Control Systems LAB Digital Assignment 9

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Faculty: **Professor Dhanamjayalu C**

Course: **EEE-3001**

Course Name: **Control Systems Lab**

Lab Slot: **L45 + L46**

Determination of Time – Domain Specifications

Exp No: 9

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AIM

1. To Determine the time domain specifications for a given transfer function model by using M-file Editor in MATLAB.

APPARATUS REQUIRED

Personal Computer with MATLAB.

THEORY

1. The desired performance characteristics of control systems are specified in terms of time domain specification. System with energy storage elements cannot respond instantaneously and will exhibit transient responses, whenever they are subjected to inputs or disturbances. The desired performance characteristics of a system of any order may be specified in terms of the transient response to a units step input signal. The transient response of a system to a unit step input depends on the initial conditions. Therefore, to compare the time response of various systems it is necessary to start with standard initial conditions. The most practical standard is to start with the system at rest and output, and all time derivatives there of zero. The transientresponse of a practical control system often exhibits damped oscillation beforereaching steady state. The transient response characteristics of a control systemto a unit step input are specified in terms of the following time domain specifications.
2. Delay time, td
3. Rise time, tr
4. Peak time, tp
5. Maximum overshoot, Mp
6. Setting time, ts

PROCEDURE

1. Enter the command window of the MATLAB
2. Create a new M-file by selecting File-New-M-file
3. type and save the program

4. Execute the program by either pressing F5 or Debug-Run
5. View the results
6. Analyze the stability of the system.

PROBLEM STATEMENT

Write a program in MATLAB to obtain the Polar Plot of the following function

(i) For the second order system below, find ξ, ωn, Ts, Tp, Tr, % overshoot, and plot the step response using MATLAB.

$$T(s) = \frac{130}{s^2 + 15s + 130}$$

(ii) A higher-order system is defined by

$$\frac{C(s)}{R(s)} = \frac{7s^2 + 16s + 10}{s^4 + 5s^3 + 11s^2 + 16s + 10}$$

(a) Plot the unit-step response curve of the system using MATLAB

(b) Obtain the rise time, peak time, maximum overshoot, and settling time using MATLAB.

SOLUTION

```
clc
close all
num=130;
den=[1 15 130];
T=tf(num,den)
omegan=sqrt(den(3))
zeta=den(2)/(2*omegan)
theta=acos(zeta)
omegad=omegan*sqrt(1-zeta^2);
tp=pi/omegad
tr=(pi-theta)/omegad
ts=4/(zeta*omegan);
percent=exp(-zeta*pi/sqrt(1-zeta^2))*100;
step(T)
title('Time Domain Specifications')
```

(i) $T(s) = \dfrac{130}{s^2 + 15s + 130} = \dfrac{C(s)}{R(s)}$ (given)

also wkt $\dfrac{C(s)}{R(s)} = \dfrac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$

Characteristic eq^n. $1 + G(s)H(s) = 0$

$\therefore \quad s^2 + 2\xi\omega_n s + \omega_n^2 = 0 \qquad - (1)$

and $\quad s^2 + 15s + 130 = 0 \qquad - (2)$

Comparing (1) & (2), we get

$\rightarrow \omega_n^2 = 130 \qquad \therefore \omega_n = 11.4018$ rad/sec

$\rightarrow 2\xi\omega_n = 15 \qquad \Rightarrow \therefore \xi = \dfrac{15}{2 \times 11.4018}$

$\xi = 0.6578$

$\rightarrow \theta = \cos^{-1}(\xi) = \cos^{-1}(0.6578)$

$\therefore \theta = 0.8529$ rad

$\omega_d = \omega_n\sqrt{1-\xi^2} = 11.4018\sqrt{1-(0.6578)^2}$

$\omega_d = 8.5878$ rad/sec

$\rightarrow T_s = \dfrac{4}{\xi\omega_n} = \dfrac{4}{0.6578 \times 11.4018} = 0.5333$ sec

$\rightarrow T_p = \dfrac{\pi}{\omega_d} = \dfrac{\pi}{8.5878} = 0.3658$ sec

$\rightarrow T_r = \dfrac{\pi - \theta}{\omega_d} = \dfrac{\pi - 0.8529}{8.5878} = 0.2665$ sec

$\rightarrow \% M_p = e^{-\pi\xi/\sqrt{1-\xi^2}} \times 100$

$= e^{-\pi \times 0.6578/\sqrt{1-(0.6578)^2}} \times 100 = e^{-2.7437} \times 100$

