Automation and Automatic Control Lab

Experiment 1

Introduction to SIMULINK

Objectives:

By the end of this experiment, the student should be able to:

1. Build and simulate simple system model using Simulink
2. Use Simulink test and measurement tools.

1. Introduction

Simulink is a program for simulating signals and dynamic systems. Simulink has two phases of use: model definition and model analysis. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

Simulink provides toolboxes for designing, simulating, and analysing communications systems. The Simulink enables source coding, channel coding, interleaving, analogue and digital modulation, equalization, synchronization, and channel modelling.

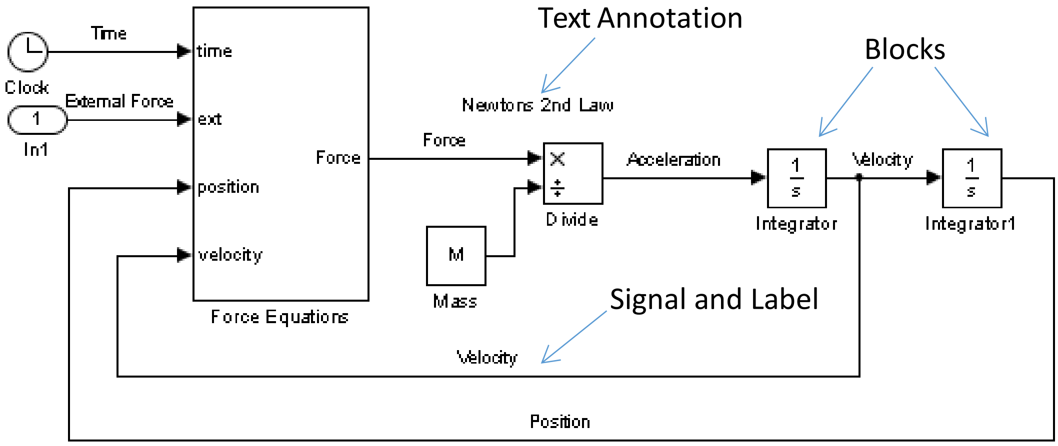
A typical session starts by either defining a new model or by recalling a previously defined model, and then proceeds to analyse that model. In order to facilitate the model definition, Simulink has a large library of blocks. Models are created by combining proper blocks from the library and edited in the model window principally using mouse-driven operation (Drag and Drop) . An important part of mastering Simulink is to become familiar with manipulations of various model components in these windows.

After you create (or define) a model, you can analyse it either by choosing options from the Simulink menus in the model window or by entering commands in the Matlab command window. The progress of an ongoing simulation can be viewed while it is running, and the results can be made available in the Matlab workspace when the simulation is complete.

Simulink is a visual programming interface designed to make modelling systems intuitive. It offers a way to solve equations numerically using a graphical user interface, rather than requiring code.

Models contain **blocks**, **signals** and **annotation** on a background**:**.

- **Blocks** are mathematical functions, they can have varying numbers of inputs and outputs.
- **Signals** are lines connecting blocks, transferring values between them. Signals are different data types, for example numbers, vectors or matrices. Signals can be **labelled**.
- **Annotations** of text or images can be added to the model, and while not used in the calculations they can make it easier for others to understand design decisions in the model.



1.1 Open the Simulink Library Browser:

You need MATLAB® running before you can open the Simulink® Library Browser.

1. In the MATLAB Command Window, enter **simulink**.
   A short delay occurs the first time you open the Simulink Library Browser. The figure 1 shows the Library Browser with the Out1 block selected in the Simulink/Commonly Used Blocks sub library. A block description that appears when you hover over it.

2. The Library Browser keeps a repository of all the libraries it shows. If your library has missing repository information, a notification bar appears above the Libraries pane when you refresh the Library Browser. To prevent this notification from appearing again, click on Fix in the notification bar and choose Resave libraries in SLX file format. This saves all libraries in .slx format with Enable Repository property set to on. You can also open the Simulink Library Browser from the MATLAB Tool strip, by clicking the Simulink Library button. To keep the Library Browser above all other windows on your desktop, in the toolbar, select the Stay on top button.

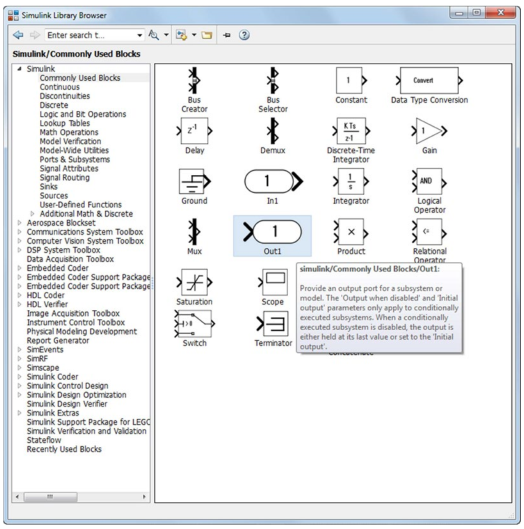


Figure 1.1: Simulink Library

1.2 Create a New Simulink Model

Create a new Simulink model from the Simulink Library Browser.

