ECE311 Quiz 2

Note: Use of a calculator is not permitted for this quiz.

Problem: Determine the number of 1) LHP (left half plane), 2) RHP (right half plane), and 3) IA (imaginary axis) roots for each of the following polynomials using the Routh-Hurwitz criteria.

1) $s^3 + s^2 + 2s + 8$

2) $s^5 + 2s^4 + 2s^3 + 4s^2 + 11s + 10$

3) $s^4 + s^3 + 3s^2 + 2s + 2$

SOLUTIONS

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a) $s^3 + s^2 + 2s + 8$

s^3	1	2
s^2	1	8
s^1	-6	0
s^0	8	

2 SIGN CHANGES $\Rightarrow$

$\#$ RHP = 2

$\Rightarrow$ $\#$ LHP = $3-2=1$

$\Rightarrow$ $\#$ IA = 0

NOTE: USING MATLAB ROOTS ARE

-2, ← 1 × LHP

$0.5 \pm 1.94j$ ← 2 × RHP

b) $s^5 + 2s^4 + 2s^3 + 4s^2 + 11s + 10$

s^5	1	2	11
s^4	2	4	10
s^3	0	6	
s^2			
s^1			
s^0			

REPLACE THIS ROW WITH

0	6
-6	0
-6	6

$\Rightarrow$

s^5	1	2	11
s^4	2	4	10
s^3	-6	6	0
s^2	6	10	
s^1	16	0	
s^0	10		

$\#$ SIGN CHANGES

$\Rightarrow \#$ RHP = 2

$\Rightarrow$ $\#$ LHP = $5-2=3$

$\#$ IA = 0

PROBLEM

b. USING MATLAB ROOTS ARE:

$0.895 \pm 1.46j$ ← 2× RHP

$-1.24 \pm 1.09j$, -1.31 } 3 × LHP

$$\frac{\begin{vmatrix} 2 & 4 \\ -6 & 6 \end{vmatrix}}{-(-6)} = \frac{12+24}{6} = \frac{36}{6} = 6$$

$$\frac{\begin{vmatrix} 2 & 10 \\ -6 & 0 \end{vmatrix}}{-(-6)} = 10$$

$$\frac{\begin{vmatrix} -6 & 6 \\ 6 & 10 \end{vmatrix}}{-6} = \frac{-60-36}{-6} = \frac{96}{6} = 16$$

c) $s^4 + s^3 + 3s^2 + 2s + 2$

s^4	1	3	2
s^3	1	2	
s^2	1	2	
s^1	0		
s^0			

← ROW OF ZEROES. REPLACE WITH DERIVATIVE OF DIVISOR POLYNOMIAL

2 × IA ROOTS

$P(s) = s^2 + 2$

$\frac{dP(s)}{ds} = 2s$

$\Rightarrow$

s^4	1	3	2
s^3	1	2	
s^2	1	2	
s^1	2	0	
s^0	2		

$\Rightarrow$ NO SIGN CHANGES

$\Rightarrow$ $\#$ RHP = 0

$\#$ IA = 2

$\Rightarrow$ $\#$ LHP = $4-2 = 2$

USING MATLAB ROOTS ARE:

$\pm 1.4142j$ ← 2× IA

$-0.5 \pm 0.866j$ ← 2 × LHP