF	STEP-TF	ARBIT-TF
1		any comment		1...72	1...72	1...72
2	24I3	N_R	-- NR			1...3
		N_C	NI, NI, NC	1...3	1...3	4...6
		N_F	NF, NF, NF	4...6	4...6	7...9
		L_F	LF, LF, LF	7...9	7...9	10...12
		Freq.	IFREQ	10...12	10...12	13...15
		Plotting	IPLOT	13...15	13...15	16...18
		Closed/Open Loop	LOOP	16...18	16...18	19...21
3	12 E 6.2	$\Delta T_R/\text{sec}$	-- TR	--	--	1...6
		$\Delta T_C/\text{sec}$	T, T, TC	1...6	1...6	7...12
		SF_R	SFI, SFI, SFR	7...12	7...12	13...18
		SF_C	SF2, SF2, SFC	13...18	13...18	19...24
		G_R	G1, G1, GR	19...24	19...24	25...30
		G_C	G2, G2, GC	25...30	25...30	31...36
		IRI, IRI, --	STI, STI, --	31...36	31...36	--
4 a, b,...	12 E 6.2	$R = V_R/\text{sec}$	-- R	--	--	1...72
5 a, b,...	12 E 6.2	$C = V_C/\text{sec}$	P, P, C	1...72	1...72	1...72
6 a, b,...	12 E 6.2	w/f	WI, WI, WI	1...72	1...72	1...72

- N_R = Number of data points for the input variable (200 max.)
 N_C = Number of data points for the output variable (200 max.)
 N_F = Number of frequencies at which the frequency response is to be calculated (36 max.)
 L_F = 0, if frequencies are to be given in radians per second
= 1, if frequencies are to be given in cycles per second
Freq. = 0, if frequency cards are not to be read
= 1, if frequency cards are to be read
Plotting = 1, if plots are wanted (not used here)
LOOP = 0, if the measured transient is for a closed loop system
= 1, if the measured transient is for an open loop system
 ΔT_R = Time increment between input points in seconds
 ΔT_C = Time increment between output points in seconds
 SF_R = Scale Factor of the input variable
 SF_C = Scale factor of the output variable

DATA CARDS

(Continued)

G_R = Gain of recorder on which the input variable is recorded (volts/division)
 G_C = Gain of recorder on which the output variable is recorded (volts/division)
 $Wf, w/f$ = Frequency, radians per second/cycles per second
 IRI = Magnitude of input step or strength of input impulse

APPENDIX C

COMPUTER TEST RUNS WITH GRAPHS

The following is a series of computer test runs utilizing the "IMPULSE-TF", "STEP-TF" and "ARBIT-TF" digital programs previously discussed.

Each run consists generally of the following: a) computer printout showing the data input and resulting frequency response output, b) specification of the system for which the computations were made and conditions under which run was made, c) Bode diagrams for the original closed/open loop frequency response and the derived open/closed loop response assuming unity feedback.

In each Bode diagram the gain points are identified by circles (O) and the phase points are identified by triangles (Δ); the solid lines indicate, unless otherwise specified, what the correct gain and phase values are.

The following is a listing of the test runs made:

<u>Run No.</u>	<u>Program</u>	<u>Description</u>
1	"IMPULSE-TF"	frequency response computed from the open loop system response to impulse input.
2	"IMPULSE-TF"	frequency response for the closed loop system with unity feedback, derived from the open loop system response to impulse input.

<u>Run No.</u>	<u>Program</u>	<u>Description</u>
3	"IMPULSE-TF"	frequency response for the open loop system, assuming unity feed-back, derived from the closed loop system response to impulse input.
4	"STEP-TF"	frequency response computed from the open loop system response to step input.
5	"STEP-TF"	frequency response for the closed loop system, assuming unity feed-back, derived from the open loop system response to step input.
6	"STEP-TF"	frequency response computed from the closed loop system response to step input.
7	"STEP-TF"	frequency response for the open loop system, assuming unity feed-back, derived from the closed loop system response to step input.
8	"STEP-TF"	frequency response computed from the system response to step input with the numerical values of the response rounded to ± 0.5 per cent of the final value.
9	"STEP-TF"	frequency response for a closed loop system computed from a recorded response of the system to a step input.
10	"STEP-TF"	frequency response for the open loop system, assuming unity feed-back, derived from the recorded closed loop system response to a step input.

<u>Run No.</u>	<u>Program</u>	<u>Description</u>
11	"STEP-TF"	comparison between the system frequency response computed from a step response with the directly measured frequency response for the analog model of the actual system.
12	"STEP-TF"	comparison of several approximately equivalent frequency response measurements with the frequency response computed from the system step response.
13	"ARBIT-TF"	frequency response computed from the open loop system response to rectangular pulse input.
14	"ARBIT-TF"	frequency response for the closed loop system, assuming unity feedback, derived from the open loop system response to a rectangular pulse input.
15	"ARBIT-TF"	frequency response for the open loop system, assuming unity feedback, derived from the closed loop system response to rectangular pulse input.

FREQ. RESPONSE OF SECOND ORDER SYSTEM FROM 100-IMPULSE, $Z=.5, W=1.$

[illegible]

ORIGINAL
OPEN LOOP FREQUENCY RESPONSE

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.7645E-01	-7.9537E-03	9.7649E-01	-2.0667E-01	-0.47
0.0200	9.7694E-01	-1.5930E-02	9.7707E-01	-2.0149E-01	-0.93
0.0300	9.7743E-01	-2.3948E-02	9.7772E-01	-1.9569E-01	-1.40
0.0400	9.7805E-01	-3.2026E-02	9.7857E-01	-1.8815E-01	-1.88
0.0500	9.7881E-01	-4.0180E-02	9.7964E-01	-1.7871E-01	-2.35
0.0600	9.7973E-01	-4.8434E-02	9.8092E-01	-1.6728E-01	-2.83
0.0700	9.8079E-01	-5.6805E-02	9.8244E-01	-1.5392E-01	-3.31
0.0800	9.8200E-01	-6.5313E-02	9.8417E-01	-1.3863E-01	-3.81
0.0900	9.8333E-01	-7.3973E-02	9.8611E-01	-1.2148E-01	-4.30
0.1000	9.8479E-01	-8.2803E-02	9.8827E-01	-1.0253E-01	-4.81
0.1300	9.8976E-01	-1.1048E-01	9.9591E-01	-3.5617E-02	-6.37
0.1600	9.9532E-01	-1.4023E-01	1.0052E 00	4.4644E-02	-8.02
0.2000	1.0029E 00	-1.8368E-01	1.0196E 00	1.6817E-01	-10.38
0.2500	1.0107E 00	-2.4477E-01	1.0399E 00	3.4021E-01	-13.61
0.3200	1.0140E 00	-3.4329E-01	1.0705E 00	5.9176E-01	-18.70
0.4000	9.9796E-01	-4.7192E-01	1.1039E 00	8.5870E-01	-25.31
0.5000	9.3516E-01	-6.4516E-01	1.1361E 00	1.1084E 00	-34.60
0.6300	7.7035E-01	-8.5508E-01	1.1509E 00	1.2208E 00	-47.98
0.7900	4.6063E-01	-1.0163E 00	1.1158E 00	9.5163E-01	-65.62
1.0000	1.7445E-02	-9.8237E-01	9.8253E-01	-1.5312E-01	-88.98
1.2600	-3.0805E-01	-6.6586E-01	7.3366E-01	-2.6901E 00	-114.83
1.5800	-3.1689E-01	-3.1919E-01	4.4978E-01	-6.9400E 00	-134.79
2.0000	-2.2677E-01	-1.6377E-01	2.7973E-01	-1.1065E 01	-144.16
2.5100	-1.5560E-01	-7.0163E-02	1.7087E-01	-1.5347E 01	-155.76
3.1600	-9.9834E-02	-2.9226E-02	1.0402E-01	-1.9657E 01	-163.68
3.9800	-6.5237E-02	-2.0047E-02	6.8248E-02	-2.3318E 01	-162.92
5.0100	-3.7001E-02	-4.1118E-03	3.7228E-02	-2.8582E 01	-173.66
6.3100	-2.8088E-02	-1.9700E-03	2.8157E-02	-3.1008E 01	-175.99
7.9400	-1.9334E-02	-1.0469E-03	1.9362E-02	-3.4261E 01	-176.90
10.0000	-1.0712E-02	2.8271E-03	1.1079E-02	-3.9110E 01	-194.78

