Simulation of differential equations using SIMULINK

1. INTRODUCTION

Simulink is a graphical extension to MATLAB for modeling and simulation of systems. In Simulink, systems are drawn on screen as block diagrams. Many elements of block diagrams are available, such as transfer functions, summing junctions, etc., as well as virtual input and output devices such as function generators and oscilloscopes.

Simulink is started from the MATLAB command prompt

>> Simulink

2. BASIC ELEMENTS

There are two major classes of items in Simulink: blocks and lines.

Blocks are used to generate, modify, combine, output, and display signals. Lines are used to transfer signals from one block to another.

A. Blocks

There are several general libraries of blocks such as:

• Sources: Used to generate various signals

• Sinks: Used to output or display signals

• Continuous-time system elements and connections

(summing junctions, gains, etc.)

B. Lines

Lines transmit signals in the direction indicated by the arrow.

Example 1

Simulate the following differential equation of the mass spring damper model by using SIMULINK:

$$m\ddot{x} + b\dot{x} + kx = u(t)$$

Where m=5, b=1,and k=1

And $\dot{x}(0) = 0, x(0) = 0,$

Solution:

$$m\ddot{x} = u(t) - b\dot{x} - kx$$

$$\ddot{x} = \frac{1}{m}(u(t) - b\dot{x} - kx)$$

$$x = \iint \frac{1}{m}(u(t) - b\dot{x} - kx) \ dt$$

Simulink Block Name	parameters	Group
Step	Step time=0 Final value=1	Source Operations
Sum1	List of signs=+--	Math Operations
Gain	Gain=1/5	Math Operations
Gain1	Gain=1	Math Operations
Gain2	Gain=1	Math Operations
Integrator1	Initial condition=0	continuous group
Integrator	Initial condition=0	continuous group
Scope		Sink group

