Control Systems

G V V Sharma*

Contents

***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 Stability

1.1 Second order System

1.1. Consider the following second order system with the transfer function

$$G(s) = \frac{1}{1+2s+s^2} \tag{1.1.1}$$

Is the system stable?
Solution:

1.2. Find and sketch the step response $c(t)$ of the system.
Solution:

1.3. Find the steady state response of the system.
Solution:

1.4. Find the time system output c(t) to reach 94% of its steady state value.
Solution:

*The author is with the Department of Electrical Engineering, Indian Institute of Technology, Hyderabad 502285 India e-mail: gadepall@iith.ac.in.

Solution:

$$G(s) = (\frac{1}{1+2s+s^2}) \tag{1.4.1}$$

From given expression of G(s),both poles of G(s) are at (-1,0) which is on the left half of s-plane, therefore we can conclude that the system is stable.

$$C(s) = R(s).G(s) = (\frac{1}{s})(\frac{1}{1+2s+s^2}) \tag{1.4.2}$$

$$C(s) = \frac{1}{s(1+s)^2} \tag{1.4.3}$$

We found C(s) as:

$$C(s) = \frac{1}{s(1+s)^2} \tag{1.4.4}$$

Therefore,

$$C(s) = \frac{1}{s} - \frac{1}{(1+s)} - \frac{1}{(1+s)^2} \tag{1.4.5}$$

Therefore;

$$c(t) = L^{-1}\left[\frac{1}{s}\right] - L^{-1}(\frac{1}{(1+s)}) - L^{-1}(\frac{1}{(1+s)^2}) \tag{1.4.6}$$

Using the Known inverse transforms:

$$c(t) = (1 - e^{-t} - te^{-t}).u(t) \tag{1.4.7}$$

To know the steady state value of c(t), we calculate

$$\lim_{t\to\infty} c(t) = (1+0+0).(1) = 1 \tag{1.4.8}$$

Now, 94% of 1 is 0.94, so we should now solve for a positive t such that

$$(1 - e^{-t} - te^{-t}) = 0.94 \tag{1.4.9}$$

$$t = 4.5228 \tag{1.4.10}$$

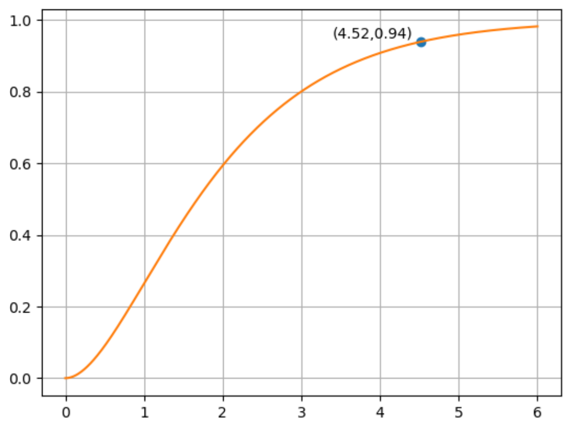

Fig. 1.4

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot