

# Computer Aided Design (CAD)



## Lecture 8

Introduction to Simulink

Dr.Eng. Basem ElHalawany

# Schedule (Draft)

Topics	Estimated Duration (# Lectures)
Introduction	1
Introduction to Matlab Environment	1
Matlab Programing (m-files) (1)	5
Modeling using Matlab Simulink Tool	4 (1/4)
Communication Systems Simulation (Applications)	3
Midterm	8 <sup>th</sup> Week
Introduction to FPGA + Review on Digital Logic/Circuits	2
VHDL Modeling Language	4
VHDL Application	2
Introduction to OPNET Network Simulator	3
Course Closeout / Feedback/ project (s) Delivery	1



The Lecture is based on :

# Modeling of Digital Communication Systems Using **SIMULINK**<sup>®</sup>



Arthur A. Giordano • Allen H. Levesque



## B. Modeling of Digital Communication Systems Using SIMULINK

### This book:

- Introduces the reader to Simulink ( An extension of the widely-used MATLAB modeling tool, and
- Introduces the use of Simulink in modeling and simulating digital communication systems, including wireless communications systems.

**In contrast with other books** that treat MATLAB in depth but treat Simulink only at an introductory level

- This book enables the communication systems engineer to **learn and use the extensive capabilities** of Simulink to model a wide selection of **digital communications systems** and **evaluate their performance** for many important channel conditions.



# 1

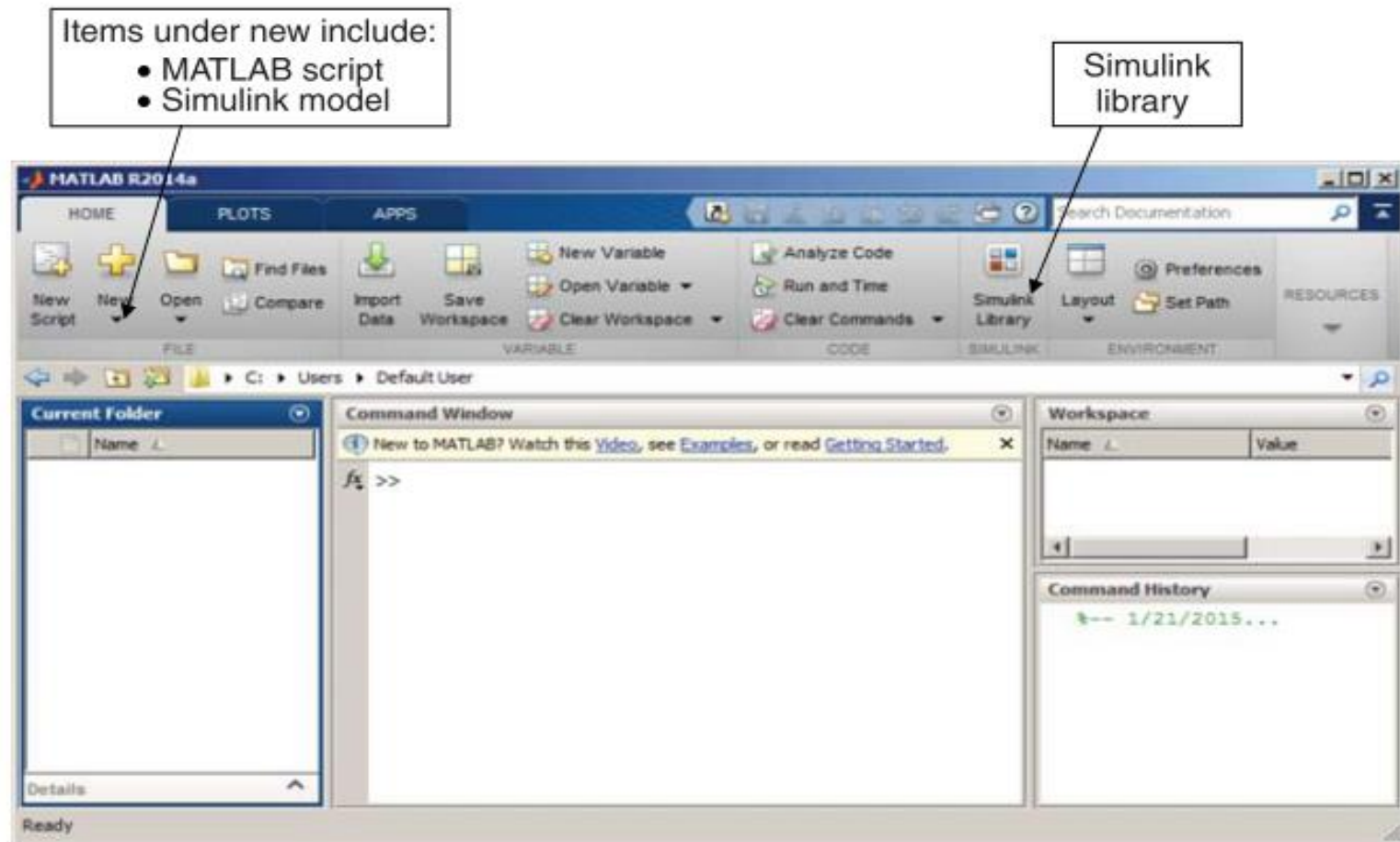
## GETTING STARTED WITH SIMULINK

- Simulink is a block diagram environment for **multi-domain** simulation and Model-Based Design.
- It supports system-level design, simulation, and continuous test and verification of embedded systems.
- Simulink provides a **graphical editor**, customizable block **libraries**, and **solvers** for modeling and simulating dynamic systems.
- It is integrated with MATLAB, enabling you to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis.

