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

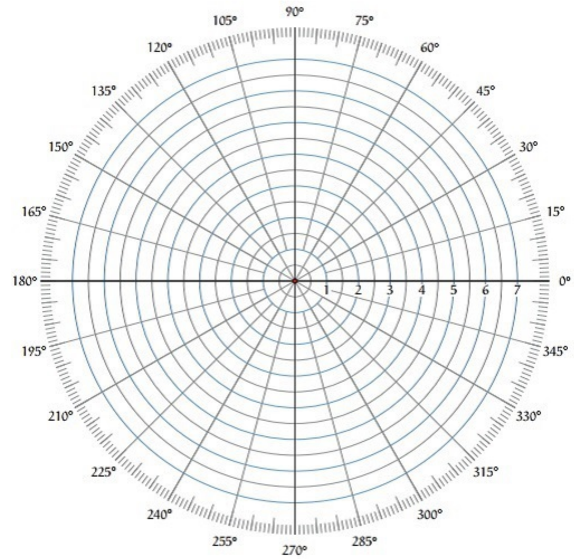

Fig. 6.0: Polar Plot

Substituting s = $j\omega$ in the given transfer function gives
G(jω) = $\frac{10(1+j\omega)}{(10+j\omega)}$
Here, taking 1 + jω = $\sqrt{1+\omega^2}e^{j\tan^{-1}(\omega)}$, and
10 + jω = $\sqrt{10^2+\omega^2}e^{j\tan^{-1}(\frac{\omega}{10})}$,

G(jω) = $10\sqrt{\frac{1+\omega^2}{100+\omega^2}}e^{j(\tan^{-1}(\omega)-\tan^{-1}(\frac{\omega}{10}))}$. As
$0 \le \omega < \infty$,
$0 \le \tan^{-1}(\omega), \tan^{-1}(\frac{\omega}{10}) < \frac{\pi}{2}$;
And as $\tan^{-1}$(x) is a monotonically increasing function,
[$\frac{d}{dx}\tan^{-1}(x) = \frac{1}{1+x^2} > 0$]
$\tan^{-1}(\omega) \ge \tan^{-1}(\frac{\omega}{10})$, 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) is: widthheightcenter

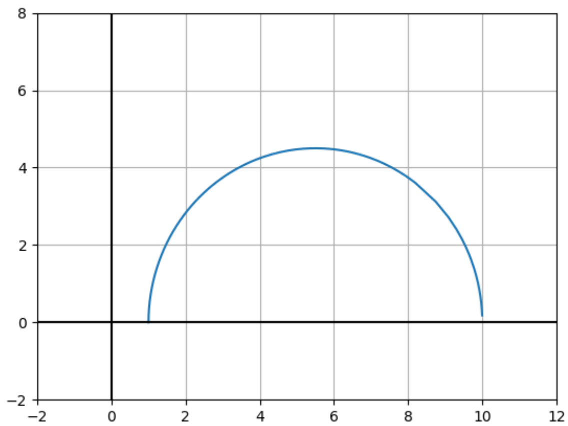

Fig. 6.0: Plot

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