block diagram:
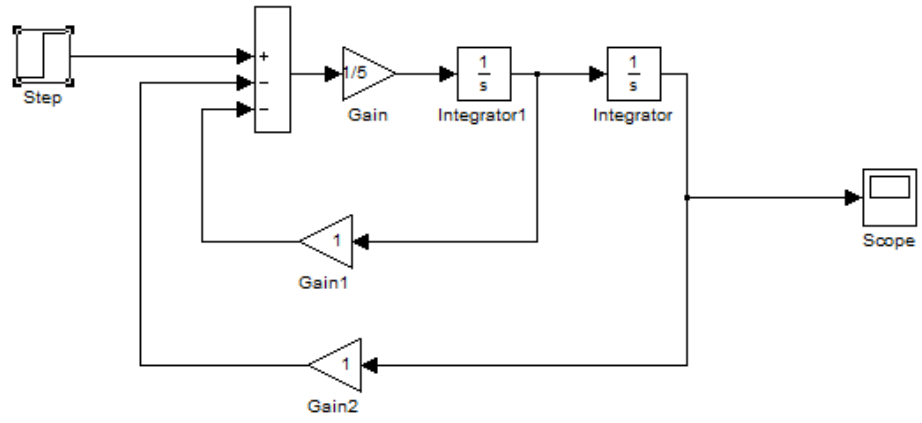
Scope:
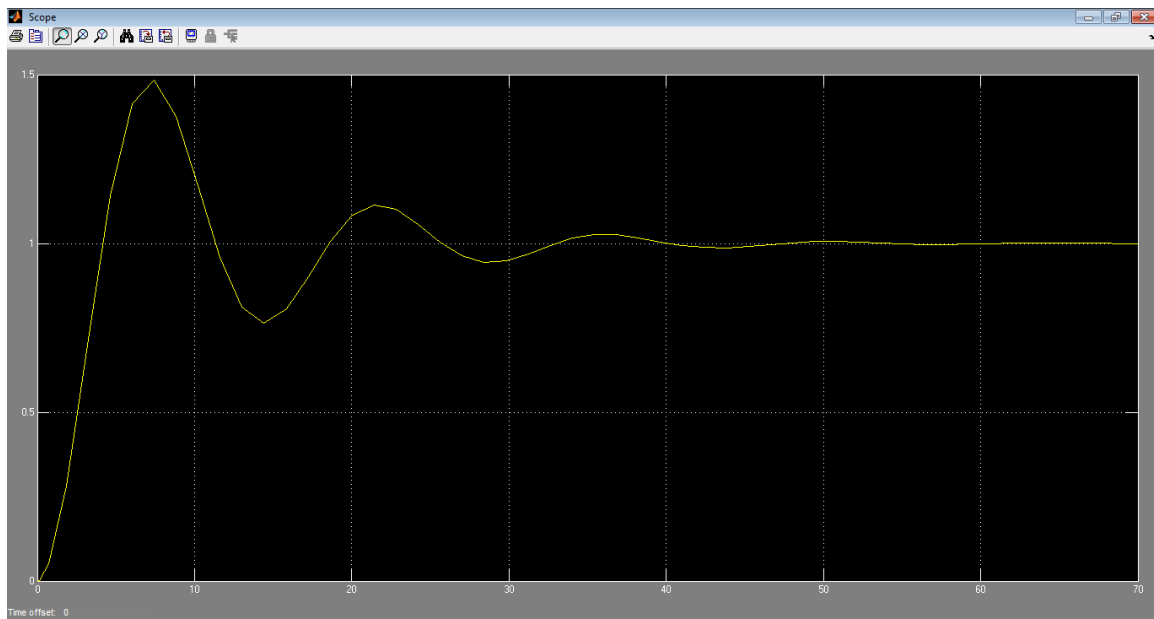
Example 2
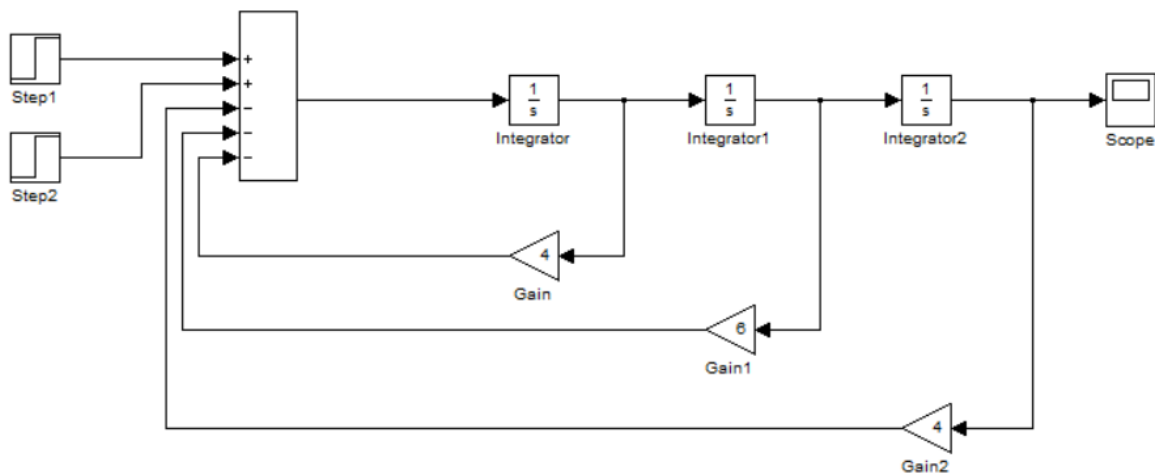Simulate the following differential equation by using SIMULINK:

$$x''' + 4x'' + 6x' + 4x = 2u(t) - 2u(t-3)$$
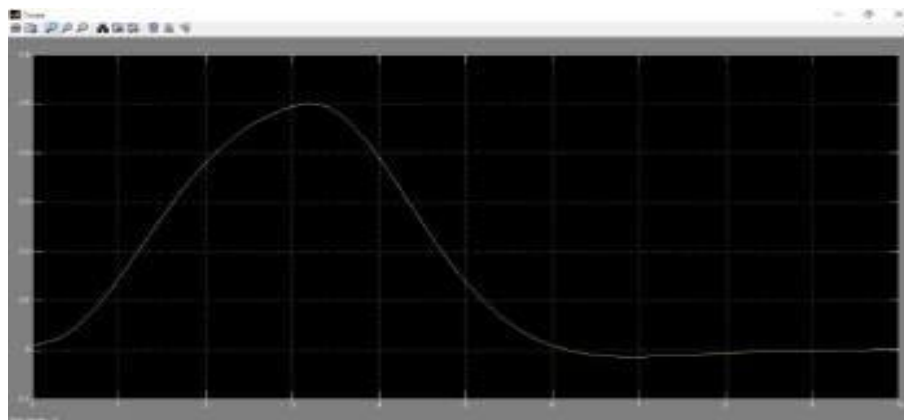
Where $x''(0) = 0.03$, $x'(0) = 0.02$, and $x(0) = 0.01$

