

# 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 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

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## 5 STATE-SPACE MODEL

### 5.1 Controllability and Observability

### 5.2 Second Order System

### 5.3 Example

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### 5.6 Example

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## 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.

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

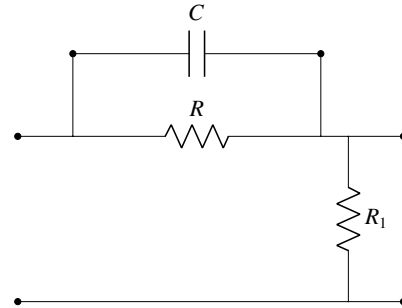


Fig. 7.0

Solution:

The transfer function for the following circuit is

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

Let

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

and

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

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

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

$$\tau = R_1 C = 0.5 \quad (7.0.8)$$

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

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

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

$$RC = 3 \quad (7.0.13)$$

## 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