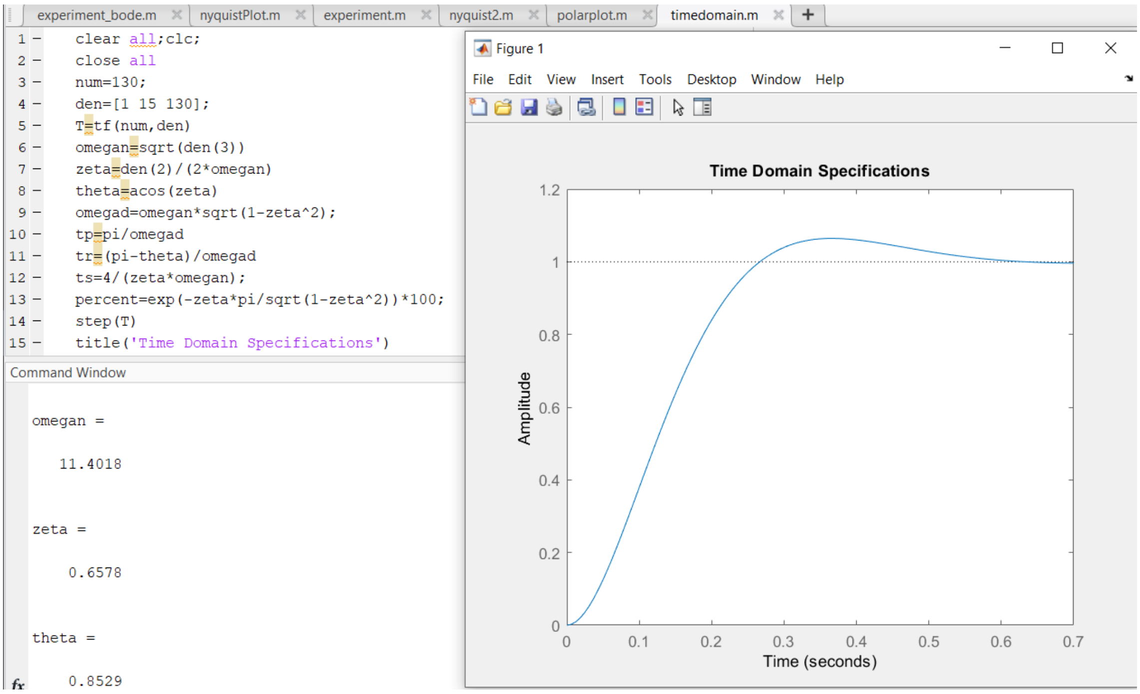
$= 0.06433 \times 100$

$= 6.433\ \%$

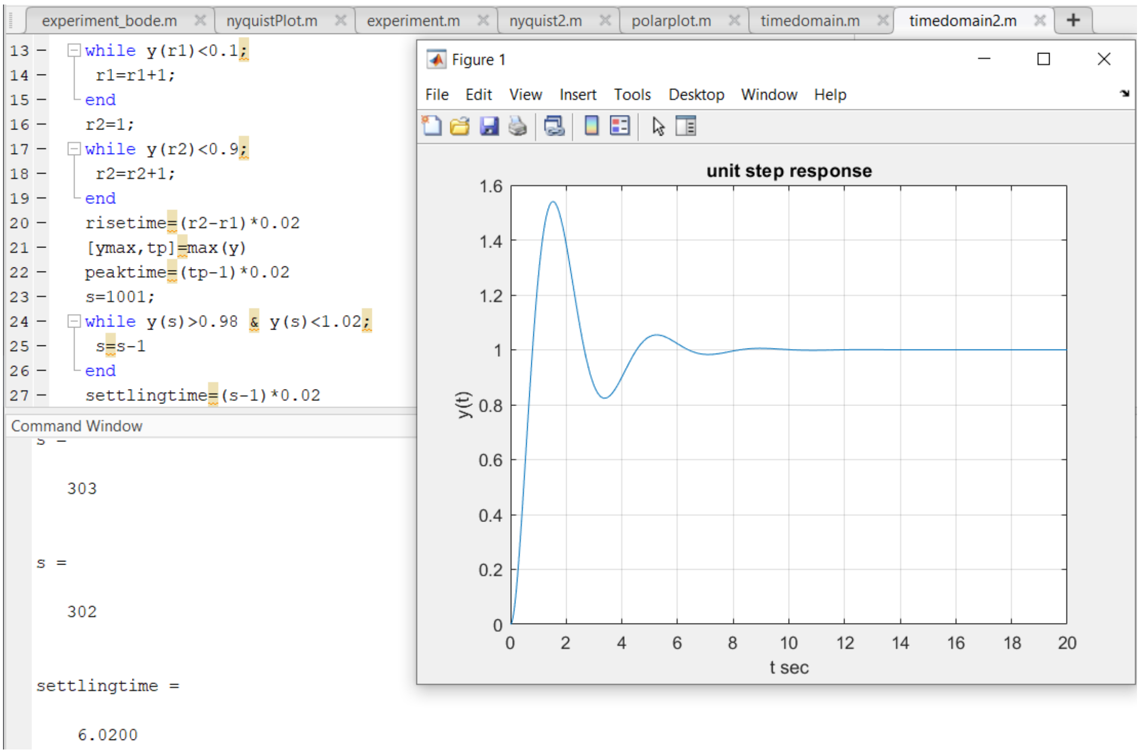
```
close all
clc
num=[0 0 7 16 10];
```

```
den=[1 5 11 16 10];
t=0:0.02:20;
[y,x,t]=step(num,den,t);
plot(t,y)
grid
title('unit step response')
xlabel('t sec')
ylabel('y(t)')
r1=1;
while y(r1)<0.1;
 r1=r1+1;
end
r2=1;
while y(r2)<0.9;
 r2=r2+1;
end
risetime=(r2-r1)*0.02
[ymax,tp]=max(y)
peaktime=(tp-1)*0.02
s=1001;
while y(s)>0.98 & y(s)<1.02;
 s=s-1
end
settlingtime=(s-1)*0.02
```

The output of the program will be



SYSTEM RESPONSE



POSSIBLE INFERENCES

1. The given system is an underdamped system as the damping ratio lies between 0 and 1.
2. The values of Tr (Response time), Tp (Peak Time), (Damping ratio), (Percentage overshoot and Ts (Settling time) was calculated manually and crosschecked using MATLAB.