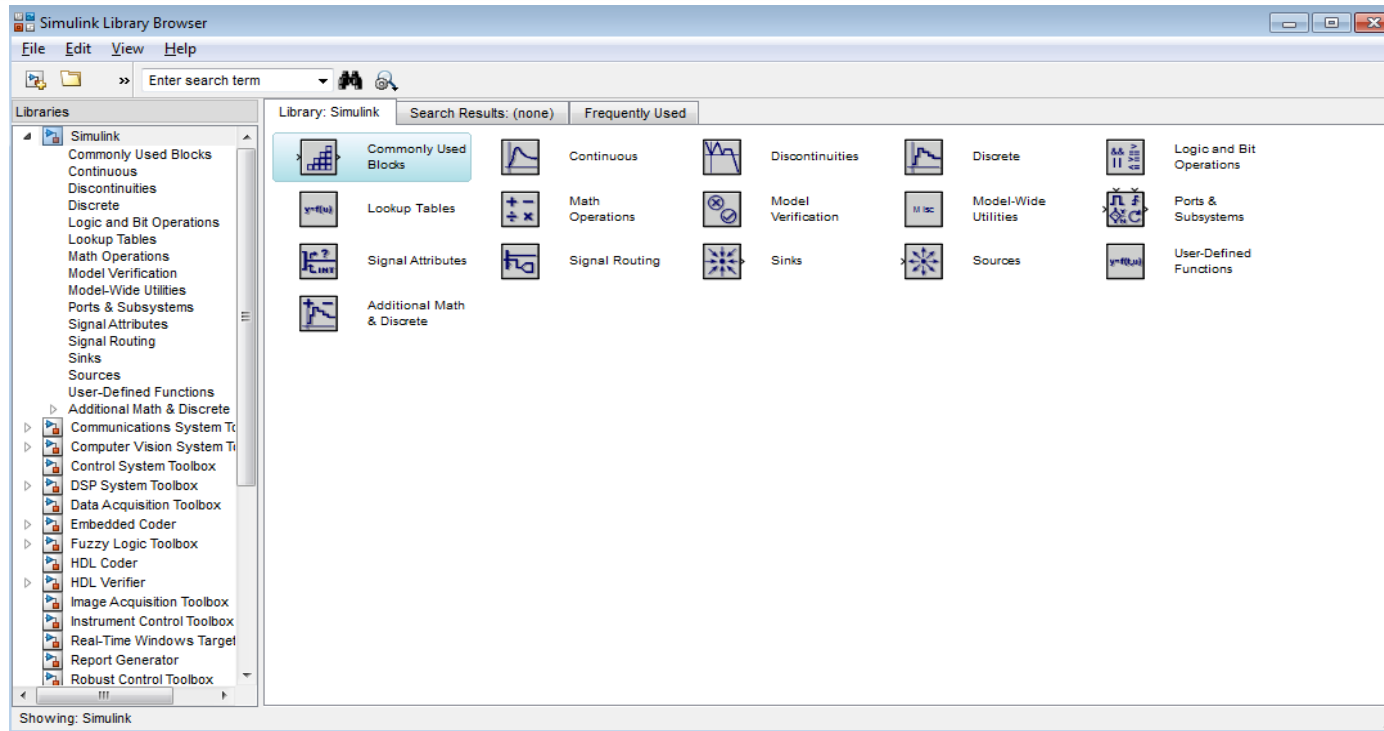


## 1.3 SIMULINK BLOCK LIBRARIES

- Building a Simulink model consists of selecting individual blocks contained in libraries and joining them in a block diagram of the system to be simulated.



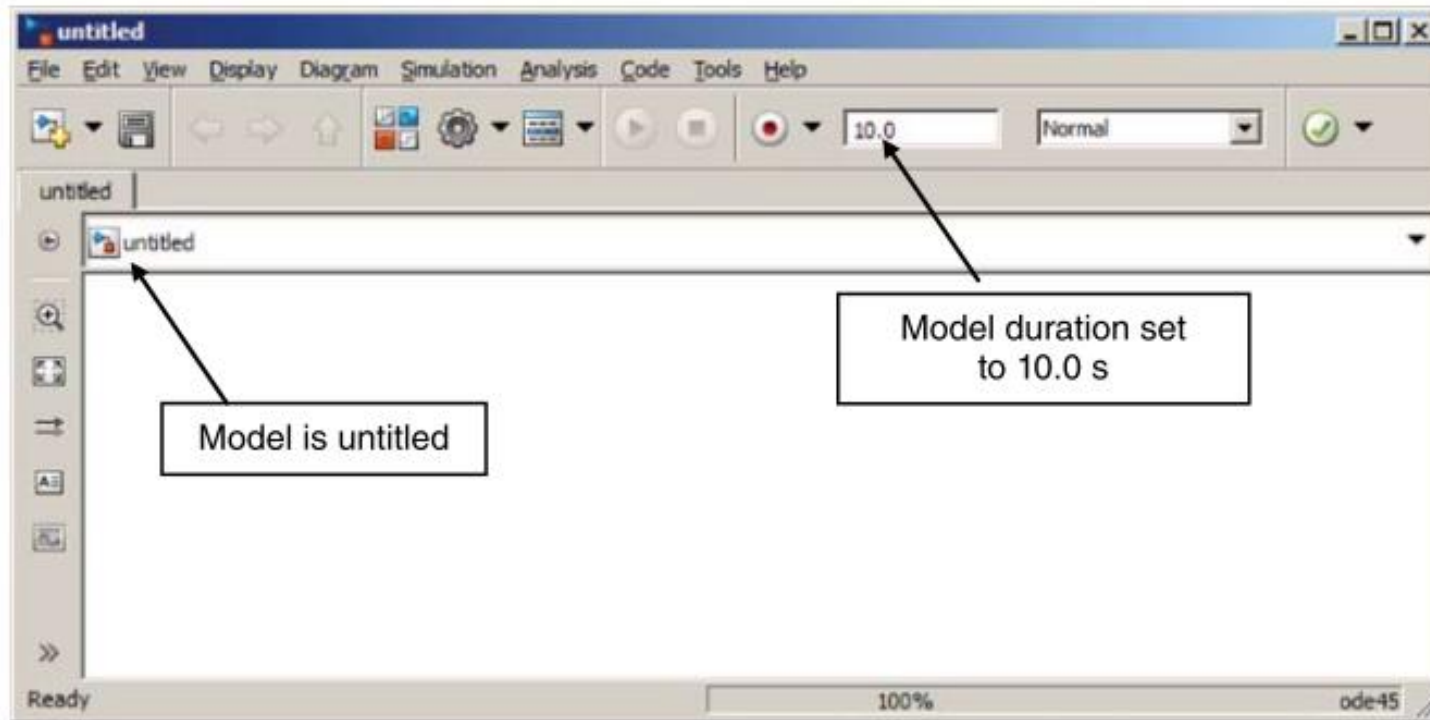
- To view available blocks, select Simulink Library on the MATLAB toolbar.
- This opens the window shown in Figure 1.2.



