RECOMP II USERS' PROGRAM NO. 1061

PROGRAM TITLE:	S-PLANE FREQUENCY RESPONSE
PROGRAM CLASSIFICATION:	General Topics
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PURPOSE:	To compute data for gain-phase, Bode and Nyquist plots from transfer functions in the S-plane.
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PROGRAM TITLE: S-PLANE FREQUENCY RESPONSE

1. INTRODUCTION

1.1 The purpose of this program is to produce data for gain-phase, Bode and Nyquist plots from transfer functions in the s-plane. The operator may supply the computer with either un-normalized polynomials or normalized factors.

2. METHOD

2.1 The program produces data for frequency response plots from transfer functions having the form of:

$$Ks^R \frac{A_N s^N + A_{N-1} s^{N-1} + \ldots + A_1 s + A_o}{B_M s^M + B_{M-1} s^{M-1} + \ldots + B_1 s + B_o}$$

or

$$Ks^R \frac{(s + E_1)\ (s + E_2^2 \ldots (s + E_c)\ (s + F_1 \pm jG_1) \ldots (s + F_D \pm jG_D)}{(s + H_1)\ (s + H_2) \ldots (s + H_p)\ (s + I_1 \pm jJ_1) \ldots (s + I_Q \pm jJ_Q)}$$

2.2 If the transfer function is entered in factor form, it is first expanded into a polynomial. Then, for entered values of w the transfer function G(s) is evaluated to determine the imaginary portion of G(jw), the real portion of G(jw), $|G(jw)|$, $20 \log_{10} |G(jw)|$ and the phase angle of G(jw). These results are then printed out.

3. RESTRICTIONS

The maximum order of the numerator and denominator s-plane polynomials is 56.

The maximum number of linear s-plane factors is 56 and the maximum number of complex s-plane factor pairs is 28. The total number of s-plane factors (linear and complex) should not exceed 56.

4. USAGE

4.1.0 After loading the tape, put sense switch C down if the form of the transfer function is normalized factors, and proceed with step 4.2.1. If the form of the transfer function is polynomials, put sense switch C up and proceed with step 4.1.1.

4.1.1 Press the Start 1 button on the right side of the control console. The typewriter will type an N.

4.1.2 Enter the degree of the numerator, NN, by typing two digits from "00" to "60". The typewriter will then type A(NN) where NN is the degree of the numerator just typed.

4.1.3 Enter A_N in floating point from the typewriter (see floating point input instructions 4.3.0. The typewriter will then type A(NN-1) after which A_{N-1} must be entered, etc. until A(00) is typed and A_0 is entered.

4.1.4 The typewriter will type M. Enter the order of the denominator in the same way as the order of the numerator was entered, and enter the denominator polynomial in the same way the numerator polynomial was entered (See 4.1.2 and 4.1.3).

4.1.5 The typewriter will type R. Enter the number of zeros minus poles at the origin by typing a sign (+ or -) and two digits (00 through 99).

4.1.6 The typewriter will type K. Enter in floating point the transfer function ~~Main~~ GAIN. (See floating point input instructions, Section 4.3.0).

4.1.7 The typewriter will type "ERROR?". If an error was made during any of the above input procedure, type those characters typed by the computer preceding the error and then the correct type in. If no errors were made, or after all errors have been corrected, type a carriage return.

4.1.8 The typewriter will type W. Enter in floating point the frequency in radians at which the transfer function is to be evaluated. (See Section 4.3.0).

4.1.9 The typewriter will type DW. Enter in floating point the incremental frequency in radians which you wish W to be incremented by for each evaluation.

4.1.10 If a new W and DW is desired, set sense switch B down and W will again print out. Set sense switch B up and proceed from 4.1.8.

4.2.1 Press the Start 1 button on the right side of the control console. The typewriter will type C. Enter the number of linear factors in the numerator by typing two digits ranging from 00 to 60. The typewriter will type E(CC) where CC is the number of linear factors in the numerator.

4.2.2 Type the value of E_C in floating point. (See Section 4.3.0). The typewriter will type E(CC-1). Type E_{C-1} and continue this procedure until all the linear numerator factors have been entered. The typewriter will then type D.

4.2.3 Enter the number of complex pairs in the numerator by typing two digits, DD. The typewriter will then type F(DD).

4.2.4 Enter in floating point the real part of the first complex pair (See Section 4.3.0). The typewriter will then type G(DD). Enter in floating point the imaginary part of the first complex pair. The typewriter will then type F(DD-1) etc. until all of the numerator complex factors are entered.

