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
```

1 Signal Flow Graph

1.1 Mason's Gain Formula

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2 Bode Plot

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4 Routh Hurwitz Criterion

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5 State-Space Model

5.1 Controllability and Observability

5.2 Second Order System

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5.4 Example

6 Nyquist Plot

6.1. Sketch the Polar Plot of

$$G(s) = \frac{1}{s\left(1+s^2\right)} \tag{6.1.1}$$

Solution: Given the Open Loop Transfer Function

$$G(s) = \frac{1}{s(1+s^2)} \tag{6.1.2}$$

Now we have substitute s=$\jmath\omega$

$$G(\jmath\omega) = \frac{1}{\jmath\omega(1-\omega^2)} \tag{6.1.3}$$

6.2. Find the Magnitude of the Transfer Function

$$G(\jmath\omega) = \frac{1}{\jmath\omega(1-\omega^2)} \tag{6.2.1}$$

$$|G(\jmath\omega)| = \frac{1}{|\omega(1-\omega^2)|} \tag{6.2.2}$$

6.3. Find the Phase of Transfer Function

$$\angle G(\jmath\omega) = \angle G(\jmath\omega)_{num} - \angle G(\jmath\omega)_{den} \tag{6.3.1}$$

for $\omega\left(1-\omega^2\right) < 0$

$$\angle G(\jmath\omega) = \frac{\pi}{2} \tag{6.3.2}$$

for $\omega\left(1-\omega^2\right) > 0$

$$\angle G(\jmath\omega)) = -\frac{\pi}{2} \tag{6.3.3}$$

6.4. Draw Polar Plot using phase of transfer function For ω=0

$$\left|G(\jmath\omega)\right| = \infty \tag{6.4.1}$$

$$\angle G(\jmath\omega) = \frac{\pi}{2} \tag{6.4.2}$$

For w= ∞

$$\left|G(\jmath\omega)\right| = 0 \tag{6.4.3}$$

$$\angle G(\jmath\omega) = \frac{\pi}{2} \tag{6.4.4}$$

Polar Plot drawn by varying ω from 0 to ∞.

6.5. Verify the Polar Plot the running the following Code

```
https://github.com/srikanth2001/EE2227/tree/
    master/codes
```

6.6. Stability

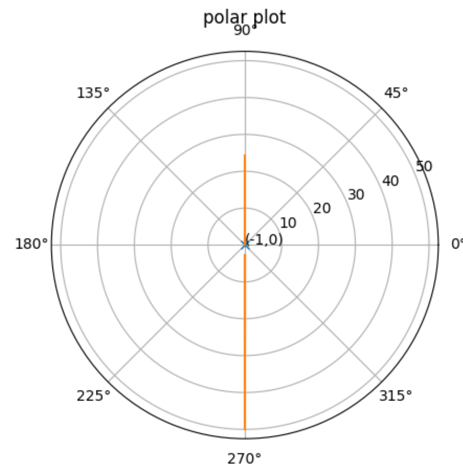

Fig. 6.4

for the given transfer function

$$G(s) = \frac{1}{s(1+s^2)} \tag{6.6.1}$$

The polar plots use open loop transfer function, hence the reference point for determining stability is shifted to $(-1, 0)$

If $(-1{,}0)$ is exactly on the polar plot then the system is marginally stable polar plot useful to find the stability of given transfer function from the graph we can see that (-1,0) is lying exactly on polar plot

so the system is marginally stable

7 Compensators

7.1 *Phase Lead*

7.2 *Example*

8 Gain Margin

8.1 *Introduction*

8.2 *Example*

9 Phase Margin

10 Oscillator