Control Systems

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***Abstract*—The objective of this manual is to introduce control system design at an elementary level.**

Download python codes using

```
svn co https://github.com/gadepall/school/trunk/
    control/ketan/codes
```

1 Polar Plot

1.1 Introduction

1.2 Example

1.3 Example

1.4 Example

1.5 Example

1.6 Example

1.7 Example

2 Bode Plot

2.1 Gain and Phase Margin

2.1.1. Sketch the Bode magnitude and phase plots for

$$G(s) = \frac{(1+0.2s)(1+0.025s)}{s^3(1+0.005s)(1+0.001s)} \tag{2.1.1.1}$$

Also compute the gain margin and phase margin.

Solution:

$$G(j\omega) = \frac{(1+0.2j\omega)(1+0.025j\omega)}{-j\omega^3(1+0.005j\omega)(1+0.001j\omega)} \tag{2.1.1.2}$$

Zeros: -5, -40

Poles: 0, 0, 0, -200, -1000

For definitions of phase margin and gain margin, refer to the sections 2.2 and 2.3.

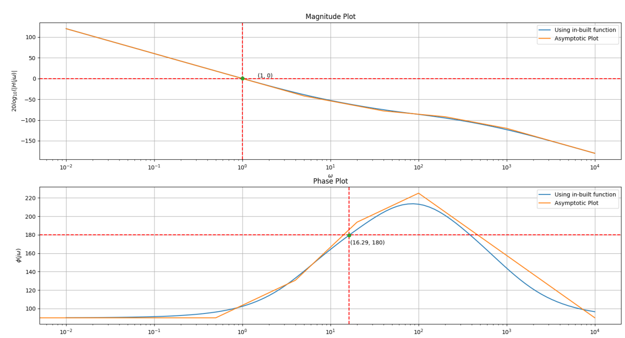

Fig. 2.1.1: Bode plot

Solving (using the plot)

$$\frac{\sqrt{1+(0.2\omega)^2}\sqrt{1+(0.025\omega)^2}}{|\omega|^3\sqrt{1+(0.005\omega)^2}\sqrt{1+(0.001\omega)^2}} = 1 \tag{2.1.1.3}$$

We get the gain cross-over frequency as $\omega_{gc} = 1$. Computing

$$\angle G\left(\jmath\omega_{gc}\right) = \tan^{-1}\left(0.2\omega_{gc}\right)+\tan^{-1}\left(0.025\omega_{gc}\right)+90^0 \\ -\tan^{-1}\left(0.005\omega_{gc}\right)-\tan^{-1}\left(0.001\omega_{gc}\right) = 102.4^0 \tag{2.1.1.4}$$

$$\text{Phase Margin, } \angle G\left(\jmath\omega_{gc}\right) = 282.4^0 \tag{2.1.1.5}$$

In the phase plot, $\phi(j\omega)$ reaches 180^0 at $\omega_{pc} =$

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16.29. From fig. 2.1.1,

$$20log_{10}\left(|G\left(j\omega_{pc}\right)|\right) = -61.436dB \quad (2.1.1.6)$$

The program for plotting bode plot and finding phase margin and gain margin -

codes/ee18btech11039/bode_plot.py

3 PID Controller

3.1 Introduction