The Frequency Response Computed From the Open Loop System,

$$G(S) = \frac{1}{1 + S + S^2}, \text{ Response to Impulse Input}$$

DERIVED
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	4.9405E-01	-2.0361E-03	4.9406E-01	-6.1245E 00	-0.24
0.0200	4.9420E-01	-4.0757E-03	4.9422E-01	-6.1216E 00	-0.47
0.0300	4.9437E-01	-6.1236E-03	4.9440E-01	-6.1183E 00	-0.71
0.0400	4.9458E-01	-8.1832E-03	4.9465E-01	-6.1140E 00	-0.95
0.0500	4.9485E-01	-1.0257E-02	4.9496E-01	-6.1086E 00	-1.19
0.0600	4.9518E-01	-1.2350E-02	4.9534E-01	-6.1020E 00	-1.43
0.0700	4.9557E-01	-1.4466E-02	4.9578E-01	-6.0943E 00	-1.67
0.0800	4.9601E-01	-1.6608E-02	4.9628E-01	-6.0854E 00	-1.92
0.0900	4.9650E-01	-1.8779E-02	4.9685E-01	-6.0754E 00	-2.17
0.1000	4.9704E-01	-2.0983E-02	4.9749E-01	-6.0644E 00	-2.42
0.1300	4.9897E-01	-2.7818E-02	4.9975E-01	-6.0250E 00	-3.19
0.1600	5.0129E-01	-3.5048E-02	5.0252E-01	-5.9770E 00	-4.00
0.2000	5.0488E-01	-4.5407E-02	5.0692E-01	-5.9012E 00	-5.14
0.2500	5.0993E-01	-5.9657E-02	5.1341E-01	-5.7907E 00	-6.67
0.3200	5.1749E-01	-8.2247E-02	5.2398E-01	-5.6137E 00	-9.03
0.4000	5.2594E-01	-1.1198E-01	5.3773E-01	-5.3888E 00	-12.02
0.5000	5.3494E-01	-1.5505E-01	5.5695E-01	-5.0836E 00	-16.16
0.6300	5.4199E-01	-2.2122E-01	5.8543E-01	-4.6510E 00	-22.20
0.7900	5.3869E-01	-3.2097E-01	6.2706E-01	-4.0538E 00	-30.79
1.0000	4.9134E-01	-4.9112E-01	6.9471E-01	-3.1640E 00	-44.99
1.2600	2.4964E-01	-7.2206E-01	7.6400E-01	-2.3382E 00	-70.93
1.5800	-2.0156E-01	-5.6144E-01	5.9652E-01	-4.4875E 00	-109.75
2.0000	-2.3776E-01	-2.6216E-01	3.5391E-01	-9.0221E 00	-132.21
2.5100	-1.7643E-01	-9.7775E-02	2.0171E-01	-1.3905E 01	-151.01
3.1600	-1.0974E-01	-3.6031E-02	1.1550E-01	-1.8748E 01	-161.82
3.9800	-6.9298E-02	-2.2932E-02	7.2994E-02	-2.2734E 01	-161.69
5.0100	-3.8403E-02	-4.4337E-03	3.8659E-02	-2.8255E 01	-173.41
6.3100	-2.8896E-02	-2.0855E-03	2.8971E-02	-3.0761E 01	-175.87
7.9400	-1.9714E-02	-1.0886E-03	1.9744E-02	-3.4091E 01	-176.84
10.0000	-1.0820E-02	2.8886E-03	1.1199E-02	-3.9017E 01	-194.95

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WANT-TME-1338

The Frequency Response for the Closed Loop System
With Unity Feedback Derived From the Open Loop System,

$$G(S) = \frac{1}{1 + S + S^2}, \text{ Response to Impulse Input}$$

WANL-TME-1338

FREQ.RESPONSE OF SECOND ORDER SYSTEM FROM 100-IMPULSE,Z=.5,W=1.

42

ORIGINAL
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.7645E-01	-7.9537E-03	9.7649E-01	-2.0667E-01	-0.47
0.0200	9.7694E-01	-1.5930E-02	9.7707E-01	-2.0149E-01	-0.93
0.0300	9.7743E-01	-2.3948E-02	9.7772E-01	-1.9569E-01	-1.40
0.0400	9.7805E-01	-3.2026E-02	9.7857E-01	-1.8815E-01	-1.88
0.0500	9.7881E-01	-4.0180E-02	9.7964E-01	-1.7871E-01	-2.35
0.0600	9.7973E-01	-4.8434E-02	9.8092E-01	-1.6728E-01	-2.83
0.0700	9.8079E-01	-5.6805E-02	9.8244E-01	-1.5392E-01	-3.31
0.0800	9.8200E-01	-6.5313E-02	9.8417E-01	-1.3863E-01	-3.81
0.0900	9.8333E-01	-7.3973E-02	9.8611E-01	-1.2148E-01	-4.30
0.1000	9.8479E-01	-8.2803E-02	9.8827E-01	-1.0253E-01	-4.81
0.1300	9.8976E-01	-1.1048E-01	9.9591E-01	-3.5617E-02	-6.37
0.1600	9.9532E-01	-1.4023E-01	1.0052E 00	4.4644E-02	-8.02
0.2000	1.0029E 00	-1.8368E-01	1.0196E 00	1.6817E-01	-10.38
0.2500	1.0107E 00	-2.4477E-01	1.0399E 00	3.4021E-01	-13.61
0.3200	1.0140E 00	-3.4329E-01	1.0705E 00	5.9176E-01	-18.70
0.4000	9.9796E-01	-4.7192E-01	1.1039E 00	8.5870E-01	-25.31
0.5000	9.3516E-01	-6.4516E-01	1.1361E 00	1.1084E 00	-34.60
0.6300	7.7035E-01	-8.5508E-01	1.1509E 00	1.2208E 00	-47.98
0.7900	4.6063E-01	-1.0163E 00	1.1158E 00	9.5163E-01	-65.62
1.0000	1.7445E-02	-9.8237E-01	9.8253E-01	-1.5312E-01	-88.98
1.2600	-3.0805E-01	-6.6586E-01	7.3366E-01	-2.6901E 00	-114.83
1.5800	-3.1689E-01	-3.1919E-01	4.4978E-01	-6.9400E 00	-134.79
2.0000	-2.2677E-01	-1.6377E-01	2.7973E-01	-1.1065E 01	-144.16
2.5100	-1.5580E-01	-7.0163E-02	1.7087E-01	-1.5347E 01	-155.76
3.1600	-9.9834E-02	-2.9226E-02	1.0402E-01	-1.9657E 01	-163.68
3.9800	-6.5237E-02	-2.0047E-02	6.8248E-02	-2.3318E 01	-162.92
5.0100	-3.7001E-02	-4.1118E-03	3.7228E-02	-2.8582E 01	-173.66
6.3100	-2.8088E-02	-1.9700E-03	2.8157E-02	-3.1008E 01	-175.99
7.9400	-1.9334E-02	-1.0469E-03	1.9362E-02	-3.4261E 01	-176.90
10.0000	-1.0712E-02	2.8271E-03	1.1079E-02	-3.9110E 01	-194.78