1. From the Simulink Library Browser toolbar, click the New Model button . An empty model diagram figure 1.2 opens in the Simulink Editor.

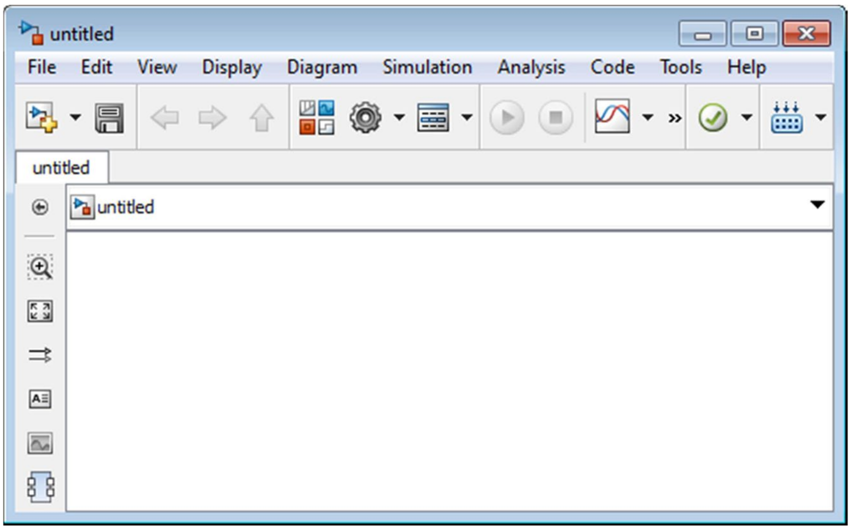


Figure 1.2: Simulink New Model

Example 1: Model the differential Equation (Time Domain)

$$\dot{x}(t) = 2x(t) + u(t) \quad (1)$$

where u(t) is a square wave with an ***amplitude of 1 and a frequency of 1 rad/sec***, use an integrator block and a gain block.

The Integrator block integrates its input $\dot{x}(t)$ to produce $x(t)$. Other blocks needed in this model include a Gain block and a Sum block. To generate a square wave, use a Signal Generator block and select the Square Wave form but change the default units to radians/sec. Again, view the output using a Scope block. Gather the blocks and define the gain.

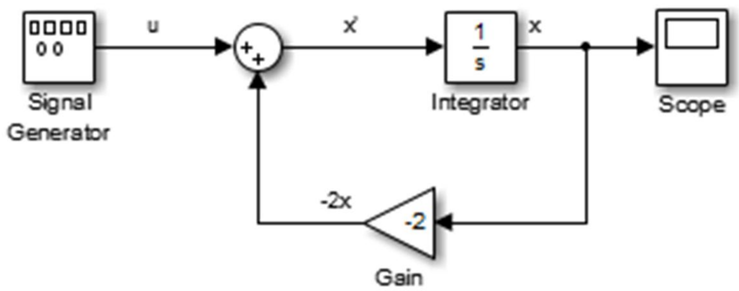


Figure 1.3: Blocks representation of equation 1

An important concept in this model is the loop that includes the Sum block, the Integrator block, and the Gain block.

In this equation, $x(t)$ is the output of the Integrator block. It is also the input to the blocks that compute $\dot{x}(t)$, on which it is based. This relationship is implemented using a loop.

The Scope displays $x(t)$ at each time step. For a simulation lasting 10 seconds, the output shows in figure 4:

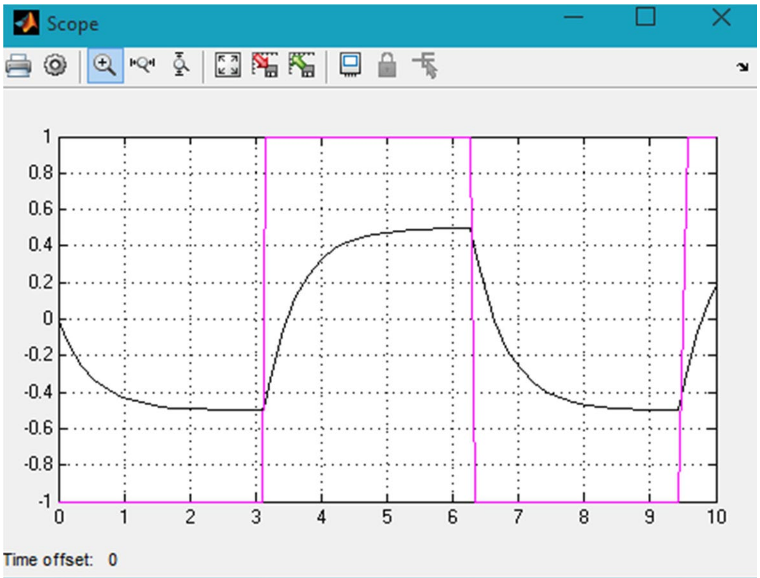


Figure 1.4: The simulation result of x(t)

Example .2: Model the differential Equation (Frequency Domain- Transfer Function)

$$\dot{x}(t) = 2x(t) + u(t) \tag{2}$$

The equation you modeled in this example can also be expressed as a transfer function. The model uses the ***Transfer Fcn block***, which accepts *u* as input and outputs x(t).