- The Simulink Library Browser shows a listing of available Simulink blocks.
- The focus in this book is on modeling digital communication systems, and the blocks you will find most useful are contained in:
  - ✓ The basic Simulink block library
  - ✓ The Communications System Toolbox and
  - ✓ The DSP System Toolbox.

## 1.4 BUILDING A NEW SIMULINK MODEL

- To begin building a new Simulink model, on the MATLAB toolbar, under the HOME tab, pull down New and select Simulink Model.
- This will open a blank Simulink model window, shown in Figure 1.3.



The duration of the model execution, is set to 10.0 s

Figure 1.3 Simulink Model Blank Window.





# First Simulink Model

## 1.4.1 Inserting Signal Source and Scope

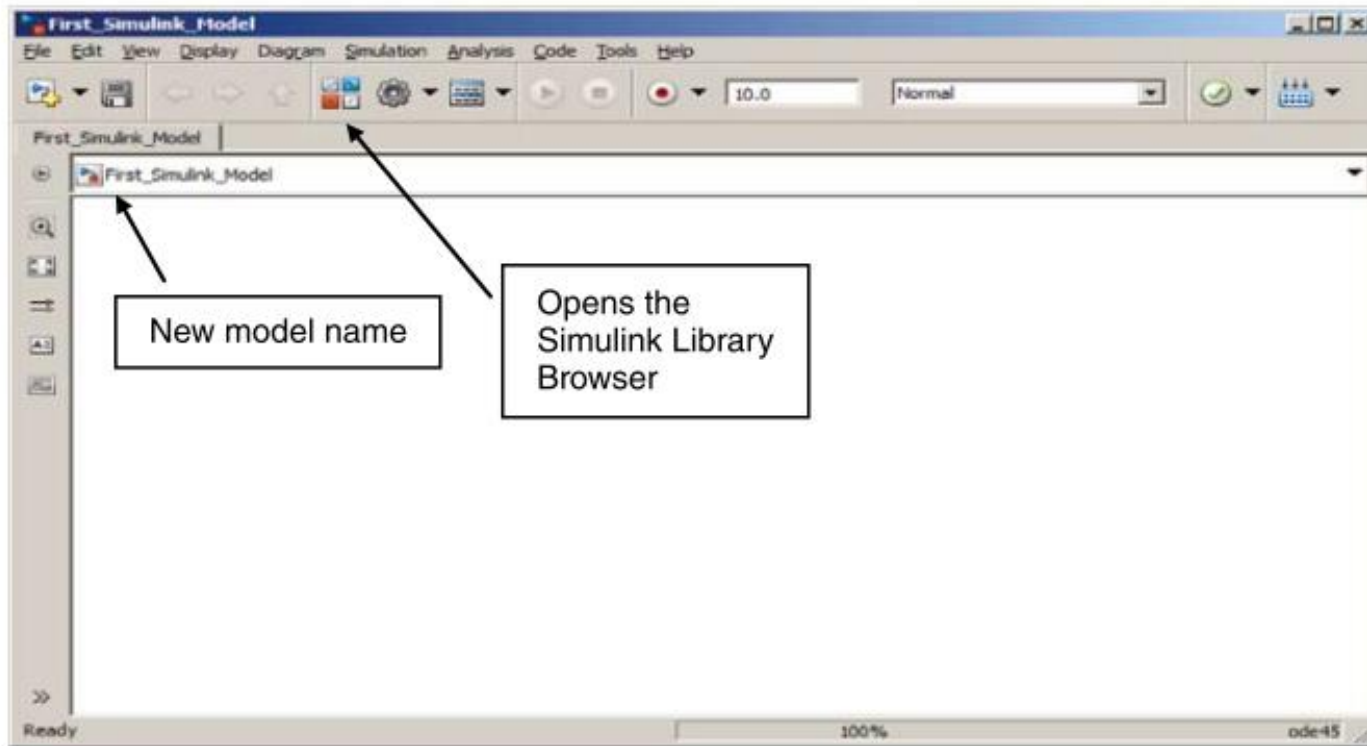
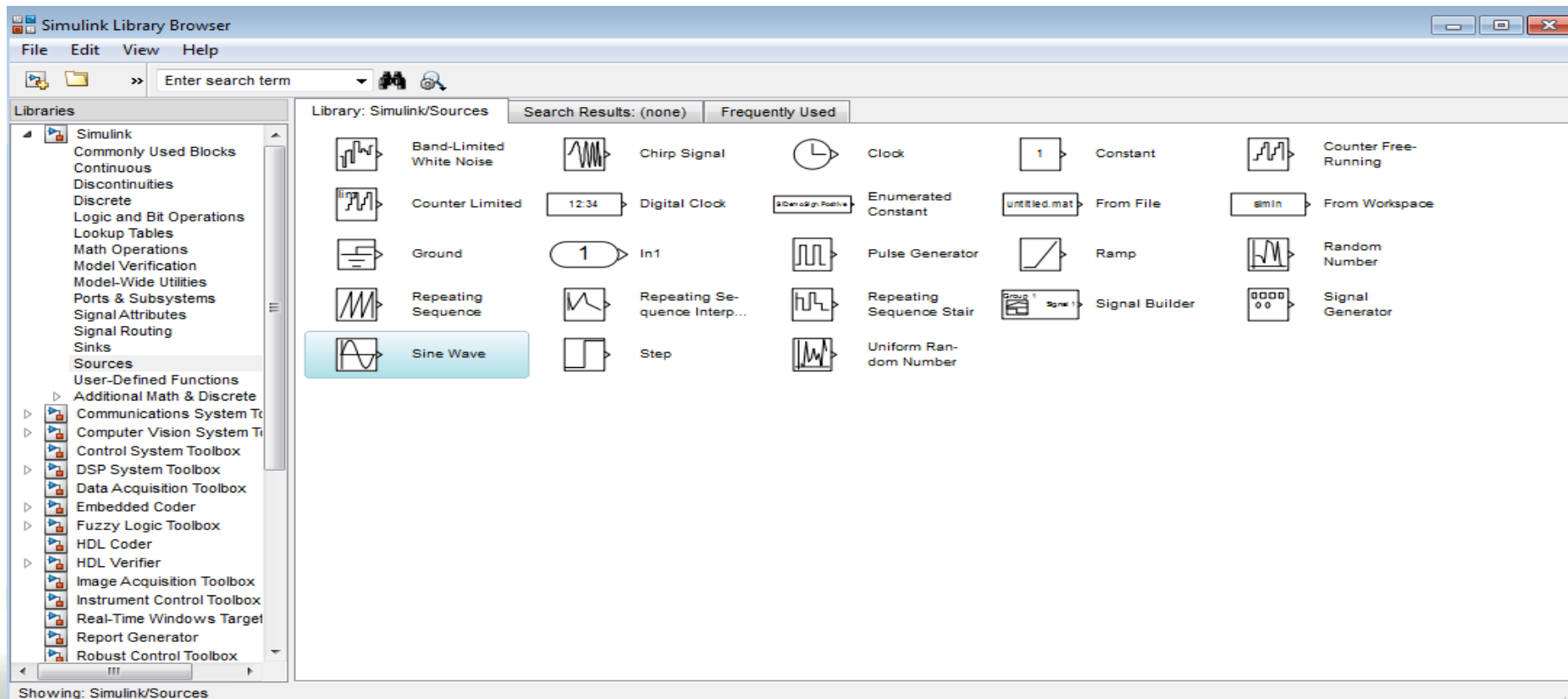


