1

Control Systems

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		with the Department of Electrical Engineers f Technology, Hyderabad 502285 India e-m		$s(s^3 + 2s^2 + s + 1) + k(s^2 + s + 1) = 0$ (6.1.1)

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is stable.

Solution: The General form of characteristic equation :

$$1 + G(s)H(s) = 0 (6.1.2)$$

6.2. For a system to be marginally stable , nyquist plot passes through (-1,0). Generally we will draw nyquist plot for open loop gain G(s)H(s).So, 1+G(s)H(s) passes through through (0,0)

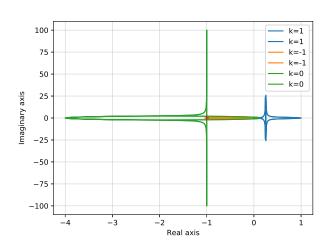
Real part =
$$\omega^4 - \omega^2(k+1) + k = 0$$
 (6.2.1)

$$Imaginary part = -\omega^3 + \omega(w+1) = 0 (6.2.2)$$

By equating real and imaginary to 0 .We get,

$$k = 0 \tag{6.2.3}$$

- 6.3. For a nyquist plot,no.of clock wise encirclement's around the point(-1,0) for a open loop transfer function gives the total no. right hand side zeros,
- 6.4. We can verify it through nyquist plot



The following python code generates the nyquist plot:

Verify it through routh hurwitz criterion.

$$s^4 + 2s^3 + s^2(k+1) + s(k+1) + k = 0$$
 (6.4.1)

$$\begin{vmatrix} s^{4} \\ s^{3} \\ s^{2} \\ s^{1} \\ s^{0} \end{vmatrix} = \begin{vmatrix} 1 & k+1 & k \\ 2 & k+1 & 0 \\ \frac{k+1}{2} & k & 0 \\ \frac{(k-1)^{2}}{2} & 0 & 0 \\ k & 0 & 0 \end{vmatrix}$$

6.5. For the system to be stable, all values of that matrix should be greater than or equal to 0.So, minimum value of k is,

$$k = 0$$
 (6.5.1)

The range of k system to be stable

$$0 < k < \infty \tag{6.5.2}$$

verify it using following routh -hurwitz code.

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