

# Control Systems

G V V Sharma\*

CONTENTS				
<b>1</b>	<b>Signal Flow Graph</b>	2	<b>7</b>	<b>Compensators</b>
1.1	Mason's Gain Formula . . . . .	2	7.1	Phase Lead . . . . .
1.2	Matrix Formula . . . . .	2	7.2	Lag Lead . . . . .
1.3	Example . . . . .	2	7.3	Example . . . . .
<b>2</b>	<b>Bode Plot</b>	2	<b>8</b>	<b>Gain Margin</b>
2.1	Introduction . . . . .	2	8.1	Introduction . . . . .
2.2	Example . . . . .	2	8.2	Example . . . . .
2.3	Phase . . . . .	2	8.3	Example . . . . .
<b>3</b>	<b>Second order System</b>	2	<b>9</b>	<b>Phase Margin</b>
3.1	Damping . . . . .	2	9.1	Intoduction . . . . .
3.2	Example . . . . .	2	9.2	Example . . . . .
3.3	Settling Time . . . . .	2	<b>10</b>	<b>Oscillator</b>
<b>4</b>	<b>Routh Hurwitz Criterion</b>	2	10.1	Introduction . . . . .
4.1	Routh Array . . . . .	2	10.2	Example . . . . .
4.2	Marginal Stability . . . . .	2	<b>11</b>	<b>Root Locus</b>
4.3	Stability . . . . .	2	11.1	Introduction . . . . .
4.4	Example . . . . .	2		
4.5	Example . . . . .	2		
<b>5</b>	<b>State-Space Model</b>	2		
5.1	Controllability and Observability . . . . .	2		
5.2	Second Order System . . . . .	2		
5.3	Example . . . . .	2		
5.4	Example . . . . .	2		
5.5	Example . . . . .	2		
5.6	Example . . . . .	2		
5.7	Example . . . . .	2		
<b>6</b>	<b>Nyquist Plot</b>	2		
6.1	Introduction . . . . .	2		
6.2	Example . . . . .	2		

*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>

\*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in. All content in this manual is released under GNU GPL. Free and open source.

## 1 SIGNAL FLOW GRAPH

### 1.1 Mason's Gain Formula

### 1.2 Matrix Formula

### 1.3 Example

## 2 BODE PLOT

### 2.1 Introduction

### 2.2 Example

### 2.3 Phase

## 3 SECOND ORDER SYSTEM

### 3.1 Damping

### 3.2 Example

### 3.3 Settling Time

## 4 ROUTH HURWITZ CRITERION

### 4.1 Routh Array

### 4.2 Marginal Stability

### 4.3 Stability

### 4.4 Example

### 4.5 Example

## 5 STATE-SPACE MODEL

### 5.1 Controllability and Observability

### 5.2 Second Order System

### 5.3 Example

### 5.4 Example

### 5.5 Example

### 5.6 Example

### 5.7 Example

## 6 NYQUIST PLOT

### 6.1 Introduction

### 6.2 Example

## 7 COMPENSATORS

### 7.1 Phase Lead

### 7.2 Lag Lead

### 7.3 Example

▢ lead Compensator network includes a parallel combination of R and C in feed-forward path. If the transfer function of compensator is

$$G_c(s) = \frac{s+2}{s+4} \quad (7.0.1)$$

, the value of RC is ?

And also find the value of RC for a lead compensator used in previous example.

$$G_c(s) = \frac{3(s + \frac{1}{3})}{s + 1} \quad (7.0.2)$$

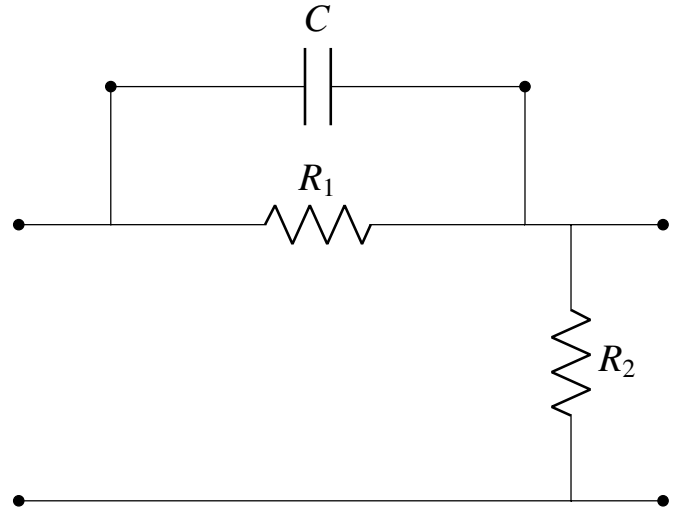


Fig. 7.0

Solution:

The transfer function for the following circuit is

$$T(s) = \frac{V_o}{V_i} \quad (7.0.3)$$

Let

$$\alpha = \frac{R_2}{R_1 + R_2} \quad (7.0.4)$$

$$\tau = R_1 C \quad (7.0.5)$$

Now our T(s) is

$$T(s) = \frac{R_2}{\frac{\frac{1}{sC}R_1}{\frac{1}{sC} + R_1} + R_2} \quad (7.0.6)$$

Simplifying T(s)

$$T(s) = \frac{s + \frac{1}{\tau}}{s + \frac{1}{\tau\alpha}} \quad (7.0.7)$$

Comparing with the given

$$G_c(s) = \frac{s+2}{s+4} \quad (7.0.8)$$

$$\tau = R_1 C = 0.5$$

for

$$T(s) = \frac{3(s + \frac{1}{3})}{s + 1} \quad (7.0.9)$$

here this is a lead compensator with a gain of 3. so we can simply write passive circuit part as.

$$T(s) = \frac{(s + \frac{1}{3})}{s + 1} \quad (7.0.10)$$

again by comparing with

$$T(s) = \frac{s + \frac{1}{\tau}}{s + \frac{1}{\tau\alpha}} \quad (7.0.11)$$

$$\tau = 3RC = 3 \quad (7.0.12)$$

## 8 GAIN MARGIN

### 8.1 Introduction

### 8.2 Example

### 8.3 Example

## 9 PHASE MARGIN

### 9.1 Introduction

### 9.2 Example

## 10 OSCILLATOR

### 10.1 Introduction

### 10.2 Example

## 11 ROOT LOCUS

### 11.1 Introduction