Control Systems

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Contents

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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 Phase

3 Second order System

3.1 Damping

3.2 Peak Overshoot

3.3 Settling Time

4 Routh Hurwitz Criterion

4.1 Routh Array

4.2 Marginal Stability

4.3 Stability

5 State-Space Model

5.1 Controllability and Observability

5.2 Second Order System

6 Nyquist Plot

6.1 Introduction

7 Compensators

7.1 Phase Lead

7.2 Lag Lead

8 Gain Margin

8.1 Introduction

8.2 Example

8.1. Sketch the Bode Magnitude and Phase plot for the following system. Also compute the gain margin and the phase margin.

$$G(s) = \frac{10}{s(1+0.5s)(1+.01s)} \tag{8.1.1}$$

Solution: The system is defined as follows:

$$G(s) = \frac{10}{s(1+0.5s)(1+.01s)} \tag{8.1.2}$$

Zeros	Poles
-	0
	-2
	-100

TABLE 8.1: Zeros and Poles

The magnitude and phase plot are as follows: Fig8.1

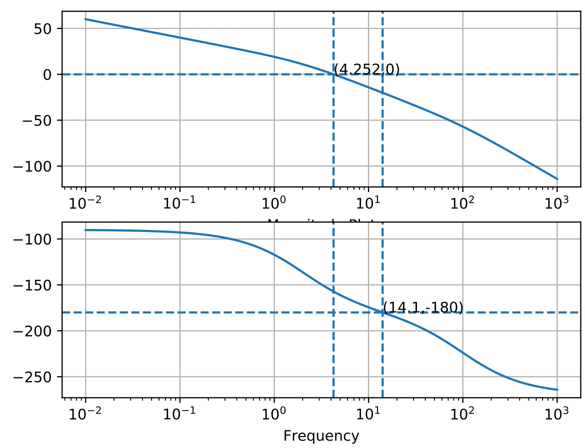

Fig. 8.1: Graphs

The python code to obtain the graphs:

```
codes/ee18btech11048.py
```

8.2. Finding the Phase Margin (PM).

$$G(j\omega) = \frac{10}{j\omega(1+0.5j\omega)(1+.01j\omega)} \tag{8.2.1}$$

$$PM = \angle G(\jmath\omega_{gc}) + 180^\circ \tag{8.2.2}$$

where ω_{gc} is frequency when gain = 1 .
Solution:

$$\frac{100}{\omega\sqrt{(0.5\omega)^2+1}\sqrt{(0.01\omega)^2+1}} = 1 \tag{8.2.3}$$

Solving Eq. (8.2.3) *or* from Fig 8.1 :

$$\implies \omega_{gc} = 4.25 \tag{8.2.4}$$

$$\angle G\left(\jmath\omega_{gc}\right) = -157.2 \tag{8.2.5}$$

$$\implies PM = 22.8 \tag{8.2.6}$$

8.3. Finding the Gain Margin (GM)

$$GM = 0 - G(\jmath\omega_{pc})db \tag{8.3.1}$$

where ω_{pc} is frequency when phase = -180°
Solution:

$$\arctan(0) - \arctan\left(\frac{\omega}{0}\right) - \arctan\left(\frac{\omega}{2}\right) - \arctan\left(\frac{\omega}{100}\right) = -180^\circ \tag{8.3.2}$$

Solving Eq. (8.3.2) *or* from Fig 8.1 :

$$\implies \omega = 14.1 \tag{8.3.3}$$

$$-G(\jmath\omega)db = -20.2 \tag{8.3.4}$$

$$\implies GM = 20.2db \tag{8.3.5}$$

9 Phase Margin

9.1 Intodiction

10 Oscillator

10.1 Introduction

11 Root Locus