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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.Q.The polar plot for the transfer function

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

for
$0 \le \omega < \infty$ 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

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

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

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

For $0 \le \omega < \infty$, $0 \le \tan^{-1}(\omega), \tan^{-1}(\frac{\omega}{10}) < \frac{\pi}{2}$;
And as $\tan^{-1}$(x) is a monotonically increasing function, [i.e.) $\frac{d}{dx}\tan^{-1}(x) = \frac{1}{1+x^2} > 0$]
$\tan^{-1}(\omega) \ge \tan^{-1}(\frac{\omega}{10})$, with equality as $\omega \to \infty$
So, $|G(j\omega)| > 0$ and $0 \le \angle G(j\omega) < \frac{\pi}{2}$

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
```

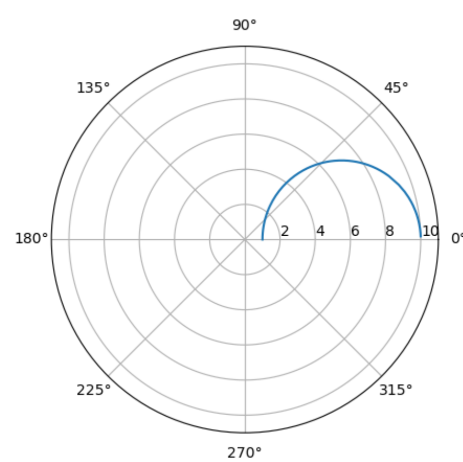

Fig. 6.0: Plot of G(s)

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