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 $r.e^{j\phi}$) obtained by varying w from 0 to ∞ where $r = |H(jw)||G(jw)|$ and $\phi = \angle H(jw)G(jw)$. Inverse Polar plot is similar, in this $r = \frac{1}{|H(jw)||G(jw)|}$ and $\phi = -\angle H(jw)G(jw)$ The system we're analysing is unity feedback which means $H(jw) = 1$ Therefore ;

$$|H(jw)||G(jw)| = |1|.\frac{1}{|jw||(1+jw)^2|} \tag{4.1.3}$$

$$|H(jw)||G(jw)| = \frac{1}{w(1+w^2)} \tag{4.1.4}$$

and to calculate Phase of G(jw)

$$H(jw)G(jw) = 1.e^0.1.e^0.\frac{1}{w.e^{\pi/2}}.\left\{\frac{1}{\sqrt{1^2+w^2}.e^{tan^{-1}(w)}}\right\}^2 \tag{4.1.5}$$

$$H(jw)G(jw) = 1.e^0.1.e^0w^{-1}.e^{-\pi/2}.(1^2+w^2)^{-1}.e^{-2tan^{-1}(w)} \tag{4.1.6}$$

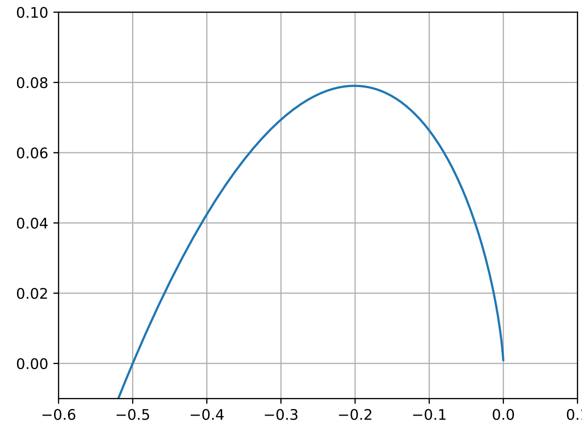

Fig. 4.1

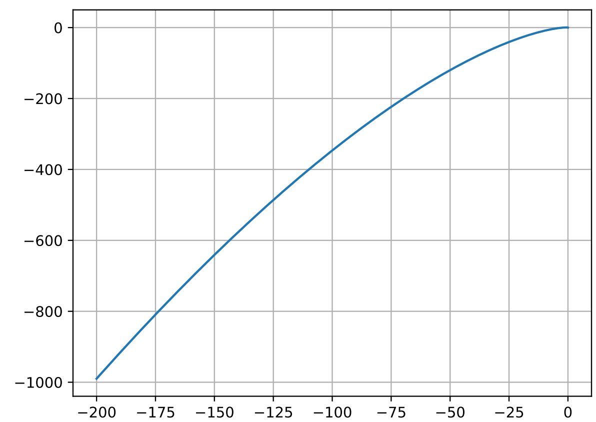

Fig. 4.1

Therefore

$$\angle H(jw)G(jw) = \frac{-\pi}{2} - 2tan^{-1}(w) \tag{4.1.7}$$

The following code plots the polar and inverse polar plots

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

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

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

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

and for the corresponding phase

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

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

codes/ee18btech11002/solution.py

and we get w = 0.682 and $\angle G(jw) = -\frac{52}{59}\pi$