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NAV-71-1338

DERIVED
OPEN LOOP FREQUENCY RESPONSE
ASSUMING UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	3.7121E C1	-1.2877E 01	3.9291E C1	3.1886E 01	-19.13
0.0200	2.8356E 01	-2.0278E 01	3.4861E 01	3.0847E 01	-35.57
0.0300	1.9842E 01	-2.2113E 01	2.9710E C1	2.9458E 01	-48.10
0.0400	1.3561E C1	-2.1243E 01	2.5203E C1	2.8029E 01	-57.45
0.0500	9.2688E 00	-1.9473E 01	2.1566E 01	2.6675E 01	-64.55
0.0600	6.3532E 00	-1.7569E 01	1.8682E 01	2.5429E 01	-70.12
0.0700	4.3418E 00	-1.5798E 01	1.6383E C1	2.4288E 01	-74.63
0.0800	2.9223E 00	-1.4230E 01	1.4527E C1	2.3243E 01	-78.39
0.0900	1.8987E 00	-1.2865E 01	1.3005E 01	2.2282E 01	-81.60
0.1000	1.1459E 00	-1.1683E 01	1.1739E 01	2.1392E 01	-84.40
0.1300	-1.6825E-01	-8.9747E 00	8.9762E 00	1.9062E 01	-91.07
0.1600	-7.6244E-01	-7.1233E 00	7.1640E 00	1.7103E 01	-96.11
0.2000	-1.0850E 00	-5.4429E 00	5.5499E 00	1.4886E 01	-101.27
0.2500	-1.1787E 00	-4.0776E 00	4.2446E 00	1.2557E 01	-106.12
0.3200	-1.1183E 00	-2.9082E 00	3.1158E 00	9.8713E 00	-111.03
0.4000	-9.9082E-01	-2.1189E 00	2.3392E 00	7.3812E 00	-115.06
0.5000	-8.4578E-01	-1.5345E 00	1.7522E 00	4.8714E 00	-118.86
0.6300	-7.0704E-01	-1.0908E 00	1.2999E 00	2.2782E 00	-122.95
0.7900	-5.9253E-01	-7.6773E-01	9.6980E-01	-2.6635E-01	-127.66
1.0000	-4.9103E-01	-5.0888E-01	7.0715E-01	-3.0097E 00	-133.98
1.2600	-3.9284E-01	-3.0907E-01	4.9985E-01	-6.0233E 00	-141.81
1.5800	-2.8277E-01	-1.7384E-01	3.3193E-01	-9.5790E 00	-148.42
2.0000	-1.9913E-01	-1.0691E-01	2.2601E-01	-1.2917E 01	-151.77
2.5100	-1.3798E-01	-5.2329E-02	1.4757E-01	-1.6620E 01	-159.23
3.1600	-9.1414E-02	-2.4144E-02	9.4548E-02	-2.0487E 01	-165.20
3.9800	-6.1574E-02	-1.7661E-02	6.4057E-02	-2.3869E 01	-164.00
5.0100	-3.5696E-02	-3.8235E-03	3.5900E-02	-2.8898E 01	-173.89
6.3100	-2.7325E-02	-1.8638E-03	2.7388E-02	-3.1249E 01	-176.10
7.9400	-1.8968E-02	-1.0076E-03	1.8995E-02	-3.4427E 01	-176.96
10.0000	-1.0606E-02	2.7675E-03	1.0961E-02	-3.9203E 01	-194.62

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1/ANT-TME-1338

610775-4A

The Frequency Response for the Open Loop System
Assuming Unity Feedback Derived From the Closed Loop System,

$$G(S) = \frac{1}{1 + S + S^2}, \text{ Response to Impulse Input}$$

WANL-TME-1338

[illegible]

ORIGINAL
OPEN LOOP FREQUENCY RESPONSE

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.9744E-01	-9.3533E-03	9.9748E-01	-2.1895E-02	-0.54
0.0200	9.9756E-01	-1.8728E-02	9.9773E-01	-1.9732E-02	-1.08
0.0300	9.9775E-01	-2.8128E-02	9.9814E-01	-1.6138E-02	-1.61
0.0400	9.9801E-01	-3.7568E-02	9.9872E-01	-1.1122E-02	-2.16
0.0500	9.9835E-01	-4.7062E-02	9.9946E-01	-4.7005E-03	-2.70
0.0600	9.9875E-01	-5.6624E-02	1.0004E 00	3.1055E-03	-3.24
0.0700	9.9922E-01	-6.6265E-02	1.0014E 00	1.2271E-02	-3.79
0.0800	9.9974E-01	-7.6000E-02	1.0026E 00	2.2766E-02	-4.35
0.0900	1.0003E 00	-8.5839E-02	1.0040E 00	3.4558E-02	-4.90
0.1000	1.0009E 00	-9.5795E-02	1.0055E 00	4.7608E-02	-5.47
0.1300	1.0029E 00	-1.2648E-01	1.0109E 00	9.3890E-02	-7.19
0.1600	1.0050E 00	-1.5858E-01	1.0174E 00	1.4983E-01	-8.97
0.2000	1.0072E 00	-2.0400E-01	1.0276E 00	2.3684E-01	-11.45
0.2500	1.0079E 00	-2.6546E-01	1.0423E 00	3.5989E-01	-14.75
0.3200	1.0017E 00	-3.6054E-01	1.0646E 00	5.4402E-01	-19.79
0.4000	9.7801E-01	-4.8044E-01	1.0896E 00	7.4568E-01	-26.16
0.5000	9.1326E-01	-6.3902E-01	1.1146E 00	9.4262E-01	-34.98
0.6300	7.5970E-01	-8.3293E-01	1.1274E 00	1.0414E 00	-47.63
0.7900	4.7439E-01	-9.9342E-01	1.1009E 00	8.3474E-01	-64.47
1.0000	4.4735E-02	-9.8834E-01	9.8935E-01	-9.3003E-02	-87.41
1.2600	-3.1294E-01	-6.9167E-01	7.5917E-01	-2.3933E 00	-114.34
1.5800	-3.3509E-01	-3.0604E-01	4.5381E-01	-6.8625E 00	-137.59
2.0000	-2.0886E-01	-1.6753E-01	2.6775E-01	-1.1446E 01	-141.27
2.5100	-1.6314E-01	-5.9714E-02	1.7843E-01	-1.4971E 01	-160.45
3.1600	-9.9398E-02	-4.9753E-02	1.1115E-01	-1.9081E 01	-153.41
3.9800	-5.1240E-02	-2.1904E-02	5.5726E-02	-2.5079E 01	-156.85
5.0100	-3.0712E-02	-1.2567E-02	3.3183E-02	-2.9582E 01	-157.75
6.3100	-2.8027E-02	-9.9950E-03	3.0322E-02	-3.0365E 01	-160.75
7.9400	-9.5327E-03	1.5571E-04	9.5340E-03	-4.0414E 01	-180.94
10.0000	-5.0828E-03	7.5933E-04	5.1392E-03	-4.5782E 01	-188.50

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WML-010-1038

The Frequency Response Computed from the
 Open Loop System, $G(S) = \frac{1}{1 + S + S^2}$, Response to Step Input

