

Name: \_\_\_\_\_ Roll No: \_\_\_\_\_

Score: \_\_\_\_\_ Signature of the Lab Tutor: \_\_\_\_\_ Date: \_\_\_\_\_

DEPARTMENT OF ELECTRONIC & TELECOMMUNICATION ENGINEERING  
MEHRAN UNIVERSITY OF ENGINEERING & TECHNOLOGY, JAMSHORO  
Feedback Control Systems (1<sup>st</sup> Term, Third Year, 03TL)  
Lab Practice # 10  
**Frequency Domain Analysis**

### 1. Introduction

Performance of a control system is measured more realistically by its time domain characteristics. These characteristics can be easily obtained by applying certain test signals to the system. However in the analysis and design of communication systems, for which the frequency response is of more importance, the frequency response approach is more suitable.

Frequency domain analysis is more convenient for the measurement of system sensitivity to noise and parameter variation. In the frequency domain analysis many graphical methods are available that can be used to determine the frequency domain specifications like resonant peak ( $M_r$ ), resonant frequency ( $\omega_r$ ) and bandwidth (BW). In this lab we will use different graphical approaches to analyze the control systems in frequency domain.

### 2. Bode Plots

The bode plot of a function  $G(j\omega)$  is composed of two plots, one with the amplitude of  $G(j\omega)$  in decibels versus  $\log_{10}\omega$  or  $\omega$ , and other with the phase of  $G(j\omega)$  in degrees as a function of  $\log_{10}\omega$  or  $\omega$ . The bode plot is known as the corner plot or the asymptotic plot of  $G(j\omega)$ .

**Example:** - In order to obtain the bode plot of the transfer function

$$G(S) = \frac{S + 1}{S(S + 3)}$$

We will write the following MATLAB code:

```
num = [1 1];  
den1 = [1 0];  
den2 = [1 3];  
den = conv(den1,den2);  
bode(num,den);
```

*bode(num,den)* draws the Bode plot of the system. The frequency range and number of points are chosen automatically.

**Exercise#1:**

(a) Obtain the bode plots of the following systems:

$$\text{i) } G(S) = \frac{10(S+10)}{S(S+2)(S+5)} \quad \text{ii) } G(S) = \frac{2500}{S(S+5)(S+50)}$$

(b) Determine the gain cross over frequency  $\omega_g$ , phase cross-over frequency  $\omega_p$ , phase margin and the gain margin.

(c) Compare and contrast the frequency response of the system given in Exercise#1 (i) and (ii) in terms of phase margin and gain margin and determine the relative stability of the system.

**3. Bode plot of Second order system**

The general representation of second order is shown below

$$G(S) = \frac{\omega_n^2}{S^2 + 2\zeta\omega_n S + \omega_n^2}$$

**Example:** - Obtain the bode plot of the system if  $\omega_n = 0.1$  rad/sec and  $\zeta=0.2$ .

$$G(S) = \frac{0.01}{S^2 + 0.04S + 0.01}$$

```
num=0.01;
den=[1 0.04 0.01];
bode(num,den);
```

**Exercise#2:**

(a) Obtain the bode plot of the system if

$$\omega_n = 0.1 \text{ rad/sec and}$$

$$\zeta = 0.1, 0.5, 1, 1.5$$

(b) What is the effect of increasing  $\zeta$  on resonant peak, phase margin and gain margin of the system?

(c) Does it improve the relative stability of the system?

**4. Polar plots or nyquist plot**

The polar plot of a function of the complex variable  $S$ ,  $G(S)$ , is a plot of the magnitude of  $G(j\omega)$  versus the phase of  $G(j\omega)$  on polar coordinates as  $\omega$  is varied from zero to infinity.

**Example:** - In order to obtain the Nyquist plot of the transfer function

$$G(S) = \frac{S+1}{(S+5)}$$

We will write the following MATLAB code:

```
num = [1 1];
den = [1 53];
nyquist(num,den);
```

**Exercise#3:**

(a) Obtain the nyquist plots of the following systems:

$$\text{i) } G(S) = \frac{10}{S(S+1)(S+2)} \qquad \text{ii) } G(S) = \frac{10}{S(S+2)}$$

(b) Determine the gain cross over frequency  $\omega_g$ , phase cross-over frequency  $\omega_p$ , phase margin and the gain margin.

(c) Compare and contrast the frequency response of the systems in terms of phase margin and gain margin and determine the relative stability of the systems.

**5. Magnitude-Phase plots or Nichols chart**

The Nichols chart (Magnitude-Phase plot) of  $G(j\omega)$  is a plot of the magnitude of  $G(j\omega)$  in decibels versus its phase in degrees, with  $\omega$  as a parameter on the curve.

**Example:** - In order to obtain the Nyquist plot of the transfer function

$$G(S) = \frac{10(S+10)}{S(S+2)(S+5)}$$

We will write the following MATLAB code:

```
num = 10*[1 10];
den1 = [1 0];
den2 = [1 2];
den3=[1 5];
den12 = conv(den1,den2 );
den=conv(den12,den3);
nichols(num,den);
```

**Exercise#4:**

(d) Obtain the nichols plots of the following systems:

$$\text{i) } G(S) = \frac{10(S+1)}{S(S+2)(S+10)} \qquad \text{ii) } G(S) = \frac{2500}{S(S+5)(S+50)}$$

(e) Determine the gain cross over frequency  $\omega_g$ , phase cross-over frequency  $\omega_p$ , phase margin and the gain margin.

(f) Compare and contrast the frequency response of the systems in terms of phase margin and gain margin and determine the relative stability of the system.