

# 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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## 1 MASON'S GAIN FORMULA

### 2 BODE PLOT

#### 2.1 Introduction

#### 2.2 Example

## 3 SECOND ORDER SYSTEM

### 3.1 Damping

3.1. The open-loop transfer function of a plant in a unity feedback configuration is given as

$$G(s) = \frac{K(s+4)}{(s+8)(s^2-9)} \quad (3.1.1)$$

The value of the gain  $K(>0)$  for which  $-1+j2$  lies on the root locus is

**Solution:** The closed loop transfer function for a negative feed back system is:

$$F(s) = \frac{G(s)}{1+G(s)H(s)} \quad (3.1.2)$$

Since it is a unity feed back system,  $H(s) = 1$ , and now using the characteristic equation at  $s_1 = -1+j2$

$$1 + G(s_1)H(s_1) = 0 \quad (3.1.3)$$

$$G(s_1) = -1 \quad (3.1.4)$$

$$|G(s_1)| = 1 \quad (3.1.5)$$

$$G(s_1) = \frac{K(s_1+4)}{(s_1+8)(s_1^2-9)} \quad (3.1.6)$$

$$G(s_1) = \frac{K(s_1+4)}{(s_1+8)(s_1+3)(s_1-3)} \quad (3.1.7)$$

$$G(s_1) = \frac{K(3+j2)}{(7+j2)(2+j2)(-4+j2)} \quad (3.1.8)$$

$$|G(s_1)| = \frac{K\sqrt{13}}{\sqrt{51}\sqrt{8}\sqrt{20}} = 1 \quad (3.1.9)$$

$$K = 25.05 \quad (3.1.10)$$

$$F(s) = \frac{25.05(s+4)}{s^3 + 8s^2 + 16.05s + 28.2} \quad (3.1.11)$$

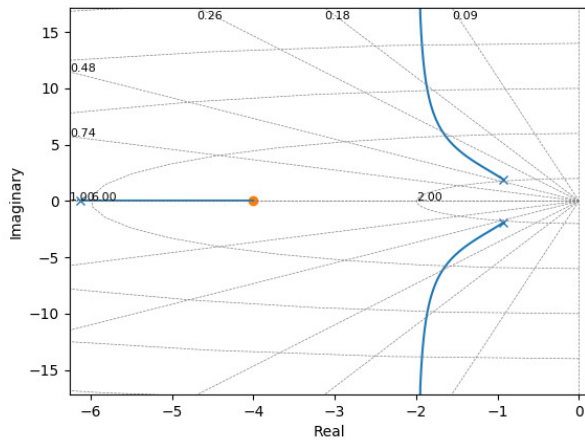


Fig. 3.1: Root locus plot for verification

$$Z_1 = -4, P_1 = -6.13, P_2 = -1 + j2, P_3 = -1 - j2$$

codes/ee18btech11052.py

### 3.2 Example

#### 4 ROUTH HURWITZ CRITERION

##### 4.1 Routh Array

##### 4.2 Marginal Stability

##### 4.3 Stability

#### 5 STATE-SPACE MODEL

##### 5.1 Controllability and Observability

##### 5.2 Second Order System

#### 6 NYQUIST PLOT

#### 7 PHASE MARGIN

#### 8 GAIN MARGIN

#### 9 COMPENSATORS

##### 9.1 Phase Lead

#### 10 OSCILLATOR