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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
```

for example the zeros of polynomial  $s^4 + 3s^3 + 3s^2 + s + 0.5 = 0$  are

$$s1 = -0.08373 + 0.45773i \quad (2.0.1.8)$$

$$s2 = -0.08373 - 0.45773i \quad (2.0.1.9)$$

$$s3 = -1.41627 + 0.55075i \quad (2.0.1.10)$$

$$s4 = -1.41627 - 0.55075i \quad (2.0.1.11)$$

2.0.2. Modify the Python code in Problem ?? to verify your solution by choosing two different values of  $k$ .

**Solution:** The following code

```
codes/ee18btech11008/ee18btech11008.py
```

provides the necessary solution.

3 COMPENSATORS

4 NYQUIST PLOT

## 1 STABILITY

## 2 ROUTH HURWITZ CRITERION

2.0.1. The characteristic equation of linear time invariant system is given by

$$\nabla(s) = s^4 + 3s^3 + 3s^2 + s + k = 0 \quad (2.0.1.1)$$

Find the condition for the system to be BIBO stable using the Routh Array.

**solution**

$$\nabla(s) = s^4 + 3s^3 + 3s^2 + s + k = 0 \quad (2.0.1.2)$$

The Routh hurwitz criterion:-

$$\begin{array}{c|ccc} s^4 & 1 & 3 & k \\ s^3 & 3 & 1 & 0 \\ s^2 & \frac{8}{3} & k & 0 \\ s^1 & \frac{\frac{8}{3} - 3k}{\frac{8}{3}} & 0 & 0 \\ s^0 & k & 0 & 0 \end{array} \quad (2.0.1.3)$$

Given system is stable if

$$k > 0, \frac{\frac{8}{3} - 3k}{\frac{8}{3}} > 0 \quad (2.0.1.4)$$

$$\frac{8}{3} - 3k > 0 \quad (2.0.1.5)$$

$$3k < \frac{8}{3} \quad (2.0.1.6)$$

$$(0 < k < \frac{8}{9}) \quad (2.0.1.7)$$