So, the block implements (s)/U(s) . If you substitute sX(s) for $\dot{x}(t)$ in the above equation, you get

$$sX(s) = -2X(s) + U(s)$$

Solving for X(s) gives

$$X(s) = \frac{U(s)}{s+2}$$

Or

$$\frac{X(s)}{U(s)} = \frac{1}{s+2}$$

The **Transfer Fcn** block uses parameters to specify the numerator and denominator coefficients. In this case, *the numerator is 1 and the denominator is s+2*. Specify both terms as vectors of coefficients of successively decreasing powers of s

In this case the numerator is [1] (or just 1) and the denominator is [1 2].

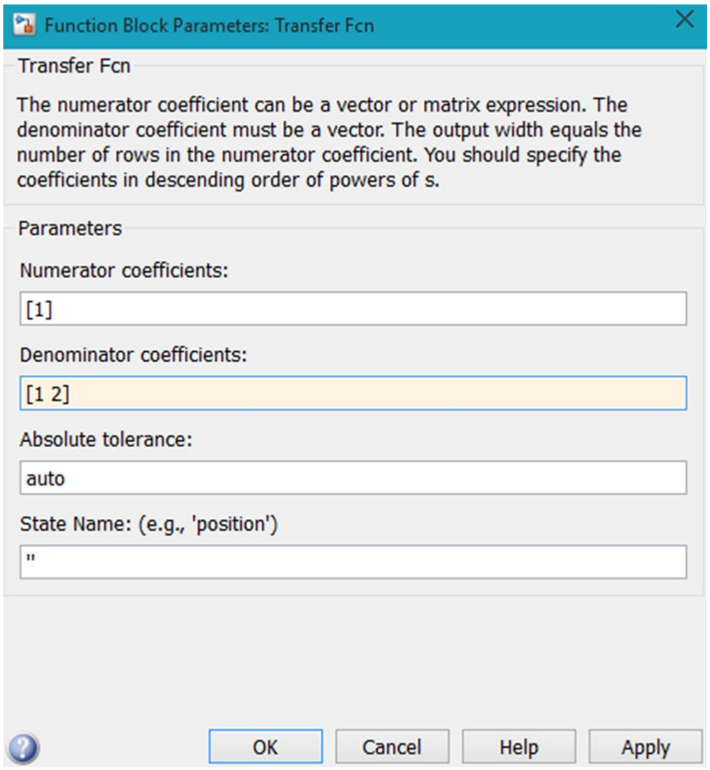


Figure 1.5: Transfer Fcn block parameter

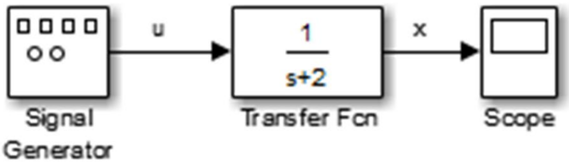
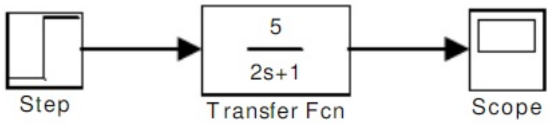


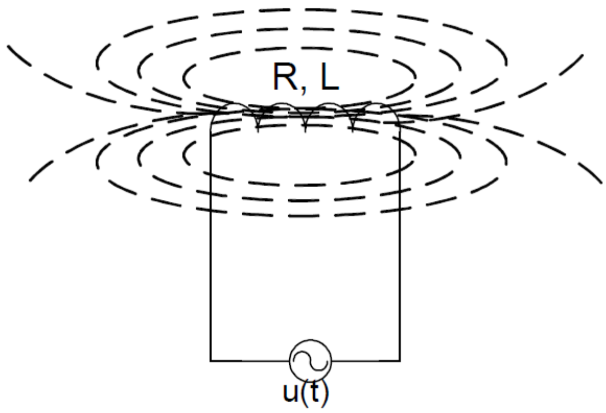
Figure 1.6: Transfer function representation of equation 2

Exercise 1: Build the following block diagram using SIMULINK



Exercise 2:

Consider the coil shown in the next figure. The voltage supply is equal to: $u(t) = i(t)R + \frac{d\psi(t)}{dt}$. Assuming that the inductance of the coil is constant the above equation is: $u(t) = i(t)R + L\frac{di(t)}{dt}$. This is a linear 1st order ODE. What is the response of the current to a sudden change of the voltage, assuming zero initial conditions?



Take R = 0.01; L= 0.01

Exercise 3: Consider the general second order equation below.

$$\dddot{y} + a\ddot{y} + b\dot{y} + cy = f(t)$$

Use SIMULINK to generate the output of the second order differential equation above.

Conclusion