Second semester (2024-2025)

EXP NO.1

1.1 Time Response: Second-Order Systems

Objectives:

In this experiment, we shall learn how to obtain the response of a typical second-order control system to a step input, ramp input and impulse input by using MATLAB and Simulink.

Theory:

Consider the second-order feedback system represented, in general, by the block diagram given in Figure 1,

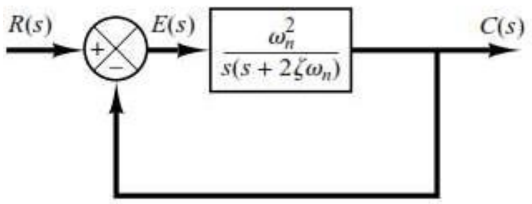


Figure 1: *Block diagram of a general second-order system.*

The closed-loop transfer function can be written in the following form:

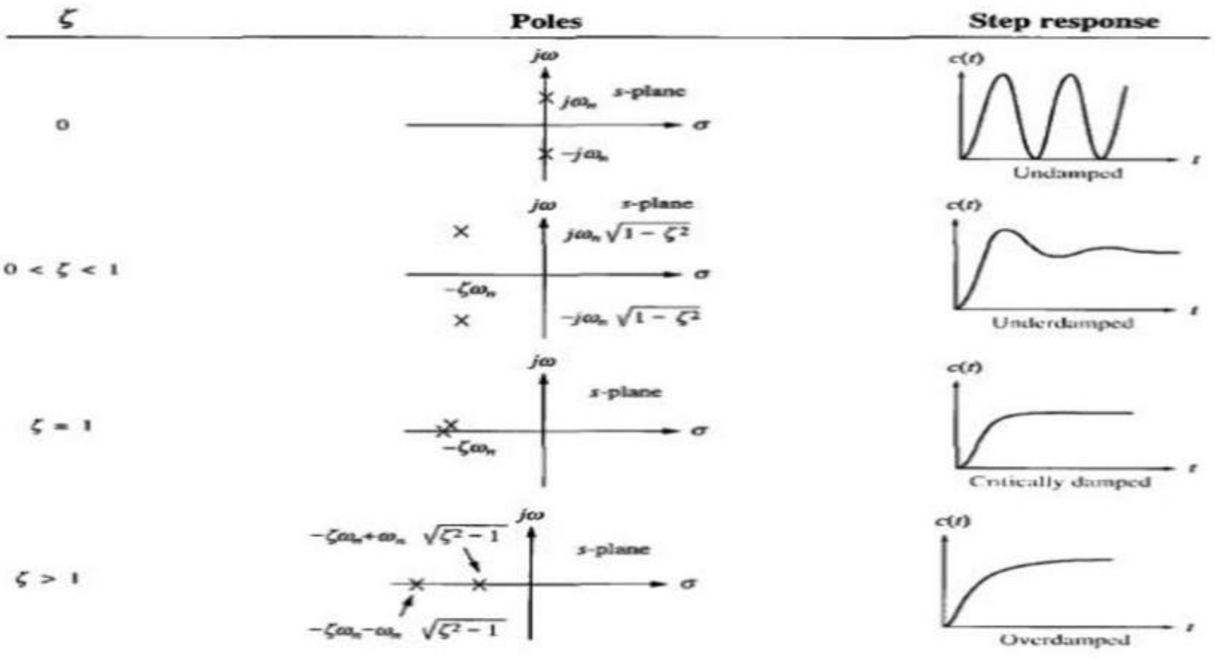
$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

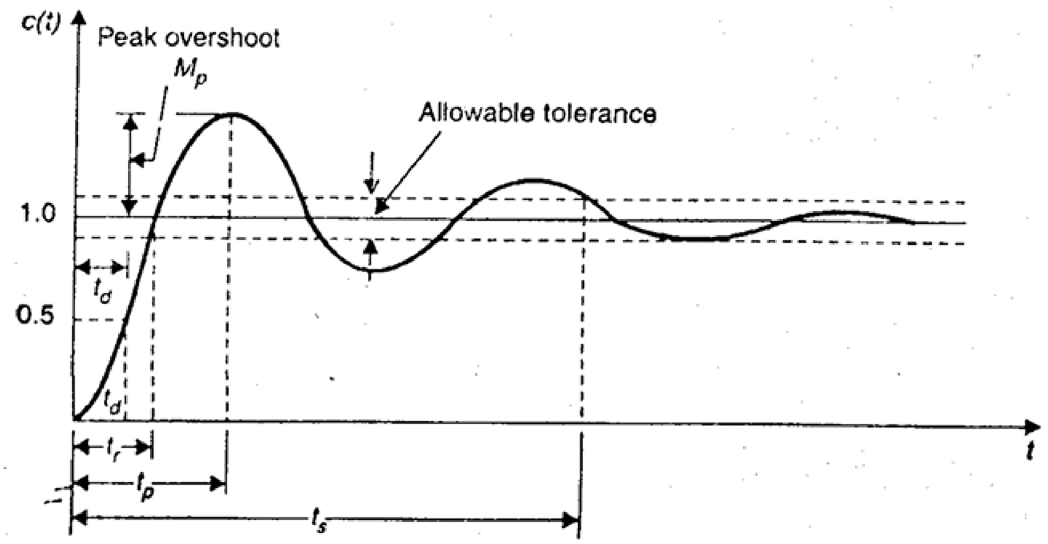
Quantities ζ is called the system damping ratio and ωn is called system natural frequency.

