

Massachusetts Institute of Technology  
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Space Guidance Analysis Memo # 17-66

TO: SGA Distribution  
FROM: Donald C. Fraser  
DATE: 11 July 1966  
SUBJECT: A Computer Program for Block Diagram Reduction

This memo describes a subroutine which has been developed to aid in the manipulation of system block diagrams. By repetitive calling of this routine one may reduce almost any linear system configuration to a desired form. The program is binary and is stored on the APOLLO userfile with the name BDALGEBRASUB.

At present there are eleven modes of operation. The first word in the call list gives the mode; the remainder of the list is made up by input data. A list of the call and return lists for each mode follows:

MODE = 0 (Multiply two polynomials and return the resulting polynomial)

Call list:

1. Mode = 0
2. Order of first polynomial
3. Gain factor of first polynomial
4. Coefficients of first polynomial - lowest order coefficient first.
5. Order of second polynomial
6. Gain factor of second polynomial
7. Coefficients of second polynomial - lowest order coefficient first.

Return list:

1. Order of resulting polynomial
2. Coefficients of resulting polynomial - lowest order coefficient first.

MODE = 1 (Multiply two polynomials, factor the result, return both polynomial and its roots)

Call list:

The call list is identical to that of MODE = 0 with the exception that MODE = 1

Return list:

1. Order of resulting polynomial
2. Coefficients of resulting polynomial - lowest order coefficient first.
3. Number of real roots.
4. Number of complex root pairs
5. All the real parts of all the root locations. All the real roots precede the real parts of the complex root locations.
6. Imaginary parts of the complex root locations.

MODE = 2 (Multiply two polynomials, factor the result, return the roots only)

Call list:

The call list is identical to that of MODE = 0 with the exception that MODE = 2

Return list:

1. Number of real roots
2. Number of complex root pairs.
3. Gain factor of result (Coefficient of highest order term in the polynomial)
4. All the real parts of all the root locations. All the real roots precede the real parts of the complex root locations.

MODE = 3 (Factor a polynomial and return its roots)

Call list:

1. Mode = 3
2. Order of polynomial
3. Gain factor of polynomial
4. Polynomial coefficients - lowest order coefficient first.

Return list:

The return list is identical to that of MODE = 2

MODE = 4 (Input the transfer functions G and H, form the transfer function  $G/(1+GH)$ , return the result as a ratio of polynomials)

Call list:

1. Mode = 4

From here the call list is divided into four parts in the following order: denominator of G, numerator of G, denominator of H, numerator of H. Repeat the next section once for each part.

2. Gain factor

3. FLAG = 0 Polynomial form input  
= 1 factored form input

If FLAG = 0

4. Order of polynomial

5. Polynomial coefficients - lowest order coefficient first.

If FLAG = 1

4. Number of real roots

5. Number of complex root pairs.

6. All the real parts of all the root locations. All the real roots should precede the real parts of complex root locations.

7. Imaginary parts of complex root locations.

Return list:

1. Order of denominator polynomial

2. Denominator coefficients - lowest order coefficients first

3. Order of numerator polynomial

4. Numerator coefficients - lowest order coefficient first.

MODE = 5 (Input the transfer functions G and H, form the transfer function  $G/(1+GH)$ , factor the result, return the result as both a ratio of polynomials and a ratio of factors.)

Call list:

The call list is identical to that of MODE = 4 with the exception that MODE = 5

Return list:

1. Order of denominator polynomial

2. Denominator coefficients - lowest order coefficient first.

3. Order of numerator polynomial

4. Numerator coefficients - lowest order coefficient first.

5. Number of real roots in denominator.

6. Number of complex root pairs in denominator
7. All the real parts of all the root locations. All the real parts of the complex root locations.
8. Imaginary parts of complex root locations.
- 9 through 12. Same as 5 through 8 except 9 through 12 describe roots of the numerator.

MODE = 6 (Input the transfer functions G and H, form the transfer function  $G/(1+GH)$ , factor the result, return the result as a ratio of factors)

Call list:

The call list is identical to that of MODE = 4 with the exception that MODE = 6

Return list:

1. Number of real roots in denominator
2. Number of complex root pairs in denominator
3. Gain factor of denominator (Coefficient of highest order term in the polynomial)
4. All the real parts of all the root locations. All the real roots should precede the real parts of the complex root locations.
5. Imaginary parts of complex root locations
- 6 through 10. Same as 1 through 5 except 6 through 10 describe the numerator.

MODE = 7 (Input polynomial factors and return the polynomial)

Call list:

1. MODE = 7
2. Gain factor
3. Number of real roots
4. Number of complex root pairs
5. All the real parts of all the root locations. All the real roots should precede the real parts of complex root locations.
6. Imaginary parts of complex root locations.

Return list:

1. Order of resulting polynomial
2. Polynomial coefficients - lowest order coefficient first.

MODE = 8 (Input the transfer functions G and H, form the transfer function(G+H), return the result as a ratio of polynomials)

Call list:

The call list is identical with that of MODE = 4 with the exception that MODE = 8

Return list:

The return list is identical with that of MODE = 4.

MODE = 9 (Input the transfer functions G and H, from the transfer function(G+H), factor the result, return the result as a ratio of polynomials and as a ratio of factors)

Call list:

The call list is identical with that of MODE = 4 with the exception that MODE = 9

Return list:

The return list is identical with that of MODE = 5.

MODE = 10 (Input the transfer functions G and H, form the transfer function(G+H), factor the result, return the results as a ratio of factors)

Call list:

The call list is identical with that of MODE = 4 with the exception that MODE = 10

Return list:

The return list is identical with that of MODE = 6.

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