Control Systems

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***Abstract*—This manual is an introduction to control systems based on GATE problems.Links to sample Python codes are available in the text.**

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/codes
```

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6.1. Find the range of k such that given characteristic equation

$$s(s^3 + 2s^2 + s + 1) + k(s^2 + s + 1) = 0 \quad (6.1.1)$$

is stable.

Solution: The General form of characteristic equation :

$$1 + G(s)H(s) = 0 \tag{6.1.2}$$

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)

$$Realpart = \omega^4 - \omega^2(k+1) + k = 0 \tag{6.2.1}$$

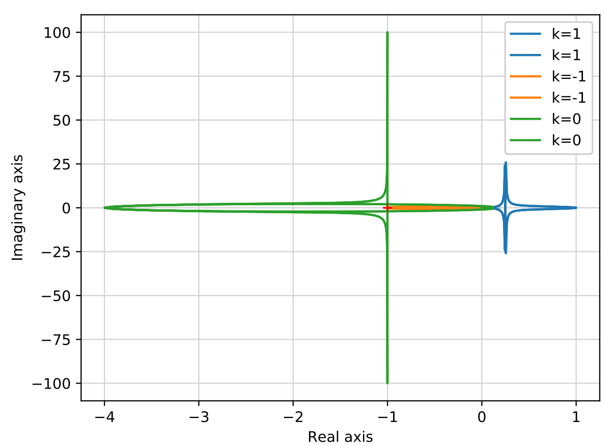
$$Imaginarypart = -\omega^3 + \omega(w+1) = 0 \tag{6.2.2}$$

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 :

```
codes/ee18btech11042_1.py
```

Verify it through routh hurwitz criterion.

$$s^4 + 2s^3 + s^2(k+1) + s(k+1) + k = 0 \tag{6.4.1}$$

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

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,

$$k = 0 \tag{6.5.1}$$

The range of k system to be stable

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

verify it using following routh -hurwitz code.

```
codes/ee18btech11042_2.py
```

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