610775-7A

WANL-TME-1338

DERIVED
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	4.9937E-01	-2.3443E-03	4.9938E-01	-6.0315E 00	-0.27
0.0200	4.9943E-01	-4.6930E-03	4.9945E-01	-6.0301E 00	-0.54
0.0300	4.9954E-01	-7.0464E-03	4.9959E-01	-6.0278E 00	-0.81
0.0400	4.9968E-01	-9.4074E-03	4.9977E-01	-6.0246E 00	-1.08
0.0500	4.9986E-01	-1.1779E-02	5.0000E-01	-6.0205E 00	-1.35
0.0600	5.0009E-01	-1.4162E-02	5.0029E-01	-6.0156E 00	-1.62
0.0700	5.0035E-01	-1.6561E-02	5.0063E-01	-6.0097E 00	-1.90
0.0800	5.0066E-01	-1.8978E-02	5.0102E-01	-6.0030E 00	-2.17
0.0900	5.0100E-01	-2.1414E-02	5.0145E-01	-5.9954E 00	-2.45
0.1000	5.0137E-01	-2.3872E-02	5.0194E-01	-5.9869E 00	-2.73
0.1300	5.0271E-01	-3.1401E-02	5.0369E-01	-5.9567E 00	-3.57
0.1600	5.0434E-01	-3.9204E-02	5.0586E-01	-5.9194E 00	-4.44
0.2000	5.0688E-01	-5.0118E-02	5.0936E-01	-5.8596E 00	-5.65
0.2500	5.1053E-01	-6.4710E-02	5.1462E-01	-5.7703E 00	-7.22
0.3200	5.1613E-01	-8.7151E-02	5.2344E-01	-5.6227E 00	-9.58
0.4000	5.2260E-01	-1.1595E-01	5.3531E-01	-5.4278E 00	-12.51
0.5000	5.2979E-01	-1.5705E-01	5.5257E-01	-5.1522E 00	-16.51
0.6300	5.3575E-01	-2.1976E-01	5.7907E-01	-4.7454E 00	-22.30
0.7900	5.3352E-01	-3.1430E-01	6.1922E-01	-4.1631E 00	-30.50
1.0000	4.9488E-01	-4.7785E-01	6.8793E-01	-3.2491E 00	-44.00
1.2600	2.7713E-01	-7.2772E-01	7.7870E-01	-2.1726E 00	-69.15
1.5800	-2.4105E-01	-5.7121E-01	6.1999E-01	-4.1523E 00	-112.88
2.0000	-2.0976E-01	-2.5617E-01	3.3109E-01	-9.6011E 00	-129.31
2.5100	-1.9596E-01	-8.5850E-02	2.1394E-01	-1.3394E 01	-156.34
3.1600	-1.0699E-01	-6.1154E-02	1.2323E-01	-1.8185E 01	-150.25
3.9800	-5.3446E-02	-2.4321E-02	5.8720E-02	-2.4624E 01	-155.53
5.0100	-3.1511E-02	-1.3374E-02	3.4232E-02	-2.9311E 01	-157.00
6.3100	-2.9362E-02	-1.0592E-02	3.1214E-02	-3.0113E 01	-160.16
7.9400	-9.6245E-03	1.5872E-04	9.6258E-03	-4.0331E 01	-180.94
10.0000	-5.1082E-03	7.6711E-04	5.1654E-03	-4.5738E 01	-188.54

The Frequency Response for the Closed Loop System
with Unity Feedback Derived from the Open Loop System,
 $G(S) = \frac{1}{1 + S + S^2}$, Response to Step Input

WANL-TME-1338

63	30	C	1	-0	O							
10.0000E-02			1.0000E 00	1.0000E 00	1.00C0E C0	1.0000E 00	1.0000E 02					
0.	0.4800		1.8700	4.0500	6.9400	10.4400	14.4600	18.9100	23.7000	28.7700	34.0300	39.420
44.8700	50.3200		55.7300	61.0500	66.2300	71.2400	76.0400	80.6200	84.9400	89.0000	92.7700	96.260
99.4500	102.3400		104.9300	107.2300	109.2400	110.9700	112.4400	113.6400	114.6000	115.3300	115.8500	116.170
116.3000	116.2600		116.0800	115.7500	115.3100	114.7700	114.1300	113.4300	112.6600	111.8400	110.9900	110.120
109.2300	108.3400		107.4600	106.5900	105.7400	104.9100	104.1200	103.3600	102.6500	101.9700	101.3400	100.760
100.2300	99.7400		99.7400									

ORIGINAL
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.9744E-01	-9.3533E-03	9.9748E-01	-2.1895E-02	-0.54
0.0200	9.9756E-01	-1.8728E-02	9.9773E-01	-1.9732E-02	-1.08
0.0300	9.9775E-01	-2.8128E-02	9.9814E-01	-1.6138E-02	-1.61
0.0400	9.9801E-01	-3.7568E-02	9.9872E-01	-1.1122E-02	-2.16
0.0500	9.9835E-01	-4.7062E-02	9.9946E-01	-4.7005E-03	-2.70
0.0600	9.9875E-01	-5.6624E-02	1.0004E 00	3.1055E-03	-3.24
0.0700	9.9922E-01	-6.6265E-02	1.0014E 00	1.2271E-02	-3.79
0.0800	9.9974E-01	-7.6000E-02	1.0026E 00	2.2766E-02	-4.35
0.0900	1.0003E 00	-8.5839E-02	1.0040E 00	3.4558E-02	-4.90
0.1000	1.0009E 00	-9.5795E-02	1.0055E 00	4.7608E-02	-5.47
0.1300	1.0029E 00	-1.2648E-01	1.0109E 00	9.3890E-02	-7.19
0.1600	1.0050E 00	-1.5858E-01	1.0174E 00	1.4983E-01	-8.97
0.2000	1.0072E 00	-2.0400E-01	1.0276E 00	2.3684E-01	-11.45
0.2500	1.0079E 00	-2.6546E-01	1.0423E 00	3.5989E-01	-14.75
0.3200	1.0017E 00	-3.6054E-01	1.0646E 00	5.4402E-01	-19.79
0.4000	9.7801E-01	-4.8044E-01	1.0896E 00	7.4568E-01	-26.16
0.5000	9.1326E-01	-6.3902E-01	1.1146E 00	9.4262E-01	-34.98
0.6300	7.5970E-01	-8.3298E-01	1.1274E 00	1.0414E 00	-47.63
0.7900	4.7439E-01	-9.9342E-01	1.1009E 00	8.3474E-01	-64.47
1.0000	4.4735E-02	-9.8834E-01	9.8935E-01	-9.3003E-02	-87.41
1.2600	-3.1294E-01	-6.9167E-01	7.5917E-01	-2.3933E 00	-114.34
1.5800	-3.3509E-01	-3.0604E-01	4.5381E-01	-6.8625E 00	-137.59
2.0000	-2.0886E-01	-1.6753E-01	2.6775E-01	-1.1446E 01	-141.27
2.5100	-1.6814E-01	-5.9714E-02	1.7843E-01	-1.4971E 01	-160.45
3.1600	-9.9398E-02	-4.9753E-02	1.1115E-01	-1.9081E 01	-153.41
3.9800	-5.1240E-02	-2.1904E-02	5.5726E-02	-2.5079E 01	-156.85
5.0100	-3.0712E-02	-1.2567E-02	3.3183E-02	-2.9582E 01	-157.75
6.3100	-2.8627E-02	-9.9950E-03	3.0322E-02	-3.0365E 01	-160.75
7.9400	-9.5327E-03	1.5571E-04	9.5340E-03	-4.0414E 01	-180.94
10.0000	-5.0828E-03	7.5933E-04	5.1392E-03	-4.5782E 01	-188.50

The Frequency Response Computed from the
 Closed Loop System, $G(S) = \frac{1}{1 + S + S^2}$, Response to Step Input

