Experiment No. 8
Stability Analysis Using Routh Hurwitz Criterion

Aim: To analyze the stability of a system using Routh Hurwitz criteria (RH criteria)

Theory: The essential requirement for the control system is that it should be **stable.** It means that the output of the system should follow the input. If the input is finite, the output also needs to be finite in order to satisfy the stability condition.

Stability with respect to the location of poles and zeroes

In terms of poles and zeroes, we can represent the transfer function as:

$$G(s) = \frac{K(s+z_1)(s+z_2)(s+z_3)\dots(s+z_m)}{s^n(s+p_1)(s+p_2)(s+p_3)\dots(s+p_n)}$$

Here, z represents **zeroes,** and p represents **poles.** The roots of the numerator can be represented as z_1, z_2, z_3,….., z_m, are known as **zeroes.** The roots of the denominator can be represented as
p_1, p_2, p_3,…., p_n, are known as **poles.** The denominator polynomial is called the characteristic equation

1. **Stable System**: If all the roots of the characteristic equation lie on the **left** half of the 'S' plane then the system is said to be a stable system.
2. **Marginally Stable System**: If all the roots of the system lie on the imaginary axis of the 'S' plane then the system is said to be marginally stable.
3. **Unstable System**: If all the roots of the system lie on the **right** half of the 'S' plane then the system is said to be an unstable system.

Routh Hurwitz criterion states that any system can be stable if and only if all the roots of the first column have the same sign and if it does not have the same sign or there is a sign change then the number of sign changes in the first column is equal to the number of roots of the characteristic equation in the right half of the s-plane i.e. equals to the number of roots with positive real parts.

Features of Routh-Hurwitz Criterion:

1. Used to find the stability of the system without solving the equation.
2. To determine the relative stability of the system.
3. To determine the range of K for stability.
4. To determine the point of intersection for root locus with an imaginary axis.
5. Applicable only for a linear system.
6. Does not provide the exact location of poles on the right and left half of the S plane.

MATLAB Code:

```
%% Routh Hurwitz criteria clear
clc
%% First two rows of routh matrix
e=input('Enter the coefficients of characteristic equation: '); l=length(e);
m=mod(l,2); if m==0
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a=rand(1,(l/2));
b=rand(1,(l/2)); for i=1:(l/2)
a(i)=e((2*i)-1); b(i)=e(2*i);
end else
e1=[e 0];
a=rand(1,((l+1)/2)); b=[rand(1,((l-1)/2)),0];
for i=1:((l+1)/2) a(i)=e1((2*i)-1);
b(i)=e1(2*i); end
end

%% Generating the remaining rows of routh matrix l1=length(a);
c=zeros(l,l1); c(1,:)=a;
c(2,:)=b;
for m=3:l
for n=1:l1-1
c(m,n)=-(1/c(m-1,1))*det([c((m-2),1) c((m-2),(n+1));c((m-1),1) c((m-1),(n+1))]);
end end
disp('The Routh matrix:') disp(c)

%% To check the stability of system if c(:,1)>0
disp('System is Stable') else
disp('System is Unstable');
end
```

Result:

(1) Enter the coefficients of characteristic equation: [1 2 6 4 1]

The Routh matrix:

1.0000	6.0000	1.0000
2.0000	4.0000	0
4.0000	1.0000	0
3.5000	0	0
1.0000	0	0

System is Stable

(2) Enter the coefficients of characteristic equation: [4 8 2 10 3]

The Routh matrix:

4	2	3
8	10	0
-3	3	0
18	0	0
3	0	0

System is Unstable