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
```

1 Signal Flow Graph

1.1 Mason's Gain Formula

1.2 Matrix Formula

2 Bode Plot

2.1 Introduction

2.2 Example

3 Second order System

3.1 Damping

3.2 Example

3.3 Peak Overshoot

3.3.1. Find the peak overshoot for the second order control system given by:

$$G(S) = \frac{100}{s^2 + 10s + 100} \tag{3.3.1.1}$$

Solution: Peak overshoot (M_p) is defined as the deviation of the response at peak time from the final value of response.

$$\implies M_p = c(t_p) - c(\infty) \tag{3.3.1.2}$$

Given,

$$G(S) = \frac{C(s)}{R(s)} = \frac{100}{s^2 + 10s + 100} \tag{3.3.1.3}$$

To calculate the unit step response,

$$r(t) = 1 \implies R(s) = \frac{1}{s} \tag{3.3.1.4}$$

$$\implies C(S) = \frac{100}{(s)(s^2+10s+100)} \tag{3.3.1.5}$$

C(s) can be expanded as:

$$C(s) = \frac{1}{s} - \frac{s+5}{(s+5)^2+75} - \frac{1}{\sqrt{3}}.\frac{\sqrt{75}}{(s+5)^2+75} \tag{3.3.1.6}$$

In time domain,

$$c(t) = \mathcal{L}^{-1}C(s) \tag{3.3.1.7}$$

$$\implies c(t) = 1 - e^{-5t}cos(\sqrt{75}t) - \frac{e^{-5t}}{\sqrt{3}}.sin(\sqrt{75}t) \tag{3.3.1.8}$$

From (3.3.1.8):

$$\lim_{t\to\infty} c(t) = 1 \tag{3.3.1.9}$$

At t_p, $c(t)$ is maximum:

$$\implies \frac{dc(t)}{d(t)} = 0 \tag{3.3.1.10}$$

Applying this condition on (3.3.1.8), we get:

$$t_p = \frac{\pi}{\sqrt{75}} \tag{3.3.1.11}$$

Substitute t_p in (3.3.1.8) to get $c(t_p)$:

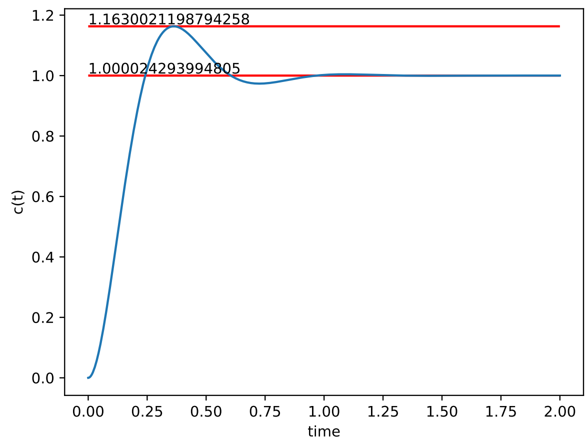
$$c(t_p) = 1 + e^{\frac{-\pi}{\sqrt{3}}} \implies c(t_p) = 1.163 \tag{3.3.1.12}$$

Substitute $c(t_p)$ and $c(\infty)$ in (3.3.1.2) to get peak overshoot:

$$M_p = 1.163 - 1 = 0.163 \tag{3.3.1.13}$$

3.3.2. Verify using a Python Plot
Solution:

```
codes/ee18btech11045.py
```



4 Routh Hurwitz Criterion

4.1 Routh Array

4.2 Marginal Stability

4.3 Stability

4.4 Example

5 State-Space Model

5.1 Controllability and Observability

5.2 Second Order System

5.3 Example

5.4 Example

5.5 Example

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