Figure 1.4 Simulink Model Window Renamed First\_Simulink\_Model.



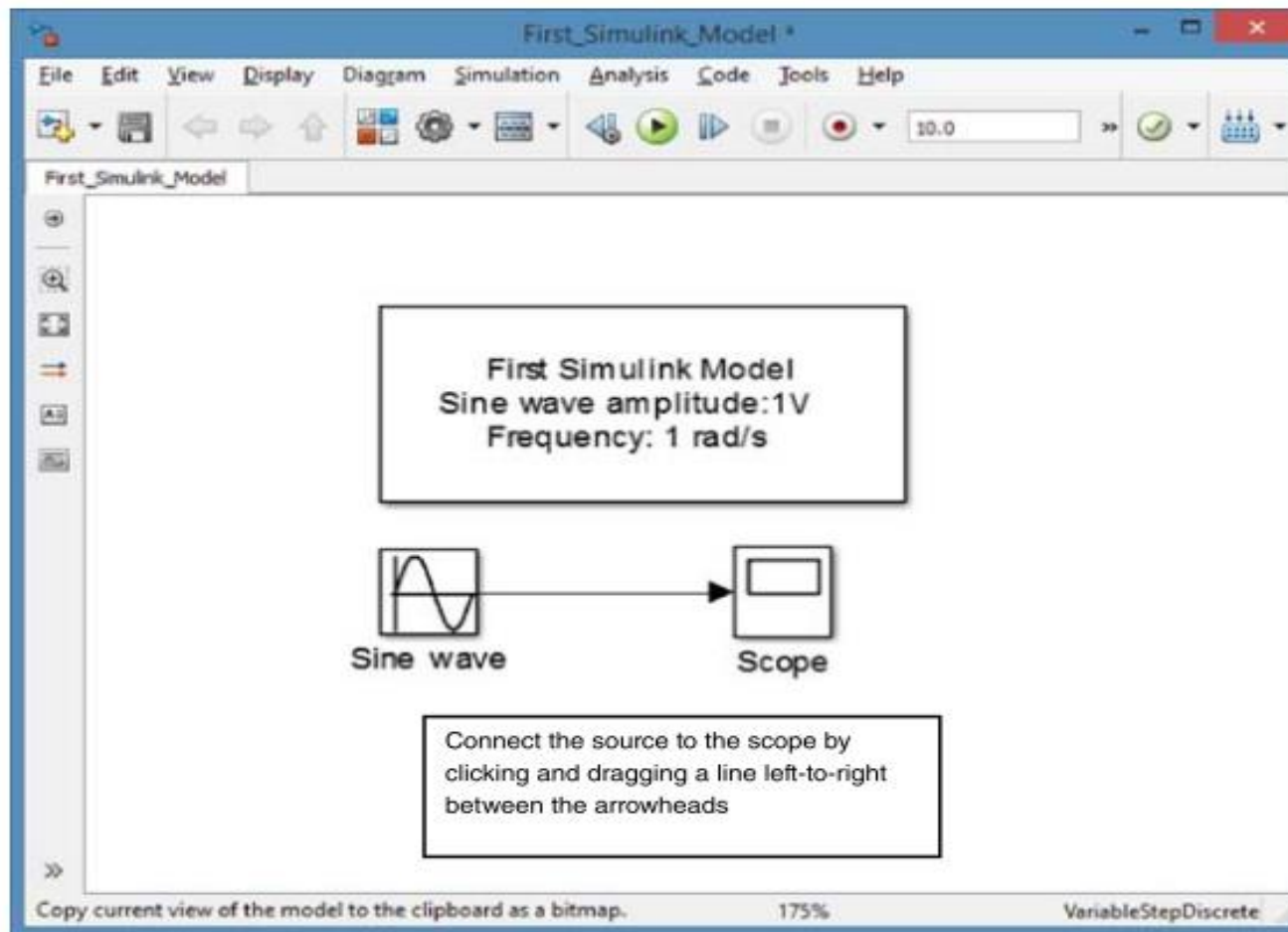
## 1.4.1 Inserting Signal Source and Scope

- First, in the library window, click on Sources to open the window shown in Fig. 1.5.
- With both the First\_Simulink\_Model window and the Simulink Library Browser window open, left-click on the Sine Wave icon and drag a copy into the model.
  - ✓ Alternatively, you can right-click on the icon in the library and select Add to First\_Simulink\_Model.



