Contents

***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 Stability

2 Routh Hurwitz Criterion

3 Compensators

4 Nyquist Plot

4.1 Polar plot

4.1. Sketch direct and inverse polar plots for a unity feedback system with open loop transfer function

$$G(s) = \frac{1}{s(1+s)^2} \tag{4.1.1}$$

Solution: For Unity feedback system, given the open loop transfer function

$$G(s) = \frac{1}{s(1+s)^2} \tag{4.1.2}$$

Now, Polar plot is defined as: The plot of points(represented as $r.e^{\jmath\phi}$) obtained by varying w from 0 to ∞ where

$$r = |H(\jmath\omega)||G(\jmath\omega)| \tag{4.1.3}$$

$$\phi = \angle H(\jmath\omega)G(\jmath\omega) \tag{4.1.4}$$

Inverse Polar plot is similar, in this we have;

$$r = \frac{1}{|H(\jmath\omega)||G(\jmath\omega)|} \tag{4.1.5}$$

$$\phi = -\angle H(\jmath\omega)G(\jmath\omega) \tag{4.1.6}$$

The system we're analysing is unity feedback which means $H(\jmath\omega) = 1$ Therefore ;

$$|H(\jmath\omega)||G(\jmath\omega)| = |1|.\frac{1}{|\jmath\omega||(1+\jmath\omega)^2|} \tag{4.1.7}$$

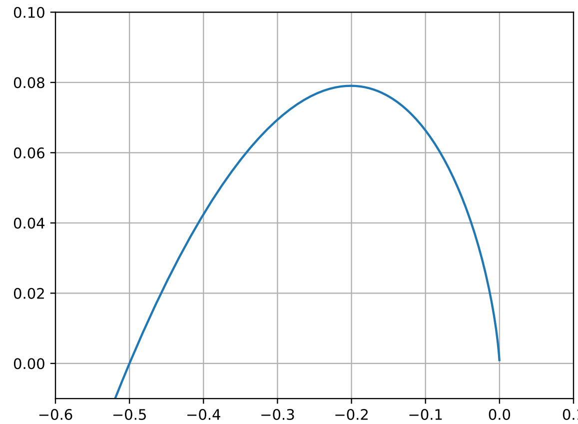

Fig. 4.1

$$|H(\jmath\omega)||G(\jmath\omega)| = \frac{1}{\omega(1+\omega^2)} \tag{4.1.8}$$

and to calculate Phase of G(jw)

$$H(\jmath\omega)G(\jmath\omega) = 1.e^0.1.e^0.\frac{1}{\omega.e^{\pi/2}}.\left\{\frac{1}{\sqrt{1^2+\omega^2}.e^{tan^{-1}(\omega)}}\right\}^2 \tag{4.1.9}$$

$$H(\jmath\omega)G(\jmath\omega) = 1.e^0.1.e^0\omega^{-1}.e^{-\pi/2}.(1^2+\omega^2)^{-1}.e^{-2tan^{-1}(\omega)} \tag{4.1.10}$$

Therefore

$$\angle H(\jmath\omega)G(\jmath\omega) = \frac{-\pi}{2} - 2tan^{-1}(\omega) \tag{4.1.11}$$

The following code plots the polar and inverse polar plots

```
codes/ee18btech11002/polarplot.py
```

4.2. Find the frequency at which $|G(\jmath\omega)| = 1$ and corresponding phase angle $\angle G(\jmath\omega)$
Solution: For $|G(\jmath\omega)| = 1$

$$\frac{1}{\omega(1+\omega^2)} = 1 \tag{4.2.1}$$

$$\omega + \omega^3 - 1 = 0 \tag{4.2.2}$$

and for the corresponding phase

$$\angle G(\jmath\omega) = \frac{-\pi}{2} - 2tan^{-1}(\omega) \tag{4.2.3}$$

The following code calculates the value of w and $\angle G(\jmath\omega)$

```
codes/ee18btech11002/solution.py
```

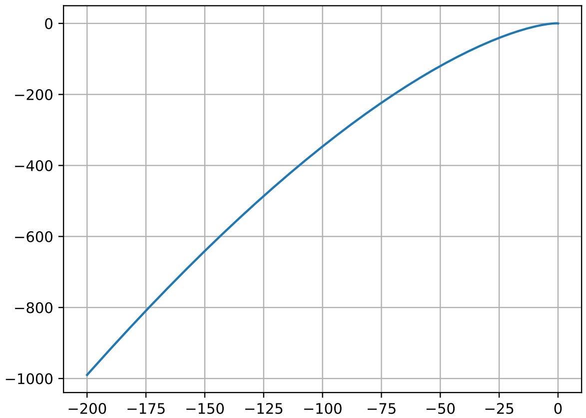

Fig. 4.2

and we get

$$\omega = 0.682 \tag{4.2.4}$$

$$\angle G(\jmath\omega) = -\frac{52}{59}\pi \tag{4.2.5}$$