MENG366 SYSTEM DYNAMICS AND CONTROL LABORATORY

LABORATORY 5: ROUTH'S STABILITY CRITERION

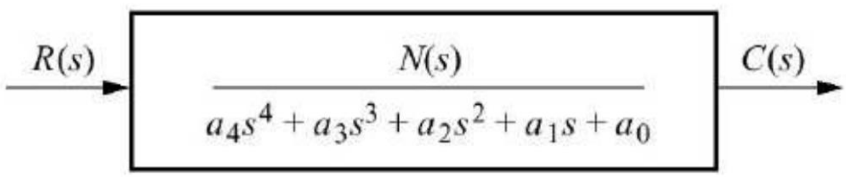
Routh Hurwitz Criterion is a tool to judge the stability of the closed loop system without solving for the poles of the closed loop system. It is comprised of two steps.

1) Generating the Routh Table
2) Interpreting the Routh Table

These two steps are explained in detail as follows.

1) Generating the Routh Table

Routh table can be generated for the closed loop system as follows.



s^4	a_4	a_2	a_0
s^3	a_3	a_1	0
s^2			
s^1			
s^0			

The remaining entries are filled up in the following manner.

s^4	a_4	a_2	a_0
s^3	a_3	a_1	0
s^2	$\frac{-\begin{vmatrix} a_4 & a_2 \\ a_3 & a_1 \end{vmatrix}}{a_3} = b_1$	$\frac{-\begin{vmatrix} a_4 & a_0 \\ a_3 & 0 \end{vmatrix}}{a_3} = b_2$	$\frac{-\begin{vmatrix} a_4 & 0 \\ a_3 & 0 \end{vmatrix}}{a_3} = 0$
s^1	$\frac{-\begin{vmatrix} a_3 & a_1 \\ b_1 & b_2 \end{vmatrix}}{b_1} = c_1$	$\frac{-\begin{vmatrix} a_3 & 0 \\ b_1 & 0 \end{vmatrix}}{b_1} = 0$	$\frac{-\begin{vmatrix} a_3 & 0 \\ b_1 & 0 \end{vmatrix}}{b_1} = 0$
s^0	$\frac{-\begin{vmatrix} b_1 & b_2 \\ c_1 & 0 \end{vmatrix}}{c_1} = d_1$	$\frac{-\begin{vmatrix} b_1 & 0 \\ c_1 & 0 \end{vmatrix}}{c_1} = 0$	$\frac{-\begin{vmatrix} b_1 & 0 \\ c_1 & 0 \end{vmatrix}}{c_1} = 0$

For the special cases where the first column contains any zero entry or entire row is zero use their corresponding methods to solve the Routh table.

2) Interpreting the Routh Table

For the system to be stable, there should be no poles in the right half plane. The first column of the Routh table is used for the analysis if there is sign change; it means there are poles in the right half plane. The number of sign change corresponds to the number.
of poles locations. If the poles are on the imaginary axis with multiplicity 1 and on the left half plane, then the system is marginally stable. If all the poles are in the left half plane the system is stable.

Experiment Objective:

The objective of this experiment is to demonstrate the use of Routh's Stability Criterion to determine the stability of a linear system. The experiment will use MATLAB or Simulink to generate the Routh table for a given system and to determine whether the system is stable or unstable. So the main objectives of this experiment are to:

- Design the system for determining the values of gain in negative feedback system for which the system is stable, unstable and marginally stable by using Routh table.
- Use Simulink show the step responses for different values of gain for each of the stable, unstable and marginally stable system.
- Show the poles locations for each of the stable, unstable and marginally stable system for varying gain values.

Experiment Procedure:

Do the following steps:

1) Find the equivalent negative feedback system shown in the figure 1

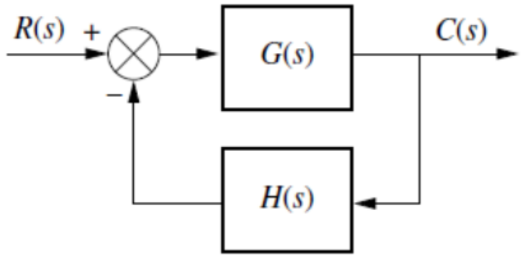


Figure 1: Negative feedback system

Here

$$G(s) = \frac{K}{s(s+2)^2} \text{ and } H(s) = 1$$

2) Generate the Routh table and find the ranges of K for the system to be stable, unstable and marginally stable.
3) Using Simulink setup of the negative feedback system for the system to be stable. Use five different values from the range of K for stable system and plot all step responses on one graph showing the response changes with respect to the varying the value of K.
4) Using Simulink setup of the negative feedback system for the system to be unstable. Use five different values from the range of K for unstable system and plot all the step responses on one graph showing the response changes with respect to the varying the value of K.
5) Using Simulink setup of the negative feedback system for the system to be marginally stable. Plot the step response for the value of K so that the system is marginally stable.
6) Using Simulink setup of the negative feedback system and compare the step response of the system to be stable, unstable and marginally with only one selected value of K for each case. Plot the step responses on one graph.
7) Using MATLAB find the location of poles for each case of the system to be stable, unstable, and marginally stable for all the values of K selected in each case.
8) Repeat previous steps for different values of the system parameters.
9) Analyze the results to gain an understanding of how the system's stability is affected by its parameters.

Note : Make a report which shows the Simulink block diagram, step responses and the poles location for each case.

Experiment Results:

The results of the experiment will vary depending on the system that is being analyzed. However, in general, the experiment should demonstrate the following:

- The ability to generate the Routh table for a linear system using MATLAB or Simulink.
- The ability to use the Routh table to determine the stability of a linear system.
- The ability to understand how the system's stability is affected by its parameters.

Experiment Safety:

There are no safety concerns associated with this experiment. However, it is important to follow the instructions carefully and to use caution when working with electrical equipment.

Experiment Creativity:

There are many ways to creatively approach this experiment. For example, you could analyze the stability of a system with multiple inputs and outputs. You could also use MATLAB or Simulink to generate a 3D plot of the system's stability region.

Experiment Conclusion:

This experiment provides a hands-on introduction to Routh's Stability Criterion. The experiment also demonstrates the use of MATLAB or Simulink for analyzing the stability of linear systems.