## 1.4.1 Inserting Signal Source and Scope

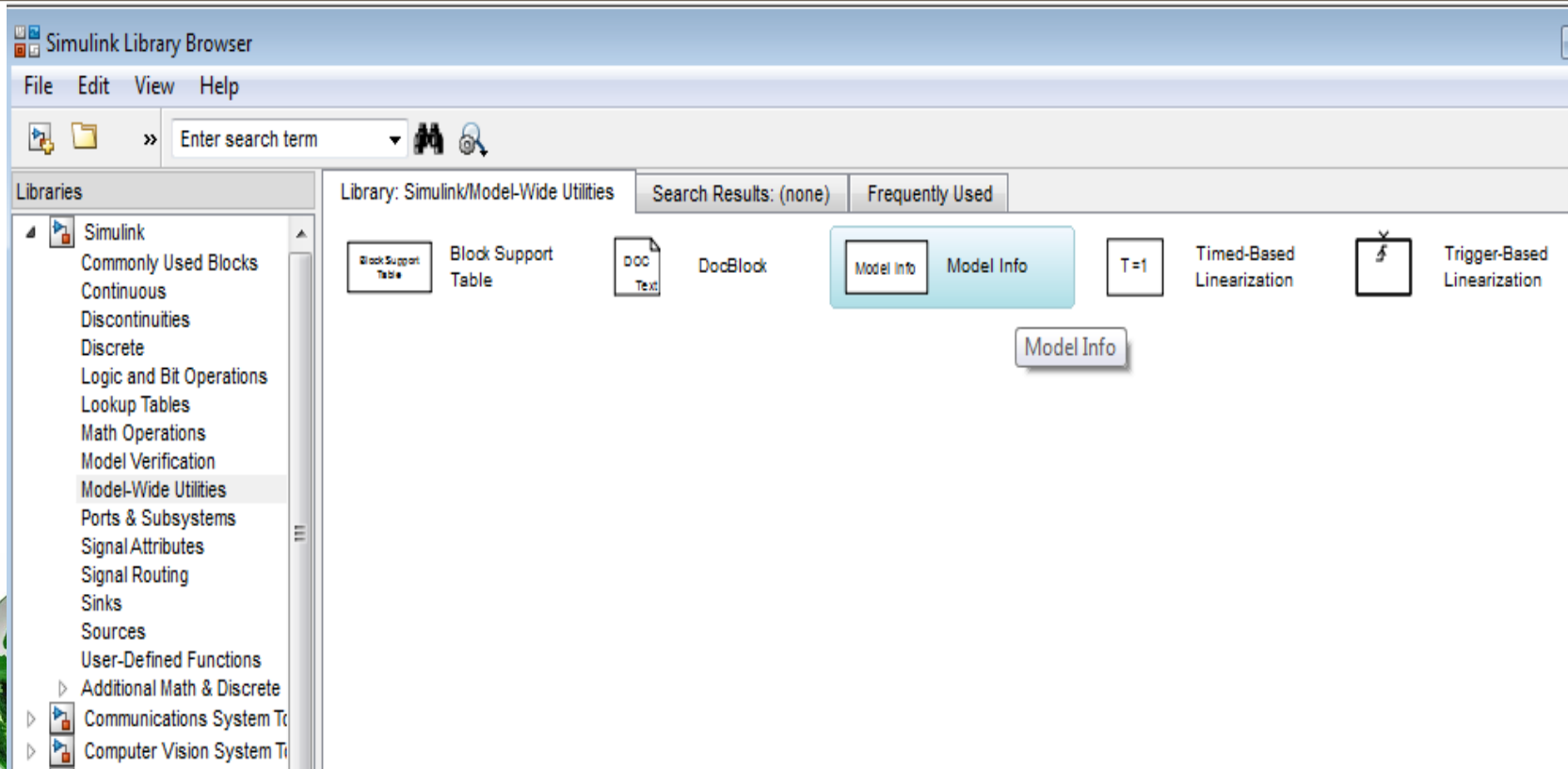
- Next, add a scope to the model by returning to the Simulink Library Browser and clicking on **-Sinks**, selecting **scope**, and dragging a copy into the model window, now shown in Figure 1.6.



In the figure, the Sine Wave block has been connected to the Scope by clicking on the arrow head at the Sine Wave output and dragging a line to the corresponding arrow head at the input to the Scope

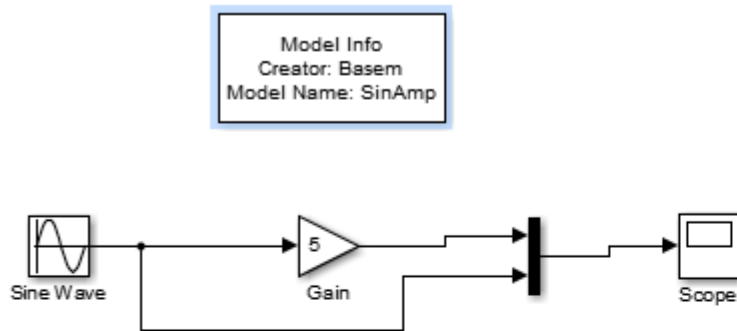
## 1.4.1 Inserting Signal Source and Scope

- Another block, **entitled Model Info**, is previous Figure and is available in the Simulink library under **Simulink Model-Wide Utilities**.
- Dragging it to your model and double clicking on this block opens a text box.
- This utility is very useful for conveniently displaying the parameters of each simulation model



## 1.4.1 Inserting Signal Source and Scope

➤ Model Info under Simulink Model-Wide Utilities.



