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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
```

## 1 STABILITY

## 2 ROUTH HURWITZ CRITERION

## 3 COMPENSATORS

## 4 NYQUIST PLOT

## 4.1 Polar plot

## 4.1. Sketch the Polar Plot for

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

**Solution:** Then the given open loop Transfer Function is

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

Now we have to substitute  $s=j\omega$

$$G(j\omega) = \frac{1}{(1+j\omega)(1+2j\omega)} \quad (4.1.3)$$

## 4.2. Then find the Magnitude of the Transfer Function

**Solution:**

$$|G(j\omega)| = \frac{1}{\sqrt{(1+(\omega^2))(1+(2\omega)^2)}} \quad (4.2.1)$$

## 4.3. Next find the Phase of Transfer Function

**Solution:**

$$\angle G(j\omega) = \angle G(j\omega)_{num} - \angle G(j\omega)_{den} \quad (4.3.1)$$

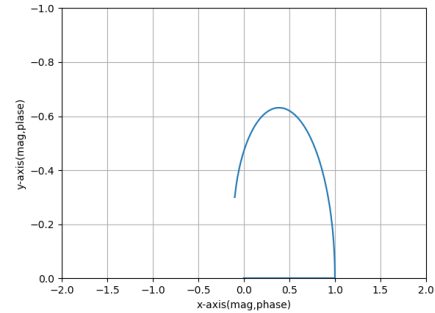


Fig. 4.4: Polar plot of given transfer function

$$\angle G(j\omega) = -\tan^{-1}(\omega) - \tan^{-1}(2\omega) \quad (4.3.2)$$

## 4.4. Polar plot is drawn based on this magnitude and phase of transfer function

**Solution:**

For  $\omega=0$

$$|G(j\omega)| = 1 \quad (4.4.1)$$

$$\angle G(j\omega) = 0 \quad (4.4.2)$$

For  $\omega = \infty$

$$|G(j\omega)| = 0 \quad (4.4.3)$$

$$\angle G(j\omega) = -\pi \quad (4.4.4)$$

Next Polar Plot is drawn by varying  $\omega$  from 0 to  $\infty$ .

## 4.5. Verify the Polar Plot by running the following Code

```
codes/ ee18btech11012_1.pyc
```