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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6.1. Sketch the polar plot for the transfer function

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

for
$0 \le \omega < \infty$. Which quadrant does it lie in?
Solution: Substituting $s = \jmath\omega$ in (6.1.1),

$$G(\jmath\omega) = \frac{10(1+\jmath\omega)}{(10+\jmath\omega)} \tag{6.1.2}$$

$$= \underbrace{10\sqrt{\frac{1+\omega^2}{100+\omega^2}}}_{r} \times \exp\left\{\jmath\underbrace{\left(\tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{10}\right)\right)}_{\theta}\right\} \tag{6.1.3}$$

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

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

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

$\because 0 < \theta < \frac{\pi}{2}$ 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+0j.
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.

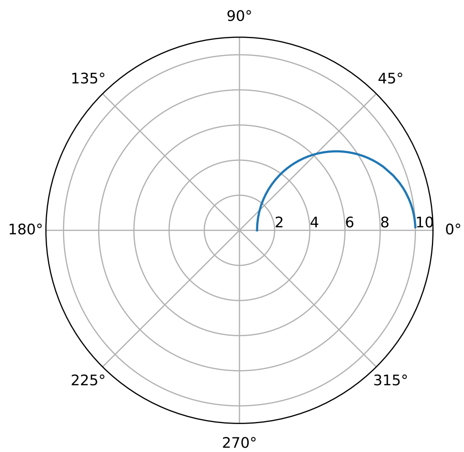

Fig. 6.1

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