WANL-TME-1338

DERIVED
OPEN LOOP FREQUENCY RESPONSE
ASSUMING UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	2.6236E C1	-9.9456E 01	1.0286E C2	4.0245E 01	-75.22
0.0200	5.8543E CC	-5.2502E 01	5.2828E C1	3.4457E 01	-83.64
0.0300	1.8290E 0C	-3.5325E 01	3.5373E C1	3.0973E 01	-87.04
0.0400	4.0354E-01	-2.6544E 01	2.6547E C1	2.8480E 01	-89.13
0.0500	-2.5610E-01	-2.1222E 01	2.1224E C1	2.6536E 01	-90.69
0.0600	-6.1150E-01	-1.7652E 01	1.7662E C1	2.4941E 01	-91.98
0.0700	-8.2213E-01	-1.5089E 01	1.5111E 01	2.3586E 01	-93.12
0.0800	-9.5497E-01	-1.3158E 01	1.3192E C1	2.2406E 01	-94.15
0.0900	-1.0421E CC	-1.1650E 01	1.1696E C1	2.1361E 01	-95.11
0.1000	-1.1005E CC	-1.0438E 01	1.0496E C1	2.0420E 01	-96.02
0.1300	-1.1828E CC	-7.9025E 00	7.9905E 00	1.8051E 01	-98.51
0.1600	-1.1972E CC	-6.2997E 00	6.4124E CC	1.6140E 01	-100.76
0.2000	-1.1725E CC	-4.8958E 00	5.0343E CC	1.4039E 01	-103.47
0.2500	-1.1125E CC	-3.7637E 00	3.9247E CC	1.1876E 01	-106.47
0.3200	-1.0133E CC	-2.7736E CC	2.9529E 00	9.4049E 00	-110.07
0.4000	-9.0492E-01	-2.0771E 00	2.2656E CC	7.1038E 00	-113.54
0.5000	-7.9143E-01	-1.5366E 00	1.7284E CC	4.7530E 00	-117.25
0.6300	-6.8028E-01	-1.1083E 00	1.3004E 00	2.2816E 00	-121.54
0.7900	-5.8389E-01	-7.8646E-01	9.7951E-01	-1.7980E-01	-126.59
1.0000	-4.9439E-01	-5.2311E-01	7.1977E-01	-2.8561E 0C	-133.38
1.2600	-4.0381E-01	-3.1408E-01	5.1157E-01	-5.8218E 00	-142.12
1.5800	-2.8838E-01	-1.6312E-01	3.3132E-01	-9.5951E 00	-150.51
2.0000	-1.8836E-01	-1.1248E-01	2.1939E-01	-1.3176E 01	-149.16
2.5100	-1.4617E-01	-4.3647E-02	1.5254E-01	-1.6332E 01	-163.37
3.1600	-9.2270E-02	-4.1079E-02	1.0100E-01	-1.9913E 01	-156.00
3.9800	-4.9155E-02	-1.9812E-02	5.2998E-02	-2.5515E 01	-158.05
5.0100	-2.9941E-02	-1.1828E-02	3.2192E-02	-2.9845E 01	-158.44
6.3100	-2.7922E-02	-9.4455E-03	2.9476E-02	-3.0610E 01	-161.31
7.9400	-9.4427E-03	1.5278E-04	9.4440E-03	-4.0497E 01	-180.93
10.0000	-5.0576E-03	7.5167E-04	5.1132E-03	-4.5826E 01	-188.45

The Frequency Response for the Open Loop System Assuming
 Unity Feedback Derived from the Closed Loop System,
 $G(S) = \frac{1}{1 + S + S^2}$, Response to Step Input

WANL-TME-1338

STEP 4A STEP - FREQ.RESPONSE OF SECOND ORDER SYSTEM FROM 100-STEP, Z=0.5, W=1.

63	35	0	1	-0
10.0000E-02	1.0000E-00	1.0000E-00	1.0000E-00	1.0000E-00
0.	0.	2.0000	4.0000	7.0000
45.0000	50.0000	56.0000	61.0000	66.0000
99.0000	102.0000	105.0000	107.0000	109.0000
116.0000	118.0000	116.0000	116.0000	115.0000
109.0000	108.0000	107.0000	107.0000	106.0000
100.0000	100.0000	100.0000	100.0000	100.0000

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	1.0000E-00	-9.5697E-03	1.0001E-00	6.7872E-04	-0.55
0.0200	1.0001E-00	-1.9156E-02	1.0003E-00	2.7171E-03	-1.10
0.0300	1.0003E-00	-2.8767E-02	1.0007E-00	6.1070E-03	-1.65
0.0400	1.0005E-00	-3.8417E-02	1.0012E-00	1.0838E-02	-2.20
0.0500	1.0008E-00	-4.8117E-02	1.0019E-00	1.6894E-02	-2.75
0.0600	1.0011E-00	-5.7881E-02	1.0028E-00	2.4256E-02	-3.31
0.0700	1.0015E-00	-6.7721E-02	1.0038E-00	3.2902E-02	-3.87
0.0800	1.0019E-00	-7.7648E-02	1.0049E-00	4.2804E-02	-4.43
0.0900	1.0024E-00	-8.7674E-02	1.0062E-00	5.3930E-02	-5.00
0.1000	1.0029E-00	-9.7811E-02	1.0077E-00	6.6247E-02	-5.57
0.1300	1.0045E-00	-1.2899E-01	1.0127E-00	1.0994E-01	-7.32
0.1600	1.0060E-00	-1.6151E-01	1.0189E-00	1.6279E-01	-9.12
0.2000	1.0075E-00	-2.0733E-01	1.0286E-00	2.4505E-01	-11.63
0.2500	1.0092E-00	-2.6903E-01	1.0425E-00	3.6153E-01	-14.95
0.3200	9.9948E-01	-3.6390E-01	1.0637E-00	5.3611E-01	-20.01
0.4000	9.7429E-01	-4.8285E-01	1.0874E-00	7.2757E-01	-26.36
0.5000	9.0854E-01	-6.3945E-01	1.1110E-00	9.1438E-01	-35.14
0.6300	7.5553E-01	-8.3055E-01	1.1228E-00	1.0059E-00	-47.71
0.7900	4.7326E-01	-9.8903E-01	1.0964E-00	7.9957E-01	-64.43
1.0000	4.7791E-02	-9.8583E-01	9.8699E-01	-1.1372E-01	-87.22
1.2600	-3.1027E-01	-6.9412E-01	7.6030E-01	-2.3802E-00	-114.08
1.5800	-3.3646E-01	-3.0831E-01	4.5635E-01	-6.8139E-00	-137.50
2.0000	-2.0840E-01	-1.6923E-01	2.6846E-01	-1.1422E-01	-140.92
2.5100	-1.7248E-01	-6.1882E-02	1.8324E-01	-1.4739E-01	-160.26
3.1600	-1.0083E-01	-5.0852E-02	1.1275E-01	-1.8957E-01	-153.19
3.9800	-4.6255E-02	-2.0086E-02	5.0428E-02	-2.5946E-01	-156.53
5.0100	-3.6977E-02	-1.6384E-02	4.0444E-02	-2.7863E-01	-156.10
6.3100	-2.7529E-02	-1.2146E-02	3.0089E-02	-3.0431E-01	-156.19
7.9400	-1.9952E-02	-8.7073E-03	2.1770E-02	-3.3243E-01	-156.42
10.0000	4.1390E-02	5.0945E-03	4.1702E-02	-2.7596E-01	7.02

The Frequency Response Computed from the System,
 $G(S) = \frac{1}{1 + S + S^2}$, Response to Step Input with the
 Numerical Values of the Response Rounded to
 ± 0.5 Per Cent of the Final Value

WANL-TME-1338

PCV-41 STEP RESPONSE

[illegible]