Step1	Step2
Step time=0 Initial value=0 Final value=2	Step time=3 Initial value=0 Final value=2

Solution:

$$x''' = -4x'' - 6x' - 4x + 2u(t) - 2u(t-3)$$
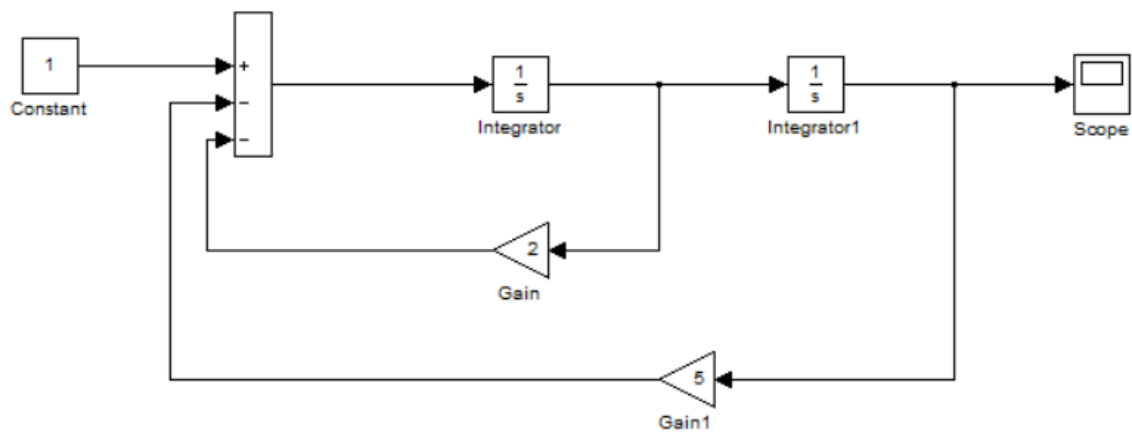

Scope:

Example 3

Simulate the following differential equation by using SIMULINK:

$$\frac{d^2y}{dt^2} + \frac{2\,dy}{dt} + 5y = 1$$

Where $y'(0) = y(0) = 0$

Solution:

$$\frac{d^2y}{dt^2} = 1 - \frac{2\,dy}{dt} - 5y$$
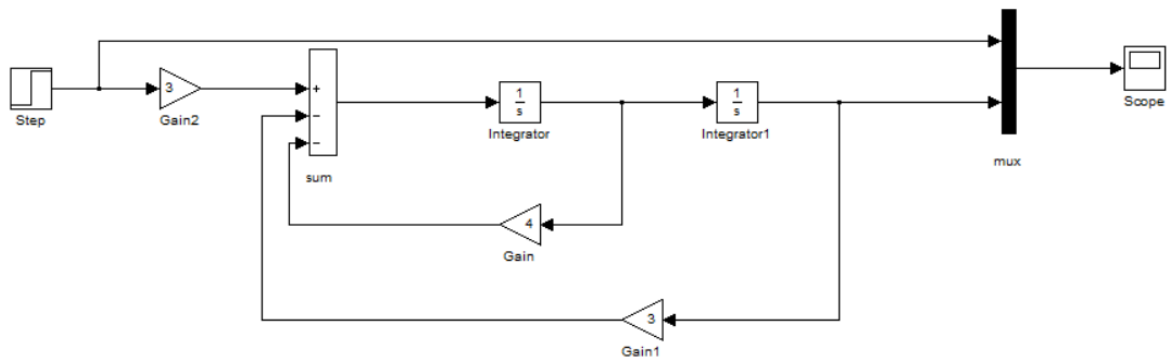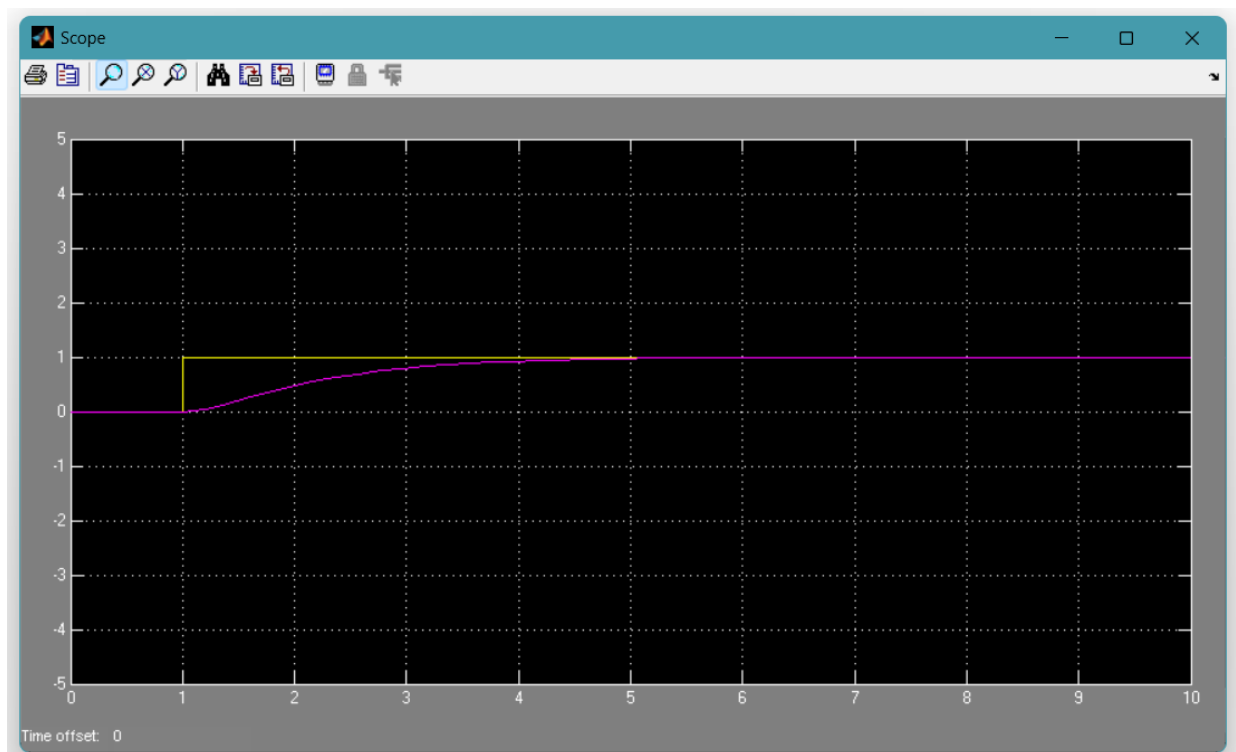

Scope:

Example 4

Simulate the following differential equation by using SIMULINK:

$$\frac{d^2vc}{dt^2} = -4\frac{dvc}{dt} - 3vc + 3u_\Omega(t)$$

Solution:

Scope:

SIMULINK Blocks

a) The Step block

The Step block provides a step between two definable levels at a specified time. If the simulation time is less than the **Step time** parameter value, the block's output is the **Initial value** parameter value. For simulation time greater than or equal to the **Step time**, the output is the **Final value** parameter value.

Library: Simulink / Sources

b) The Integrator block

The Integrator block outputs the value of the integral of its input signal with respect to time.

Library: Simulink / Continuous

c) The Sum block

The Sum block performs addition or subtraction on its inputs.

Library: Simulink / Math Operations

d) The scope block
Display signals generated during simulation.

Library: Simulink / Sinks