The screenshot shows the 'Model Info: SinAmp' dialog box. It has a title bar with standard window controls. The main area is divided into two sections. The left section, 'Model properties:', contains a list of properties: 'Created', 'Creator', 'Modified By', 'Modified Date', 'Modified Comment', 'Model Version', 'Model Name', and 'Description'. The 'Created' property is currently selected. To the right of this list is a right-pointing arrow button. The right section, 'Enter text and tokens to display on Model Info block:', contains a text area with the following content: 'Model Info', 'Creator: %<Creator>', and 'Model Name: %<ModelName>'. Below the text area is another right-pointing arrow button. At the bottom of the dialog, there is a 'Horizontal text alignment:' dropdown menu set to 'Center', a checked checkbox for 'Show block frame', and four buttons: 'OK', 'Cancel', 'Help', and 'Apply'.



## 1.4.2 Setting the Source Block Parameters

- In the model window, double-click on the Sine Wave icon; this opens an information window for the Sine Wave
- Many types of options and parameters can be changed
- For more details, you need to open help for the Simulink documentation, accessible by clicking on the Help button.

Source Block Parameters: Sine Wave

Sine Wave

Output a sine wave:

$$O(t) = \text{Amp} * \sin(\text{Freq} * t + \text{Phase}) + \text{Bias}$$

Sine type determines the computational technique used. The parameters in the two types are related through:

$$\text{Samples per period} = 2 * \pi / (\text{Frequency} * \text{Sample time})$$
$$\text{Number of offset samples} = \text{Phase} * \text{Samples per period} / (2 * \pi)$$

Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.

Parameters

Sine type:

Time (t):

Amplitude:

Bias:

Frequency (rad/sec):

Phase (rad):

Sample time:

Interpret vector parameters as 1-D

? OK Cancel Help Apply



## 1.4.3 Setting Scope Parameters

- In the model window, double-click on the Scope icon, opening the Scope display, shown in Figure 1.8.
- At this point, the display is blank, since no simulation has been started with this model.
- The gear-like icon on the toolbar opens the Scope Parameters window, which has three pages.