ORIGINAL
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.1000	9.3344E-01	-3.3708E-02	9.3405E-01	-5.9257E-01	-2.07
0.1500	9.3263E-01	-5.0591E-02	9.3400E-01	-5.9304E-01	-3.10
0.2000	9.3148E-01	-6.7506E-02	9.3392E-01	-5.9378E-01	-4.15
0.2500	9.2998E-01	-8.4462E-02	9.3381E-01	-5.9486E-01	-5.19
0.3000	9.2811E-01	-1.0147E-01	9.3364E-01	-5.9640E-01	-6.24
0.4000	9.2321E-01	-1.3562E-01	9.3312E-01	-6.0128E-01	-8.36
0.5000	9.1661E-01	-1.6996E-01	9.3223E-01	-6.0953E-01	-10.50
0.6000	9.0812E-01	-2.0441E-01	9.3084E-01	-6.2248E-01	-12.69
0.7000	8.9757E-01	-2.3883E-01	9.2880E-01	-6.4155E-01	-14.90
0.8000	8.8479E-01	-2.7303E-01	9.2595E-01	-6.6821E-01	-17.15
1.0000	8.5208E-01	-3.3967E-01	9.1728E-01	-7.4995E-01	-21.73
1.5000	7.3009E-01	-4.8066E-01	8.7411E-01	-1.1687E 00	-33.36
2.0000	5.7484E-01	-5.5938E-01	8.0209E-01	-1.9155E 00	-44.22
2.5000	4.2873E-01	-5.7529E-01	7.1750E-01	-2.8835E 00	-53.30
3.0000	3.1357E-01	-5.5503E-01	6.3748E-01	-3.9106E 00	-60.53
4.0000	1.6422E-01	-4.7382E-01	5.0147E-01	-5.9951E 00	-70.88
5.0000	1.1170E-01	-4.0047E-01	4.1576E-01	-7.6232E 00	-74.41
6.0000	7.2836E-02	-3.8071E-01	3.8761E-01	-8.2321E 00	-79.17
7.0000	1.9256E-02	-3.5963E-01	3.5015E-01	-8.8704E 00	-86.94
8.0000	-3.5111E-02	-3.2076E-01	3.2267E-01	-9.8247E 00	-96.25
10.0000	-6.1121E-02	-2.3375E-01	2.4161E-01	-1.2338E 01	-104.65
15.0000	-1.1057E-01	-1.2635E-01	1.6790E-01	-1.5499E 01	-131.19
20.0000	-1.5402E-01	-6.7253E-02	1.6806E-01	-1.5491E 01	-156.41
25.0000	-7.7628E-02	-5.9642E-03	7.7857E-02	-2.2174E 01	-175.61
30.0000	-1.2338E-01	-9.1022E-02	1.5332E-01	-1.6288E 01	-143.58
40.0000	-1.1664E-01	7.0720E-02	1.3657E-01	-1.7293E 01	-211.19
50.0000	2.9837E-02	8.2167E-03	3.0948E-02	-3.0187E 01	15.40
60.0000	-2.1222E-02	5.8662E-03	2.2018E-02	-3.3144E 01	-195.45
70.0000	-9.5120E-03	-5.8056E-02	5.8610E-02	-2.4611E 01	-99.31
80.0000	-4.2557E-03	4.6226E-02	4.5421E-02	-2.6666E 01	-264.74
100.0000	-3.6434E-02	-1.4263E-02	3.9127E-02	-2.8151E 01	-158.62

The Frequency Response for a Closed Loop System
 Computed from a Recorded Response of the System to a Step Input

610775-15A

WANL-TME-1338

DERIVED
OPEN LOOP FREQUENCY RESPONSE
ASSUMING UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.1000	1.0958E-01	-6.0562E-01	1.2520E-01	2.1952E-01	-28.93
0.1500	8.4913E-02	-7.1275E-01	1.1080E-01	2.0896E-01	-40.01
0.2000	6.4059E-02	-7.2903E-01	9.7094E-02	1.9744E-01	-48.72
0.2500	4.8172E-02	-7.0170E-01	8.5114E-02	1.8600E-01	-55.53
0.3000	3.6490E-02	-6.5017E-01	7.5081E-02	1.7511E-01	-60.92
0.4000	2.1614E-02	-5.5834E-01	5.9872E-02	1.5544E-01	-68.84
0.5000	1.3208E-02	-4.7421E-01	4.9242E-02	1.3847E-01	-74.37
0.6000	8.2933E-03	-4.0699E-01	4.1535E-02	1.2368E-01	-78.48
0.7000	5.1674E-03	-3.5365E-01	3.5741E-02	1.1063E-01	-81.69
0.8000	3.1194E-03	-3.1090E-01	3.1240E-02	9.8959E-02	-84.27
1.0000	7.7740E-04	-2.4747E-01	2.4759E-02	7.9748E-02	-88.20
1.5000	-1.1180E-03	-1.5817E-01	1.5857E-02	4.5042E-02	-94.04
2.0000	-1.3877E-03	-1.1331E-01	1.1416E-02	1.1501E-02	-96.98
2.5000	-1.3039E-03	-8.7530E-02	8.8504E-03	-1.0608E-02	-98.50
3.0000	-1.1910E-03	-7.1227E-02	7.2216E-03	-2.8273E-03	-97.49
4.0000	-9.4526E-04	-5.1333E-02	5.2196E-03	-5.6472E-03	-100.43
5.0000	-6.4406E-04	-4.2179E-02	4.2668E-03	-7.3979E-03	-98.68
6.0000	-7.7054E-04	-3.7897E-02	3.8675E-03	-8.2519E-03	-101.49
7.0000	-1.0122E-03	-3.2358E-02	3.4477E-03	-9.2494E-03	-107.07
8.0000	-1.1856E-03	-2.7314E-02	2.9776E-03	-1.0523E-02	-113.46
10.0000	-1.0122E-03	-1.9799E-02	2.2237E-03	-1.3059E-02	-117.08
15.0000	-1.1106E-03	-1.0114E-02	1.5021E-03	-1.6466E-02	-137.68
20.0000	-1.3639E-03	-5.0328E-03	1.4535E-03	-1.6750E-02	-159.75
25.0000	-7.2005E-04	-5.1357E-03	7.2243E-04	-2.2824E-02	-175.92
30.0000	-1.1304E-03	-7.1056E-03	1.3604E-03	-1.7327E-02	-148.22
40.0000	-1.0819E-03	5.6471E-03	1.2204E-03	-1.3270E-02	-207.56
50.0000	3.0031E-04	8.7233E-03	3.1898E-04	-2.9925E-02	15.38
60.0000	-2.0314E-04	5.5247E-03	2.1565E-04	-3.3327E-02	-195.12
70.0000	-1.2035E-04	-5.5767E-03	5.8165E-05	-2.4708E-02	-102.60
80.0000	-6.3430E-05	4.5730E-03	4.5170E-05	-2.6712E-02	-252.10
100.0000	-3.5330E-05	-1.3270E-03	5.7743E-06	-2.9402E-02	-159.41

The Frequency Response for the Open Loop System Assuming Unity
Feedback Derived from the Recorded Closed Loop System Response to a Step Input

WANL-TME-1338

Comparison Between the System Frequency Response Computed
From a Step Response with the Directly Measured Frequency Response
for the Analog Model of the Actual System

Comparison of Several Approximately Equivalent Frequency
Response Measurements with the Frequency Response
Computed from the System Step Response

WANL-TME-1338

ARBIT-TF REQ.RESPONSE OF SECOND ORDER SYSTEM FROM JO=0.1 PULSE,Z=.5,W=1.

100*0.1

75	75	30	C	1	-0	1							
10.0000E-02	10.0000E-02	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00							
0.	100.0000	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	C.	0.	0.	C.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.4800	1.3900	2.1800	2.8900	3.5000	4.0200	4.4500	4.7900	5.0700	5.2600	5.3900		
5.4500	5.4500	5.4100	5.3200	5.1800	5.0100	4.8000	4.5800	4.3200	4.0600	3.7700	3.4900		
3.1900	2.8900	2.5900	2.3000	2.0100	1.7300	1.6700	1.2000	0.9600	0.7300	0.5200	0.3200		
0.1300	-0.0400	-0.1800	-0.3300	-0.4400	-0.5400	-0.6400	-0.7000	-0.7700	-0.8200	-0.8500	-0.8700		
-0.8900	-0.8900	-0.8800	-0.8700	-0.8500	-0.8300	-0.7900	-0.7600	-0.7100	-0.6800	-0.6300	-0.5800		
-0.5300	-0.4900	-0.4300	-0.3900	-0.3400	-0.3000	-0.2500	-0.2000	-0.1700	-0.1300	-0.0900	-0.0600		
-0.0300	0.	C.											

