

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. All content in this manual is released under GNU GPL. Free and open source.

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1.2 Matrix Formula

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6 NYQUIST PLOT

6.1 Introduction

6.2 Example

6.1. Sketch the polar plot for the transfer function

$$G(s) = \frac{10(s+1)}{10+s} \quad (6.1.1)$$

for

$0 \leq \omega < \infty$. Which quadrant does it lie in?

Solution: Substituting $s = j\omega$ in (6.1.1),

$$\begin{aligned} G(j\omega) &= \frac{10(1+j\omega)}{(10+j\omega)} \quad (6.1.2) \\ &= \underbrace{10 \sqrt{\frac{1+\omega^2}{100+\omega^2}}}_r \\ &\quad \times \exp \left\{ j \underbrace{\left(\tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{10}\right) \right)}_{\theta} \right\} \quad (6.1.3) \end{aligned}$$

$$\therefore \frac{d}{d\omega} \tan^{-1}(\omega) = \frac{1}{1+\omega^2}, \omega > 0, \quad (6.1.4)$$

$\tan^{-1}(\omega)$ is an increasing function. Hence,

$$\tan^{-1}(\omega) \geq \tan^{-1}\left(\frac{\omega}{10}\right). \quad (6.1.5)$$

$\therefore 0 < \theta < \frac{\pi}{2}$ in (6.1.3), the polar plot of $G(s)$ lies in the first quadrant. The following code generates the polar plot in Fig. 6.1.

codes/ee18btech11051.py

According to Nyquist criterion, If the open-loop transfer function $G(s)$ is stable, then the closed-loop system is unstable for any encirclement of the point $-1+j0$.

The only pole of $G(s)$ lies in the left half of the s -plane. So, $G(s)$ is stable. And from Fig.6.1, the number of clockwise encirclements around $(-1+j0)$ is zero ($N = 0$). Therefore, the system is stable.

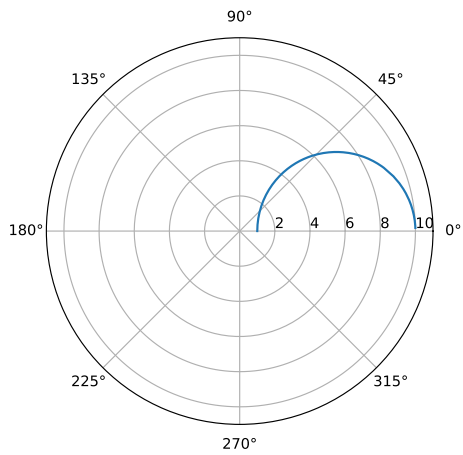


Fig. 6.1

7 COMPENSATORS

7.1 *Phase Lead*

7.2 *Lag Lead*

7.3 *Example*

8 GAIN MARGIN

8.1 *Introduction*

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9.1 *Intoduction*

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10 OSCILLATOR

10.1 *Introduction*

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11.1 *Introduction*