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Stability Analysis in time domain using Routh – Hurwitz Criterion

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Methodology:

1. Write characteristics equation from given data.
2. Routh array needs to be formed.
3. First two rows of array is written from odd and even degree coefficients using characteristic equation.
4. Next row elements are computed using formula.
5. In each row, power of S will be reduced by 1 considering first row as highest power of S.

Stability Predication:

- If elements in first column of array are positive, system is said to be stable.
    - ➢ All routs are in left of S plane
- If there is sign change
    - ➢ System is unstable
    - ➢ Number of sign changes are number of roots lying in right of S plane

Question :

The open loop transfer function of unity feedback system is

$$G(S) = \frac{5}{S^4 + 8S^3 + 18S^2 + 16s}$$

Using Routh criterion determine stability of a system.

Solution:

Step 1: Characteristics equation

(Since open loop transfer function is given, either determine closed loop transfer function by feedback rule using G(S) and H(S) or use 1+G(S)H(S)=0). If closed loop transfer function is given, denominator of closed loop transfer function is a characteristic equation

$$G(S) = S^4 + 8S^3 + 18S^2 + 16S + 5$$

Step 2: Form Routh array

(First two rows will be formed using characteristic equation. Array always starts with highest power of S as first row. Consider all even degree coefficients in first row since the highest power of s is even number and all odd degree coefficients in second row)

S^4	1	18	5	
S^3	8	16		

Step 3: Nest row computation

(Use first two row, to find next s^3 row.)

s^4	1	18	5
s^3	8	16	(0)
s^2	= {(8*18)-(1*16)} / 8 = 16	= {(8*5)-(0*1)} / 8 = 5	

Repeat this process till last s^0 row

s^4	1	18	5
s^3	8	16	(0)
s^2	= {(8*18)-(1*16)} / 8 = 16	= {(8*5)-(0*1)} / 8 = 5	(0)
s^1	= {(16*16)-(5*8)} / 16 = 13.5	= {(16*0)-(0*8)} / 16 = 0	

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s^1	= {(16*16)-(5*8)} / 16 = 13.5	= {(16*0)-(0*8)} / 16 = 0	
s^0	= {(13.5*5)-(0*16)/13.5 = 5		

Step 4: Check sign of all elements in first column of array

s^4	1	18	5
s^3	8	16	(0)
s^2	= {(8*18)-(1*16)} / 8 = 16	= {(8*5)-(0*1)} / 8 = 5	(0)
s^1	= {(16*16)-(5*8)} / 16 = 13.5	= {(16*0)-(0*8)} / 16 = 0	
s^0	= {(13.5*5)-(0*16)/13.5 = 5		

Step 5 : Conclusion

Since all elements in the first column of array (indicated by circle) are positive, System is said to be stable.

Thank you

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