ORIGINAL
OPEN LOOP FREQUENCY RESPONSE

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.9267E-C1	-8.4987E-03	9.9271E-C1	-6.3554E-02	-0.49
0.0200	9.7908E-C1	-1.4162E-02	9.7919E-C1	-1.8270E-01	-0.83
0.0300	9.7701E-C1	-2.1260E-02	9.7724E-C1	-1.9999E-01	-1.25
0.0400	9.7733E-C1	-2.9743E-02	9.7775E-C1	-1.9512E-01	-1.74
0.0500	9.7789E-C1	-3.7325E-02	9.7860E-C1	-1.8789E-01	-2.19
0.0600	9.7946E-C1	-4.5035E-02	9.8049E-C1	-1.7113E-01	-2.63
0.0700	9.8003E-C1	-5.2810E-02	9.8146E-C1	-1.6258E-01	-3.08
0.0800	9.8154E-C1	-6.0753E-02	9.8342E-C1	-1.4520E-01	-3.54
0.0900	9.8260E-C1	-6.8818E-02	9.8501E-C1	-1.3121E-01	-4.01
0.1000	9.8408E-C1	-7.7066E-02	9.8709E-C1	-1.1286E-01	-4.48
0.1300	9.8954E-C1	-1.0301E-01	9.9489E-C1	-4.4500E-02	-5.94
0.1600	9.9564E-C1	-1.3102E-01	1.0042E C0	3.6618E-02	-7.50
0.2000	1.0041E C0	-1.7214E-01	1.0188E C0	1.6143E-01	-9.73
0.2500	1.0135E C0	-2.3033E-01	1.0393E C0	3.3490E-01	-12.80
0.3200	1.0196E C0	-3.2496E-01	1.0702E C0	5.8900E-01	-17.68
0.4000	1.0082E C0	-4.4969E-01	1.1040E C0	8.5905E-01	-24.04
0.5000	9.5294E-C1	-6.1957E-01	1.1366E C0	1.1125E 00	-33.03
0.6300	7.9988E-C1	-8.2915E-01	1.1521E 00	1.2297E 00	-46.03
0.7900	5.0399E-01	-9.9763E-01	1.1177E C0	9.6655E-01	-63.20
1.0000	6.9261E-C2	-9.8283E-01	9.8527E-C1	-1.2890E-01	-85.97
1.2600	-2.6572E-C1	-6.8740E-01	7.3697E-C1	-2.6510E 00	-111.13
1.5800	-2.9367E-C1	-3.4400E-01	4.5230E-C1	-6.8915E 00	-130.49
2.0000	-2.0987E-C1	-1.8195E-01	2.7776E-C1	-1.1127E 01	-139.08
2.5100	-1.4063E-C1	-8.8816E-02	1.6632E-C1	-1.5581E 01	-147.72
3.1600	-9.6489E-C2	-4.9112E-02	1.0827E-C1	-1.9310E 01	-153.02
3.9800	-5.8541E-C2	-2.6959E-02	6.4450E-C2	-2.3815E 01	-155.27
5.0100	-3.7121E-C2	-1.8384E-02	4.1424E-C2	-2.7655E 01	-153.65
6.3100	-2.0287E-C2	-1.1153E-02	2.3151E-C2	-3.2709E 01	-151.20
7.9400	-1.4043E-C2	-6.3534E-03	1.5413E-C2	-3.6242E 01	-155.66
10.0000	-1.0040E-C2	-4.1886E-03	1.0879E-C2	-3.9268E 01	-157.35

The Frequency Response Computed from the Open Loop System,
 $G(S) = \frac{1}{1 + S + S^2}$, Response to Rectangular Pulse Input

DERIVED
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	4.9817E-C1	-2.1403E-03	4.9818E-C1	-6.0524E 00	-0.25
0.0200	4.9474E-C1	-3.6156E-03	4.9475E-C1	-6.1122E 00	-0.42
0.0300	4.9424E-C1	-5.4387E-03	4.9427E-C1	-6.1207E 00	-0.63
0.0400	4.9438E-C1	-7.6056E-03	4.9444E-C1	-6.1177E 00	-0.88
0.0500	4.9459E-C1	-9.5378E-03	4.9468E-C1	-6.1135E 00	-1.10
0.0600	4.9507E-C1	-1.1488E-02	4.9521E-C1	-6.1043E 00	-1.33
0.0700	4.9532E-C1	-1.3461E-02	4.9550E-C1	-6.0991E 00	-1.56
0.0800	4.9582E-C1	-1.5458E-02	4.9606E-C1	-6.0894E 00	-1.79
0.0900	4.9622E-C1	-1.7487E-02	4.9653E-C1	-6.0811E 00	-2.02
0.1000	4.9675E-C1	-1.9548E-02	4.9713E-C1	-6.0706E 00	-2.25
0.1300	4.9872E-C1	-2.5953E-02	4.9939E-C1	-6.0312E 00	-2.98
0.1600	5.0106E-C1	-3.2756E-02	5.0213E-C1	-5.9837E 00	-3.74
0.2000	5.0468E-C1	-4.2545E-02	5.0647E-C1	-5.9089E 00	-4.82
0.2500	5.0976E-C1	-5.6082E-02	5.1283E-C1	-5.8004E 00	-6.28
0.3200	5.1736E-C1	-7.7659E-02	5.2315E-C1	-5.6274E 00	-8.54
0.4000	5.2582E-C1	-1.0618E-01	5.3644E-C1	-5.4096E 00	-11.42
0.5000	5.3478E-01	-1.4759E-01	5.5477E-C1	-5.1178E 00	-15.43
0.6300	5.4167E-C1	-2.1114E-01	5.8137E-C1	-4.7110E 00	-21.30
0.7900	5.3826E-C1	-3.0628E-01	6.1930E-C1	-4.1620E 00	-29.64
1.0000	4.9307E-C1	-4.6596E-01	6.7840E-C1	-3.3702E 00	-43.38
1.2600	2.7420E-01	-6.7946E-01	7.3270E-C1	-2.7014E 00	-68.02
1.5800	-1.4434E-C1	-5.5732E-01	5.7571E-C1	-4.7960E 00	-104.52
2.0000	-2.0188E-C1	-2.7677E-01	3.4257E-C1	-9.3050E 00	-126.11
2.5100	-1.5134E-C1	-1.1899E-01	1.9252E-C1	-1.4311E 01	-141.82
3.1600	-1.0353E-C1	-5.9984E-02	1.1965E-C1	-1.8441E 01	-149.91
3.9800	-6.1311E-C2	-3.0390E-02	6.8430E-C2	-2.3295E 01	-153.63
5.0100	-3.8174E-C2	-1.9821E-02	4.3013E-C2	-2.7328E 01	-152.56
6.3100	-2.0575E-C2	-1.1619E-02	2.3629E-C2	-3.2531E 01	-150.55
7.9400	-1.4201E-C2	-6.5354E-03	1.5632E-C2	-3.6119E 01	-155.29
10.0000	-1.0124E-C2	-4.2739E-03	1.0989E-C2	-3.9181E 01	-157.11

The Frequency Response for the Closed Loop System with Unity

Feedback Derived from the Open Loop System,

$$G(S) = \frac{1}{1 + S + S^2}, \text{ Response to Rectangular Pulse Input}$$

ARBIT-TF REQ.RESPONSE OF SECOND ORDER SYSTEM FROM 0*0.1 PULSE,Z=.5,W=1.

