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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8.1. Plot the Bode magnitude and phase plots for the following system

$$G(s) = \frac{75(1 + 0.2s)}{s(s^2 + 16s + 100)} \tag{8.1.1}$$

Also compute gain margin and phase margin .
Solution: From (8.1.1), we have

$$G(j\omega) = \frac{75(1 + 0.2j\omega)}{j\omega\left((j\omega)^2 + 16j\omega + 100\right)} \tag{8.1.2}$$

poles = 0 , -8-6j , -8+6j
zeros = -5
Gain and phase plots are shown in Fig 8.1
The following code plots Fig 8.1

```
codes/ee18btech11049.py
```

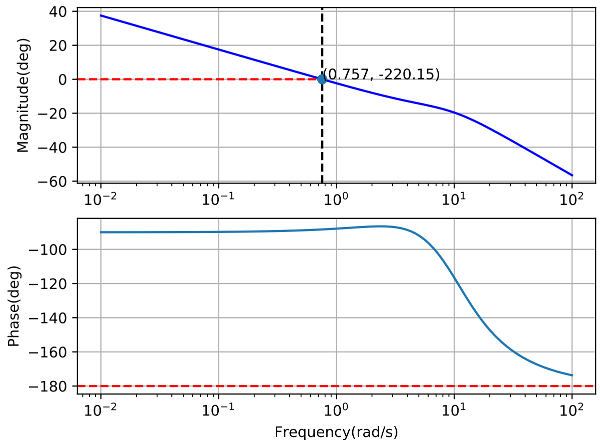

Fig. 8.1: a

8.2. Find $\angle G(\jmath\omega) + 180^\circ$, where ω is frequency when gain = 1 . This is known as *phase margin* (PM)
Solution:

$$\frac{75\sqrt{\omega^2 + 25}}{\omega\sqrt{(\omega + 6)^2 + 64}\sqrt{(\omega - 6)^2 + 64}} = 1 \tag{8.2.1}$$

Solving (8.2.1) (*or*)
from Fig 8.1 frequency at which gain = 1 ,is gain crossover frequency ω_{gc} .

$$\implies \omega_{gc} = 0.757 \tag{8.2.2}$$

$$\angle G\left(\jmath\omega_{gc}\right) = -88.3 \tag{8.2.3}$$

$$\implies PM = 91.7 \tag{8.2.4}$$

8.3. Find $-G(\jmath\omega)$ db , where ω is frequency when phase = -180° . This is known as *gain margin* (GM)
Solution: From Fig 8.1 ,we can say that phase never crosses -180° . So , the gain margin is *infinite*. Which means we can add any gain , and the equivalent closed loop system never goes unstable.

9 Phase Margin

9.1 Intoduction

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11 Root Locus