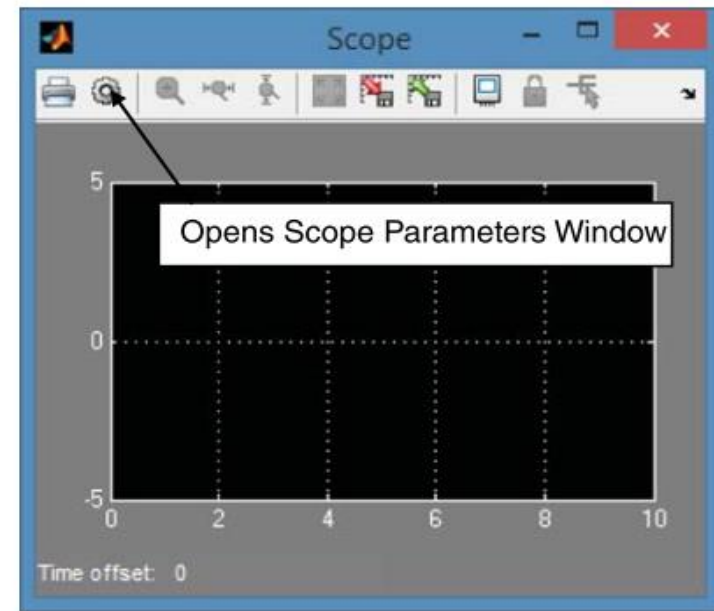
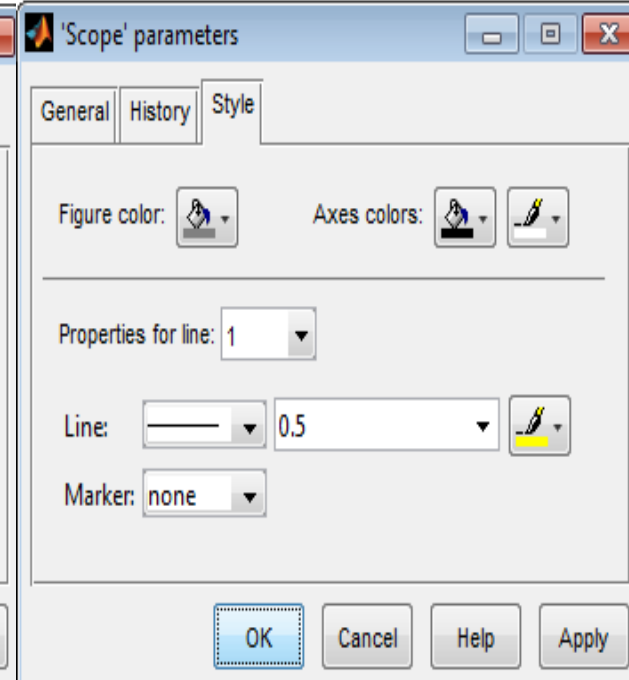
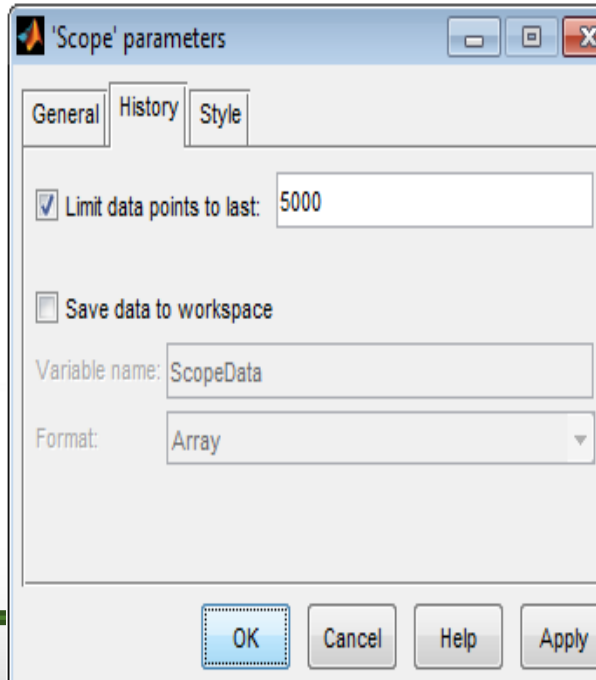
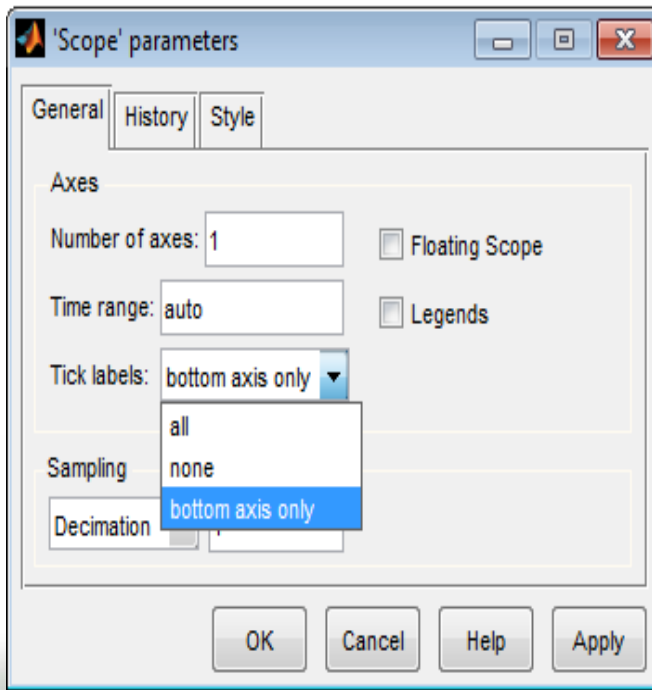
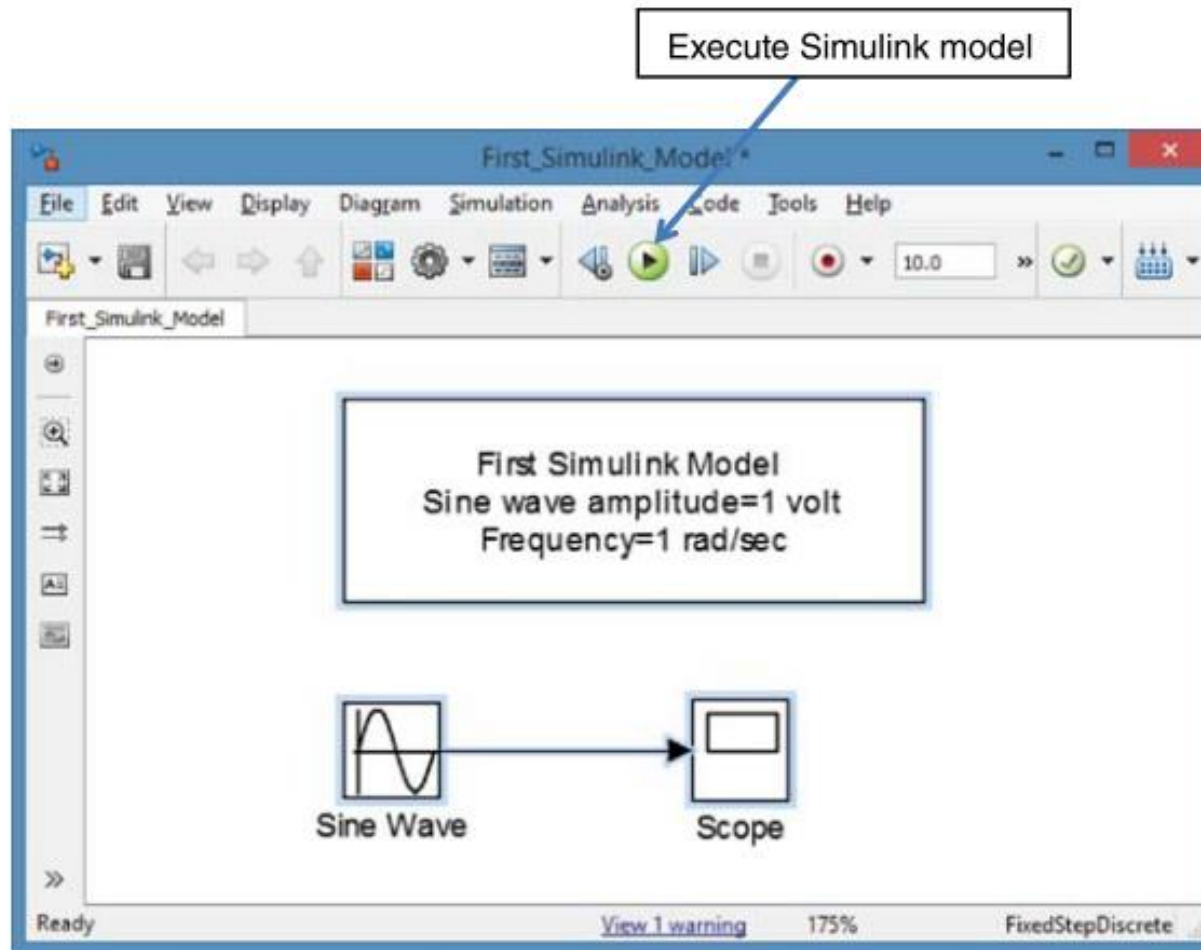


Figure 1.8 Scope Display.