Their value that determines whether the system is stable or unstable

For any test input, the response of a 2nd order system can be studied in four cases depending on the damping effect created by value of ζ as follows:

1. If $\zeta = 0$, the system is called Undamped.
2. If $0 < \zeta < 1$, the system is then called Underdamped.
3. If $\zeta = 1$, the system is called Critically damped.
4. If $\zeta > 1$, the system is called Overdamped.





Transient response terms are as follows:

Mp = maximum overshoot

Tr = rise time (the time to reach 100 %, 95 % of the input signal).

Ts=settling time (The time required for the response curve to reach and stay within a specified tolerance band of its final value or steady state value).

Td= The time required to reach half the value of the input signal.

Tp= peak time (The time required to reach a value overshoot (above normal value)).

Example:1

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & -1 \\ 6.5 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

ANS :

```
clear all
close all
clc

% Enter matrices A, B, C, and D

A = [-1 -1;6.5 0];
B = [1 1;1 0];
C = [1 0;0 1];
D = [0 0;0 0];

%creat the state space

g=ss(A,B,C,D)

%step respone of 2nd order system with ss

step(g)
```

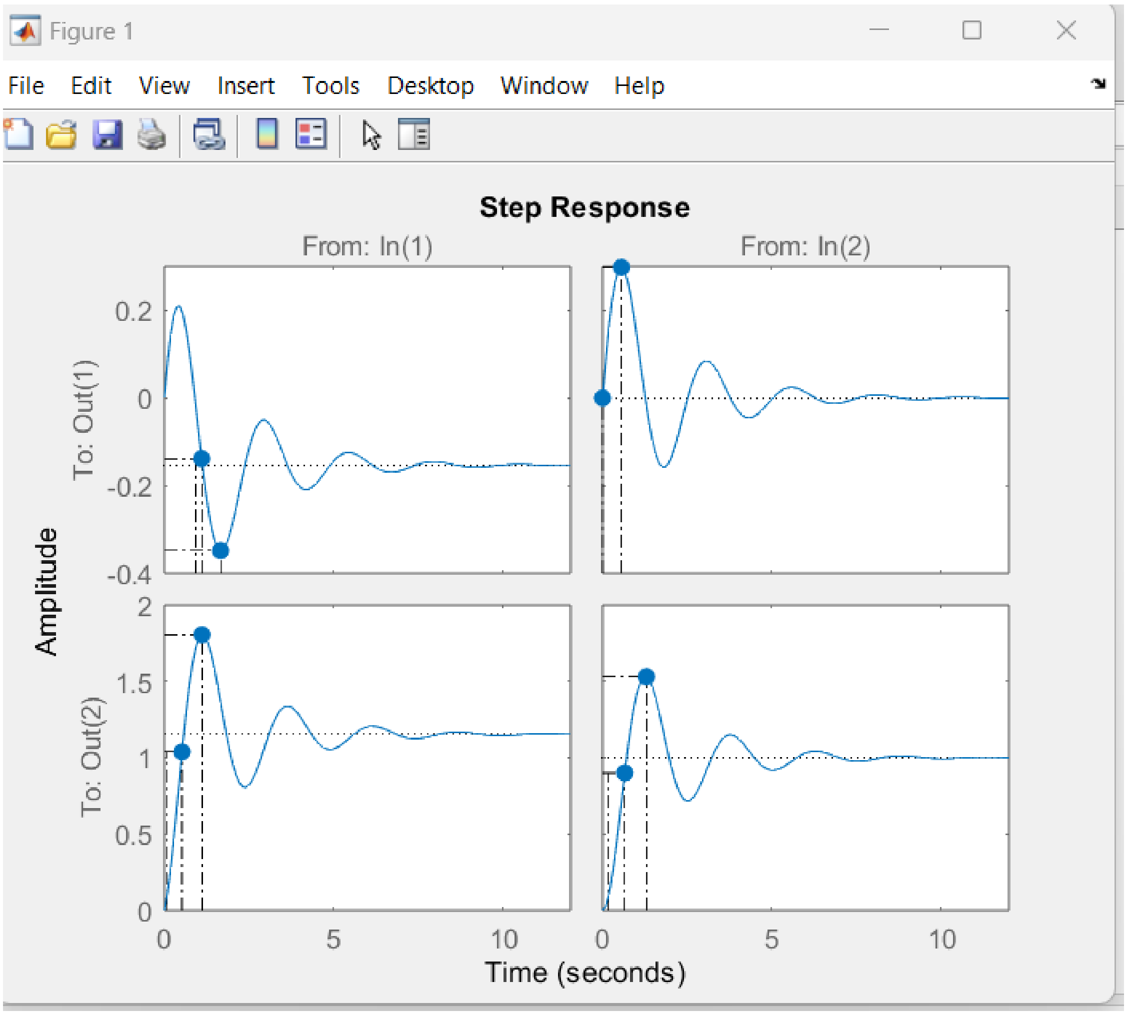


Figure 1
File Edit View Insert Tools Desktop Window Help
Step Response
From: In(1)
From: In(2)
Amplitude
To: Out(1)
To: Out(2)
0.2
0
-0.2
-0.4
2
1.5
1
0.5
0
0
5
10
0
5
10
Time (seconds)

Example:2

$$A = \begin{bmatrix} -1 & -1 \\ 6.5 & 0 \end{bmatrix}; B = \begin{bmatrix} 1 \\ 0 \end{bmatrix}; C[1 \quad 1] = ; D = 0$$

Ans:

```
clear all
close all
clc
% Enter  A, B, C, and D
A = [-1 -1;6.5 0];
B = [1;0];
C = [1 1];
D = 0;
%creat the state space
g=ss(A,B,C,D)
%step respone of 2nd order system with ss
step(g)
```