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 Routh Hurwitz Criterion

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

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

with input unit step

$$R(s) = \frac{1}{s} \tag{1.1.2}$$

Let C(s) be the corresponding output. The time taken by the system output c(t) to reach 94% of its steady state value, rounded off to two decimal places is

Solution:

$$G(s) = \left(\frac{1}{1+2s+s^2}\right) \tag{1.1.3}$$

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.

$$C(s) = R(s).G(s) = \left(\frac{1}{s}\right)\left(\frac{1}{1+2s+s^2}\right) \tag{1.1.4}$$

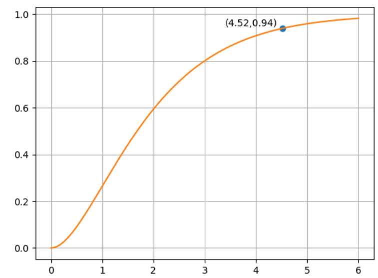
$$C(s) = \frac{1}{s(1+s)^2} \tag{1.1.5}$$

We found C(s) as:

$$C(s) = \frac{1}{s(1+s)^2} \tag{1.1.6}$$

Therefore,

$$C(s) = \frac{1}{s} - \frac{1}{(1+s)} - \frac{1}{(1+s)^2} \tag{1.1.7}$$



Therefore;

$$c(t) = L^{-1}\left(\frac{1}{s}\right) - L^{-1}\left(\frac{1}{(1+s)}\right) - L^{-1}\left(\frac{1}{(1+s)^2}\right) \tag{1.1.8}$$

Using the Known inverse transforms:

$$c(t) = (1 - e^{-t} - te^{-t}).u(t) \tag{1.1.9}$$

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

$$\lim_{t\to\infty} c(t) = (1+0+0).(1) = 1 \tag{1.1.10}$$

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

$$(1 - e^{-t} - te^{-t}) = 0.94 \tag{1.1.11}$$

$$t = 4.5228 \tag{1.1.12}$$

2 Bode Plot

3 Compensators

4 Nyquist Plot