75	75	30	0	1	-0	0						
10.0000E-02	10.0000E-02	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00	1.0000E 00					
0.	100.0000	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.4800	1.3900	2.1800	2.8900	3.5000	4.0200	4.4500	4.7900	5.0700	5.2600	5.3900	
5.4500	5.4500	5.4100	5.3200	5.1800	5.0100	4.8000	4.5800	4.3200	4.0600	3.7700	3.4900	
3.1900	2.8900	2.5900	2.3000	2.0100	1.7300	1.6700	1.2000	0.9600	0.7300	0.5200	0.3200	
0.1300	-0.0400	-0.1800	-0.3300	-0.4400	-0.5400	-0.6400	-0.7000	-0.7700	-0.8200	-0.8500	-0.8700	
-0.8900	-0.8900	-0.8800	-0.8700	-0.8500	-0.8300	-0.7900	-0.7600	-0.7100	-0.6800	-0.6300	-0.5800	
-0.5300	-0.4900	-0.4300	-0.3900	-0.3400	-0.3000	-0.2500	-0.2000	-0.1700	-0.1300	-0.0900	-0.0600	
-0.0300	0.	0.										

ORIGINAL
CLOSED LOOP FREQUENCY RESPONSE
WITH UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	9.9267E-01	-8.4987E-03	9.9271E-01	-6.3554E-02	-0.49
0.0200	9.7908E-01	-1.4162E-02	9.7919E-01	-1.8270E-01	-0.83
0.0300	9.7701E-01	-2.1260E-02	9.7724E-01	-1.9999E-01	-1.25
0.0400	9.7733E-01	-2.9743E-02	9.7779E-01	-1.9512E-01	-1.74
0.0500	9.7789E-01	-3.7325E-02	9.7860E-01	-1.8789E-01	-2.19
0.0600	9.7946E-01	-4.5035E-02	9.8049E-01	-1.7113E-01	-2.63
0.0700	9.8003E-01	-5.2810E-02	9.8146E-01	-1.6258E-01	-3.08
0.0800	9.8154E-01	-6.0753E-02	9.8342E-01	-1.4520E-01	-3.54
0.0900	9.8260E-01	-6.8818E-02	9.8501E-01	-1.3121E-01	-4.01
0.1000	9.8408E-01	-7.7066E-02	9.8709E-01	-1.1286E-01	-4.48
0.1300	9.8954E-01	-1.0301E-01	9.9489E-01	-4.4500E-02	-5.94
0.1600	9.9564E-01	-1.3102E-01	1.0042E 00	3.6618E-02	-7.50
0.2000	1.0041E 00	-1.7214E-01	1.0188E 00	1.6143E-01	-9.73
0.2500	1.0135E 00	-2.3033E-01	1.0393E 00	3.3490E-01	-12.80
0.3200	1.0196E 00	-3.2496E-01	1.0702E 00	5.8900E-01	-17.68
0.4000	1.0082E 00	-4.4969E-01	1.1040E 00	8.5905E-01	-24.04
0.5000	9.5294E-01	-6.1957E-01	1.1366E 00	1.1125E 00	-33.03
0.6300	7.9988E-01	-8.2915E-01	1.1521E 00	1.2297E 00	-46.03
0.7900	5.0399E-01	-9.9763E-01	1.1177E 00	9.6655E-01	-63.20
1.0000	6.9261E-02	-9.8283E-01	9.8527E-01	-1.2890E-01	-85.97
1.2600	-2.6572E-01	-6.8740E-01	7.3697E-01	-2.6510E 00	-111.13
1.5800	-2.9367E-01	-3.4400E-01	4.5230E-01	-6.8915E 00	-130.49
2.0000	-2.0987E-01	-1.8195E-01	2.7776E-01	-1.1127E 01	-139.08
2.5100	-1.4063E-01	-8.8816E-02	1.6632E-01	-1.5581E 01	-147.72
3.1600	-9.6489E-02	-4.9112E-02	1.0827E-01	-1.9310E 01	-153.02
3.9800	-5.8541E-02	-2.6959E-02	6.4450E-02	-2.3815E 01	-155.27
5.0100	-3.7121E-02	-1.8384E-02	4.1424E-02	-2.7655E 01	-153.65
6.3100	-2.0287E-02	-1.1153E-02	2.3151E-02	-3.2709E 01	-151.20
7.9400	-1.4043E-02	-6.3534E-03	1.5413E-02	-3.6242E 01	-155.66
10.0000	-1.0040E-02	-4.1886E-03	1.0879E-02	-3.9268E 01	-157.35

DERIVED
OPEN LOOP FREQUENCY RESPONSE
ASSUMING UNITY FEEDBACK

FREQUENCY RAD/SEC	REAL	IMAGINARY	MAGNITUDE	DECIBELS	PHASE
0.0100	5.7191E 01	-6.7500E 01	8.8470E 01	3.8936E 01	-49.73
0.0200	3.1781E 01	-2.2194E 01	3.8763E 01	3.1768E 01	-34.93
0.0300	2.2446E 01	-2.1680E 01	3.1207E 01	2.9885E 01	-44.00
0.0400	1.5208E 01	-2.1269E 01	2.6147E 01	2.8349E 01	-54.43
0.0500	1.0748E 01	-1.9832E 01	2.2557E 01	2.7066E 01	-61.54
0.0600	7.3847E 00	-1.8380E 01	1.9808E 01	2.5937E 01	-68.11
0.0700	5.2635E 00	-1.6568E 01	1.7384E 01	2.4803E 01	-72.38
0.0800	3.5779E 00	-1.5069E 01	1.5488E 01	2.3800E 01	-76.64
0.0900	2.4532E 00	-1.3658E 01	1.3876E 01	2.2846E 01	-79.82
0.1000	1.5712E 00	-1.2445E 01	1.2543E 01	2.1968E 01	-82.80
0.1300	-2.4511E-02	-9.6091E 00	9.6092E 00	1.9654E 01	-90.15
0.1600	-7.4637E-01	-7.6242E 00	7.6606E 00	1.7685E 01	-95.59
0.2000	-1.1386E 00	-5.8059E 00	5.9165E 00	1.5441E 01	-101.10
0.2500	-1.2529E 00	-4.3268E 00	4.5045E 00	1.3073E 01	-106.15
0.3200	-1.1852E 00	-3.0661E 00	3.2872E 00	1.0336E 01	-111.13
0.4000	-1.0406E 00	-2.2230E 00	2.4545E 00	7.7994E 00	-115.08
0.5000	-8.7812E-01	-1.6048E 00	1.8293E 00	5.2457E 00	-118.69
0.6300	-7.2493E-01	-1.1397E 00	1.3507E 00	2.6112E 00	-122.46
0.7900	-6.0041E-01	-8.0371E-01	1.0032E 00	2.7837E-02	-126.76
1.0000	-4.9202E-01	-5.3641E-01	7.2789E-01	-2.7587E 00	-132.53
1.2600	-3.8989E-01	-3.3135E-01	5.1167E-01	-5.8203E 00	-139.64
1.5800	-2.7805E-01	-1.9197E-01	3.3788E-01	-9.4246E 00	-145.38
2.0000	-1.9174E-01	-1.2155E-01	2.2703E-01	-1.2879E 01	-147.63
2.5100	-1.2857E-01	-6.7855E-02	1.4538E-01	-1.6750E 01	-152.18
3.1600	-8.9824E-02	-4.0767E-02	9.8642E-02	-2.0119E 01	-155.59
3.9800	-5.5916E-02	-2.4044E-02	6.0866E-02	-2.4312E 01	-156.73
5.0100	-3.6096E-02	-1.7086E-02	3.9935E-02	-2.7973E 01	-154.67
6.3100	-2.0001E-02	-1.0713E-02	2.2689E-02	-3.2884E 01	-151.83
7.9400	-1.3887E-02	-6.1784E-03	1.5199E-02	-3.6363E 01	-156.02
10.0000	-9.9573E-03	-4.1056E-03	1.0771E-02	-3.9355E 01	-157.59

The Frequency Response for the Open Loop System Assuming
 Unity Feedback Derived from the Closed Loop System,
 $G(S) = \frac{1}{1 + S + S^2}$, Response to Rectangular Pulse Input

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