4.2.5 Enter the denominator in the same way as the numerator entering the number of linear factors after P is typed, the linear factors in floating point following H(PP), H(PP-1), . . . H01, the number of quadratic pairs after Q is typed, the real part of the quadratic pairs after I(QQ), I(QQ-1), . . . , I01, and the imaginary part of the quadratic pairs after J(QQ), J(QQ-1), . . . , J01. Then follow statements 4.1.5 through 4.1.10.

4.3.0 Floating Point Input

In entering floating point numbers, type the sign of the mantissa, the mantissa assuming the decimal point is in front of the first character typed (DO NOT TYPE THE DECIMAL POINT), the sign of the exponent, the exponent, and a carriage return. Examples:

Number	Type
1	+1+1 (carriage return)
-10.76132	-1076132+2 (carriage return)
.75 x 10^{-26}	+75-26 (carriage return)
0	+0+0 (carriage return)

Numbers may range between $2^{2^{40}}$ and $2^{-2^{40}}$ and any number of digits may be typed for the mantissa, though the computer will accept no more than approximately 10 place accuracy.

4.4.1 If a transfer function with a polynomial numerator and factored denominator is to be entered, change the position of sense switch C after W has typed out.

4.4.2 If a transfer function with a factor numerator and a polynomial denominator is to be entered, change the position of sense switch C after C has been typed.

4.5.0 Program Results

After computing the frequency response, the computer will type six floating point numbers which are the values of: the frequency in radians, the imaginary part of G(jw), the real part of G(jw), $|G(jw)|$, $20 \log_{10} |G(jw)|$, and the phase angle in degrees.

4.6.0 If an error is detected at any time after Section 4.1.7 is completed, stop the computer and press Start 2 button on the right of the control console and proceed with Section 4.1.7.

4.7.0 To enter a new problem, stop the computer and proceed with Section 4.1.0.

5.0 EXAMPLES

See Appendix.

6.0 CODING INFORMATION

6.1.0 Storage Requirements

Program Storage	0000-2120
Working Storage	3000-3170

6.20 Timing

Computation time varies with the size of polynomial. The time between successive frequency response print-outs is approximately 3 seconds.

5.0 Examples

EXAMPLE NO. 1 Transfer Function $216S^2 \dfrac{S^6 + 9S^5 + 38S^4 + 90S^3 + 124S^2 + 96S + 32}{S^6 + 21S^5 + 208S^4 + 1190S^3 + 4104S^2 + 8064S + 6912}$

Sense Switch "C" is up.

```
N 06A06 +1+1
A05 +9+1
A04 +38+2
A03 +9+2
A02 +124+3
A01 +96+2
A00 +32+2

M 06B06 +1+1
B05 +21+2
B04 +208+3
B03 +119+4
B02 +4104+4
B01 +8064+4
B00 +6912+4

R +02
K +216+3
ERROR?

W +1+1

DW +1+1
```

Frequency	Imag. G(jw)	Real G(jw)	|G(jw)|	$20 \lg_{10}$ |G(jw)|	∅
99999999 00	-16189153 01	23800286 00	16363166 01	42773472 01	-81636291 02
19999999 01	-86009049 01	21111312 02	22796119 02	27157218 02	-22166251 02
29999999 01	-28578461 02	17102769 03	17339896 03	44780929 02	-94863505 01

W

EXAMPLE NO. 2

Transfer Function $216S^2 \dfrac{(S + 1)(S + 2)(S + 1 \pm j1)(S + 2 \pm j2)}{(S + 3)(S + 4)(S + 3 \pm j3)(S + 4 \pm j4)}$

Sense Switch "C" is down.

C 02
E02 +1+1
E01 +2+1

D 02
F02 +1+1
G02 +1+1
F01 +2+1
G01 +2+1

P 02
H02 +3+1
H01 +4+1

Q 02
I02 +3+1
J02 +3+1
I01 +4+1
J01 +4+1

R +02
K +216+3
ERROR?

W +1+1

DW +1+1

Frequency	Imag. G(jw)	Real G(jw)	|G(jw)|	$20\log_{10}$ |G(jw)|	Ø
99999999 00	-16189153 01	23800286 00	16363166 01	42773472 01	-81636291 02
19999999 01	-86009049 01	21111312 02	22796119 02	27157218 02	-22166251 02
29999999 01	-28578461 02	17102769 03	17339896 03	44780929 02	-94863505 01

W