

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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1 SIGNAL FLOW GRAPH

- 1.1 Mason's Gain Formula
- 1.2 Matrix Formula
- 1.3 Example

2 BODE PLOT

- 2.1 Introduction
- 2.2 Example
- 2.3 Phase

3 SECOND ORDER SYSTEM

- 3.1 Damping
- 3.2 Example
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4 ROUTH HURWITZ CRITERION

- 4.1 Routh Array
- 4.2 Marginal Stability
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- 4.5 Example

5 STATE-SPACE MODEL

- 5.1 Controllability and Observability
- 5.2 Second Order System
- 5.3 Example
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6 NYQUIST PLOT

- 6.1 Introduction
- 6.2 Example

Q. The polar plot for the transfer function $G(s) = \frac{10(s+1)}{10+s}$ for

$0 \leq \omega < \infty$ will be in the

- (A) first quadrant
- (B) second quadrant
- (C) third quadrant
- (D) fourth quadrant

The Polar plot is a plot, which can be drawn between the magnitude and the phase angle of $G(j\omega)H(j\omega)$ by varying ω from 0 to ∞ . The polar graph sheet is shown in the following figure.

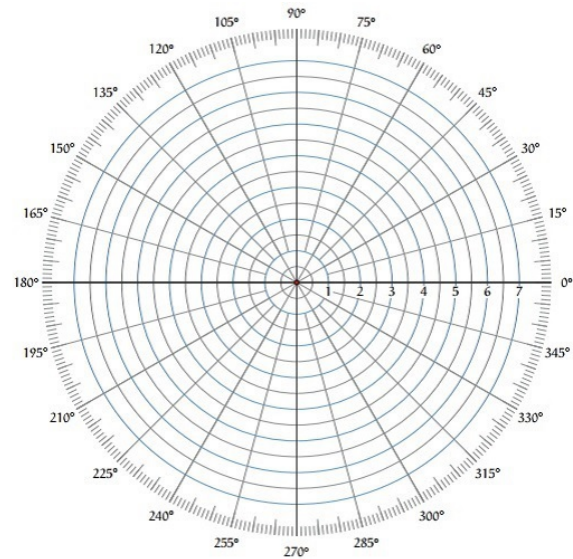


Fig. 6.0: Polar Plot

Substituting $s = j\omega$ in the given transfer function gives

$$G(j\omega) = \frac{10(1+j\omega)}{(10+j\omega)}$$

Here, taking $1 + j\omega = \sqrt{1 + \omega^2} e^{j \tan^{-1}(\omega)}$, and $10 + j\omega = \sqrt{10^2 + \omega^2} e^{j \tan^{-1}(\frac{\omega}{10})}$,

$$G(j\omega) = 10 \sqrt{\frac{1+\omega^2}{100+\omega^2}} e^{j(\tan^{-1}(\omega) - \tan^{-1}(\frac{\omega}{10}))} \quad \text{As } 0 \leq \omega < \infty,$$

$$0 \leq \tan^{-1}(\omega), \tan^{-1}(\frac{\omega}{10}) < \frac{\pi}{2};$$

And as $\tan^{-1}(x)$ is a monotonically increasing function,

$$\left[\frac{d}{dx} \tan^{-1}(x) = \frac{1}{1+x^2} > 0 \right]$$

$$\tan^{-1}(\omega) \geq \tan^{-1}(\frac{\omega}{10}), \text{ with equality as } \omega \rightarrow \infty$$

$$\text{So, } |G(j\omega)| > 0 \text{ and } 0 \leq \angle G(j\omega) < \frac{\pi}{2}$$

Therefore, the polar plot of $G(s)$ lies in the first quadrant.

The plot of $G(s)$ is: widthheightcenter

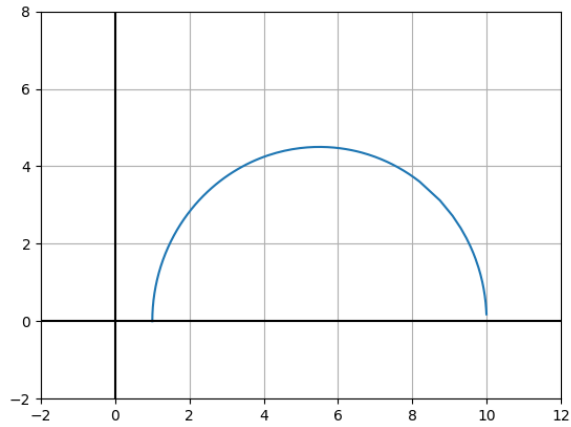


Fig. 6.0: Plot

7 COMPENSATORS

7.1 *Phase Lead*

7.2 *Lag Lead*

7.3 *Example*

8 GAIN MARGIN

8.1 *Introduction*

8.2 *Example*

8.3 *Example*

9 PHASE MARGIN

9.1 *Intoduction*

9.2 *Example*

10 OSCILLATOR

10.1 *Introduction*

10.2 *Example*

11 ROOT LOCUS

11.1 *Introduction*