Control Systems

G V V Sharma*

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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
```

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

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7.0.1. Consider a unity feedback control system as shown in Fig. 7.0.1. Find the value of K that results in a phase margin of the system to be 30°.

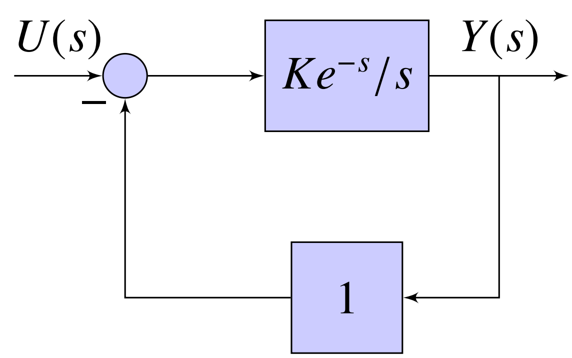

Fig. 7.0.1

Solution: Given $H(s) = 1$ and $G(s) = Ke^{-s}/s$ Phase Margin(PM) is defined as-

$$PM = \phi - (-180^\circ) \tag{7.0.1.1}$$

$$\implies \phi + 180^\circ \tag{7.0.1.2}$$

where,

$$\phi = \angle G\left(j\omega_{gc}\right)H\left(j\omega_{gc}\right) \quad (7.0.1.3)$$

ω_{gc} is the gain-cross over frequency.

7.0.2. Find ω_{gc}.
Solution:

$$\left|G\left(j\omega_{gc}\right)H\left(j\omega_{gc}\right)\right| = 1 \quad (7.0.2.1)$$

$$\implies \left|\frac{Ke^{-j\omega_{gc}}}{j\omega_{gc}}\right| = 1 \quad (7.0.2.2)$$

$$\implies \omega_{gc} = K \quad Assuming\ K > 0 \quad (7.0.2.3)$$

7.0.3. Find ϕ.
Solution:

$$\phi = \angle G\left(j\omega_{gc}\right)H\left(j\omega_{gc}\right) \quad (7.0.3.1)$$

$$\implies \angle\frac{Ke^{-jK}}{jK} \quad (7.0.3.2)$$

$$\implies -90^\circ - K\left(180/\pi\right) \quad (7.0.3.3)$$

7.0.4. By (7.0.1.1)

$$PM = 30^\circ \quad (7.0.4.1)$$

$$by(7.0.3.1) \quad K = \pi/3 \quad (7.0.4.2)$$

7.0.5. Verify result by plotting the gain and phase plots of $G\left(j\left(\omega\right)\right)$
Solution: The following code plots Fig. 7.0.5

```
codes/ee18btech11038_plot.py
```

The Phase plot is as shown-

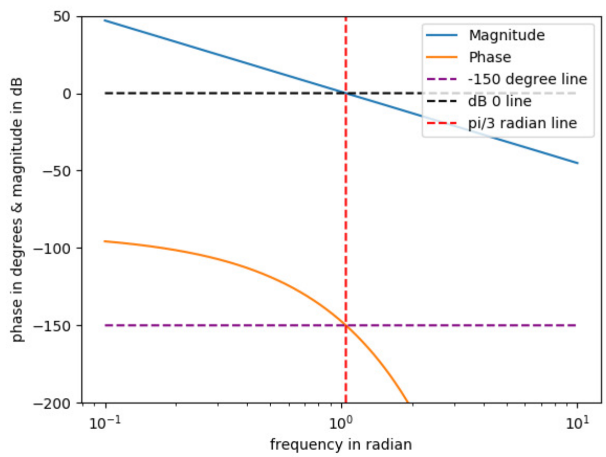

Fig. 7.0.5

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