

## 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

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

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

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

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

$$r = |H(j\omega)||G(j\omega)| \quad (4.1.3)$$

$$\phi = \angle H(j\omega)G(j\omega) \quad (4.1.4)$$

Inverse Polar plot is similar, in this we have;

$$r = \frac{1}{|H(j\omega)||G(j\omega)|} \quad (4.1.5)$$

$$\phi = -\angle H(j\omega)G(j\omega) \quad (4.1.6)$$

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

$$|H(j\omega)||G(j\omega)| = \frac{1}{\omega(1+\omega^2)} \quad (4.1.7)$$

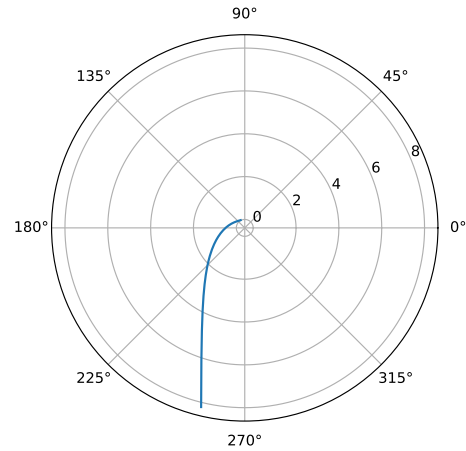


Fig. 4.1: Polar Plot

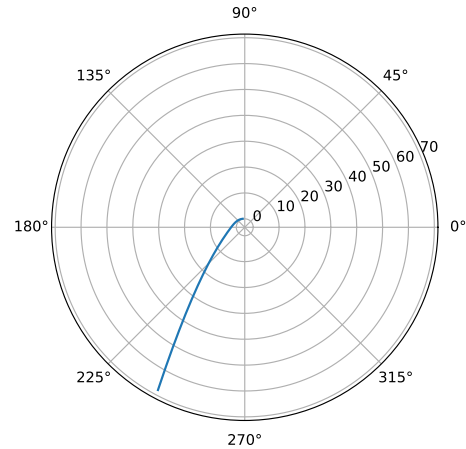


Fig. 4.1: Inverse Polar Plot

and Phase;

$$\angle H(j\omega)G(j\omega) = \frac{-\pi}{2} - 2\tan^{-1}(\omega) \quad (4.1.8)$$

The following code plots the polar and inverse polar plots

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

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

**Solution:** For  $|G(j\omega)| = 1$

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

$$\omega + \omega^3 - 1 = 0 \quad (4.2.2)$$

and for the corresponding phase

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

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

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

and we get

$$\omega = 0.682 \quad (4.2.4)$$

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