1

Control Systems

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is stable.

Solution: The General form of characteristic equation :

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

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

Realpart =
$$\omega^4 - \omega^2(k+1) + k = 0$$
 (6.1.3)

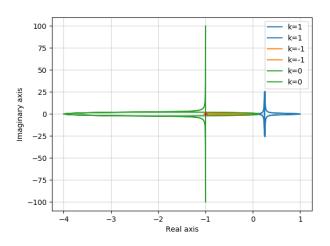
$$Imaginary part = -\omega^3 + \omega(w+1) = 0 \quad (6.1.4)$$

By equating real and imaginary to 0 .We get,

$$k = 0 \tag{6.1.5}$$

as minimum value sysytem to be stable.

6.2. For a nyquist plot,no.of clock wise encirclements around the point(-1,0J) for a open loop transfer function gives the total no. right hand side zeros, can verify it through nyquist plot



The following python code generates the nyquist plot:

6.3. Verifying k value using Routh-hurwitz criterion Characteristic equation(polynomial):

$$\begin{vmatrix} s^4 \\ s^3 \\ s^2 \\ s^1 \\ s^0 \end{vmatrix} = \begin{vmatrix} 1 & k+1 & k \\ 2 & k+1 & 0 \\ \frac{k+1}{2} & k & 0 \\ \frac{(k-1)^2}{2} & 0 & 0 \\ k & 0 & 0 \end{vmatrix}$$
 From this we can say for

system to be stable, all values of determinant should be greater than 0. So, minimum value of k is,

$$k = 0 \tag{6.3.1}$$

The range of k system to be stable

$$0 < k < \infty \tag{6.3.2}$$

- 6.4. We can verify it through following python code codes/ee18btech11042_2.py
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