

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

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4 ROUTH HURWITZ CRITERION

4.1 Routh Array

4.2 Marginal Stability

4.3 Stability

4.4 Example

4.5 Example

5 STATE-SPACE MODEL

5.1 Controllability and Observability

5.2 Second Order System

5.3 Example

5.4 Example

5.5 Example

5.6 Example

5.7 Example

6 NYQUIST PLOT

6.1 Introduction

6.2 Example

Q.The polar plot for the transfer function

$$G(s) = \frac{10(s+1)}{10+s} \quad (6.0.1)$$

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 plotted between the magnitude and the phase angle of $G(j\omega)$ on polar

coordinates by varying ω from 0 to ∞ .

Substituting $s = j\omega$ in (6.0.1) gives

$$G(j\omega) = \frac{10(1+j\omega)}{(10+j\omega)} \quad (6.0.2)$$

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

$$G(j\omega) = 10 \sqrt{\frac{1+\omega^2}{100+\omega^2}} e^{j(\tan^{-1}(\omega) - \tan^{-1}(\frac{\omega}{10}))} \quad (6.0.3)$$

For $0 \leq \omega < \infty$, $0 \leq \tan^{-1}(\omega)$, $\tan^{-1}(\frac{\omega}{10}) < \frac{\pi}{2}$;
And as $\tan^{-1}(x)$ is a monotonically increasing function, [i.e.] $\frac{d}{dx} \tan^{-1}(x) = \frac{1}{1+x^2} > 0$]
 $\tan^{-1}(\omega) \geq \tan^{-1}(\frac{\omega}{10})$, with equality as $\omega \rightarrow \infty$
So, $|G(j\omega)| > 0$ 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 $G(s)$ was plotted using the following code:

```
codes/ee18btech11051.py
```

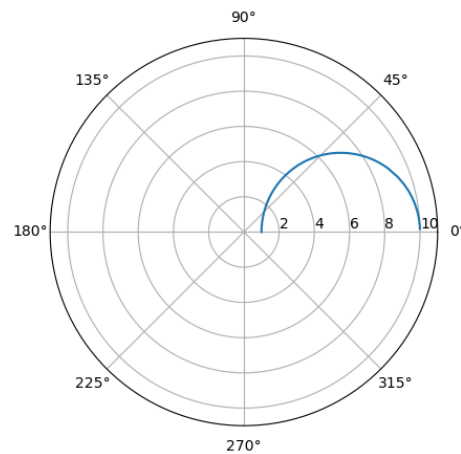


Fig. 6.0: Plot of $G(s)$

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*