Samuel Chukwuake Arnold

16/ENG04/056

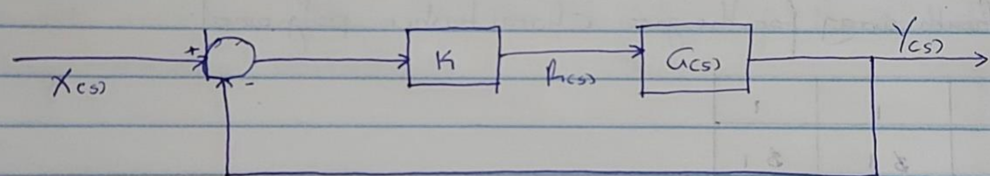
Elect/ Elect Engineering

EEE 441. SERVOMECHANISM AND CONTROL SYSTEMS

Samuel Chukwuake Arnold
16/ENG04/056
Elect/Elect Engr
EEE 441. ServoMechanism & Control Systems.

1] Briefly Explain the Root Locus Technique.

The Root Locus is a graphical technique by means of which the Locus for variation of the roots of the characteristics equation of the closed-Loop system produced by the variation of some system parameter - usually the system gain K - can be deduced from knowledge of the open Loop System together with a set of rules for constructing the Locus. From this Locus it is possible to choose a particular value of K that is Likely to result in reasonable stability, & it is then quite simple to obtain the closed-Loop transient response. This is a method of factorising the closed Loop transfer function



Closed Loop system considered above with unity feedback that uses simple proportional controller. It has a TF

$$H(s) = \frac{KG(s)}{1 + KG(s)} = \frac{n(s)}{d(s)}$$

The root Locus is the locus of the roots of characteristics equation by varying K from zero → infinity.

The poles occur at the roots $d(s)$. for the system TF above these roots occur where

$$1 + KG(s) = 0.$$

This is referred to as the Characteristics Equation of the System, therefore it is necessary that

$$1. |KG(s)| = 1$$

$$\angle G(s) = 180° \pm k360 \quad \text{for } k \in Z$$

The 2 equations are refered to as the Magnitude & Angle Criteria respectively
∴ The root Locus is the path of the roots of the characteristic equation due to K as K is traced out to infinity.

2a] Considering this Example

Find the Stability of the control System having characteristic Equation

$$s^5 + 3s^4 + s^3 + 3s^2 + s + 3 = 0$$

Step 1] Verify the necessary condition for the Routh-Hurwitz stability.

All the coefficients of the given characteristic polynomial are positive. So the control System satisfied the necessary condition.

Step 2: Form the Routh array for the given Characteristic polynomial.

s^5	1	1	1
s^4	$\cancel{3}$ 1	$\cancel{3}$ 1	$\cancel{3}$ 1
s^3	$\frac{(1\times1)-(1\times1)}{1} = 0$	$\frac{(1\times1)-(1\times1)}{1} = 0$	
s^2			
s^1			
s^0			

The row s^4 elements have the common factor of 3. So, all these elements are divided by 3.

- All the elements of row s^3 are zero. So, write the auxiliary equation, A(s) of the row s^4

$$A(s) = s^4 + s^2 + 1$$

Differentiate the above equation with respect to s

$$\frac{dA(s)}{ds} = 4s^3 + 2s.$$

s^5	1	1	1
s^4	1	1	1
s^3	$\cancel{4}$ 2	$\cancel{2}$ 1	
s^2	$\frac{(2\times1)-(1\times1)}{2}$ $=0.5$	$2\times1-(1\times1)$ $=1$	
s^1	$\frac{(0.5\times1)-(1\times2)}{0.5}$ $=\frac{-1.5}{0.5}$ $=-3$		
s^0	1		

Step 3 - Verify the Sufficient condition for the Routh-Hurwitz stability
There are 2 sign changes in the 1st Column of Routh table. Hence, the control system is unstable.

b] A whole row of zeros indicates the presence of pairs of poles that are mirrored about the imaginary axis [jω axis]