## 1.5 EXECUTING THE SIMULINK MODEL



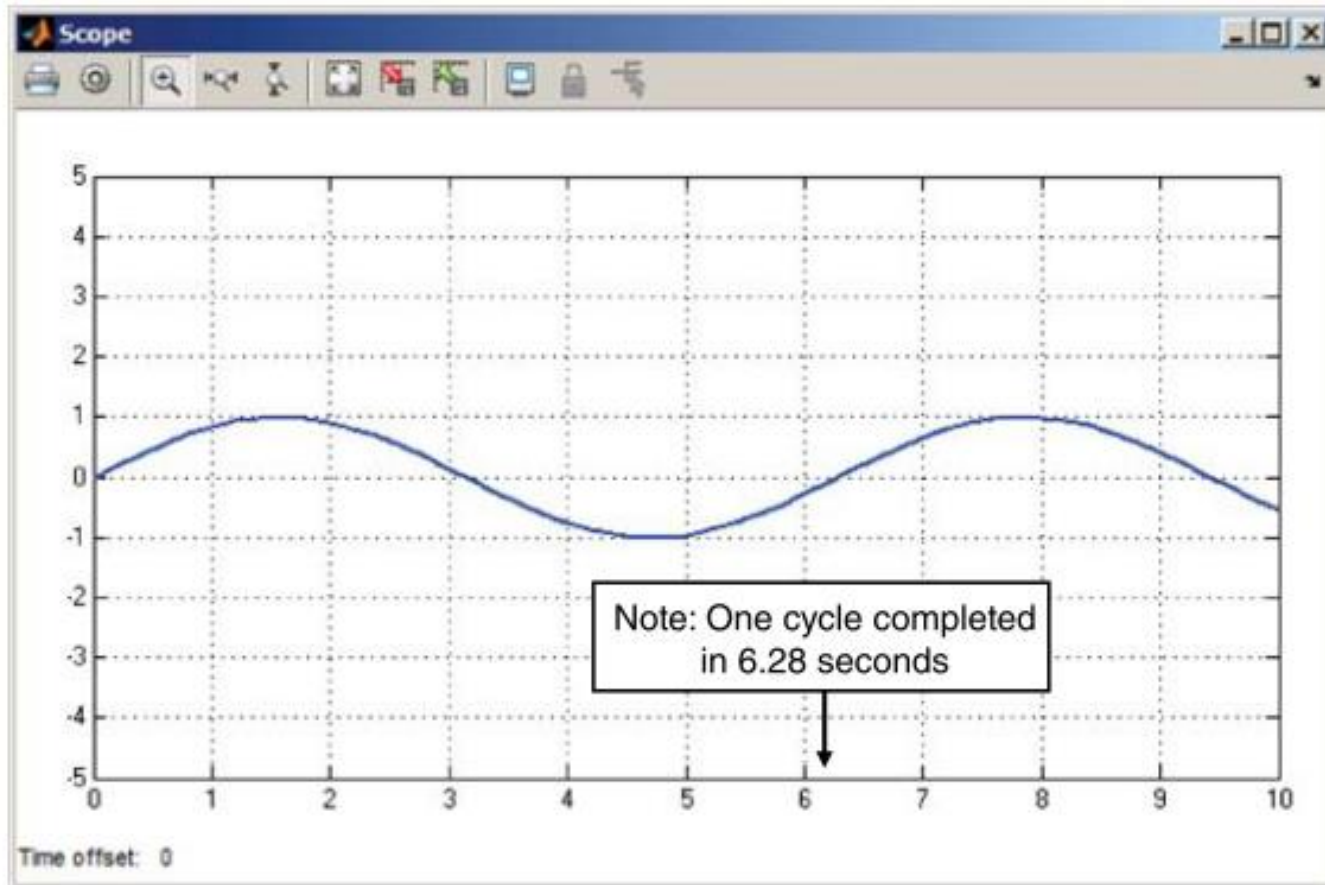
**Figure 1.12** Executing the Simulink Model.





## 1.5 EXECUTING THE SIMULINK MODEL

- After execution for 1 rad/sec sine wave



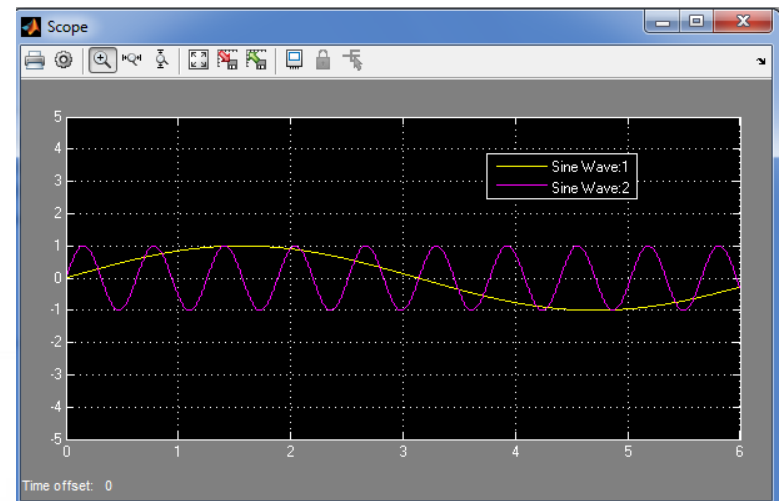
**Figure 1.13** Scope Display After Executing the Sine Wave Model.



## 1.6 RECONFIGURING THE SIGNAL BLOCK

- An important feature of Simulink: **Simulink blocks are designed to accept signals and parameter values as vector inputs.**
- The time-based Sine Wave model in Figure can be modified to **generate two sinusoids** instead of just one.
- A simple way of doing this is double-clicking on the Sine Wave block, opening the block parameters window, and **changing the frequency** (rad/s) setting by inserting the two-element **vector [1 10]**.

This configures the Sine Wave block to generate two sinusoids, one at 1 rad/s, the other at 10 rad/s.



## 1.6 RECONFIGURING THE SIGNAL BLOCK

- Another way of configuring the Sine Wave block to generate the two sinusoids is to specify the frequency (rad/s) as **f** in the block parameters window,
- and define the **variable f** by inserting the statement `f = [1 10]` into the **MATLAB Command Window**.

```
>> f = [10 20]
```

```
f =
```

```
    10    20
```

```
>> |
```

Source Block Parameters: Sine Wave

Sine Wave

Output a sine wave:

$$O(t) = \text{Amp} * \sin(\text{Freq} * t + \text{Phase}) + \text{Bias}$$

Sine type determines the computational technique used. The parameters in the two types are related through:

Samples per period =  $2 * \pi / (\text{Frequency} * \text{Sample time})$

Number of offset samples =  $\text{Phase} * \text{Samples per period} / (2 * \pi)$

Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.

Parameters

Sine type: Time based

Time (t): Use simulation time

Amplitude: 1

Bias: 0

Frequency (rad/sec): f

Phase (rad): 0



## 1.7 SAMPLE-BASED SIGNALS

- If the simulation model is changed by selecting **Sample based** in the Sine type Parameters
- the Sample time is set to 0.1 (seconds) and the number of samples per period is set to 10.

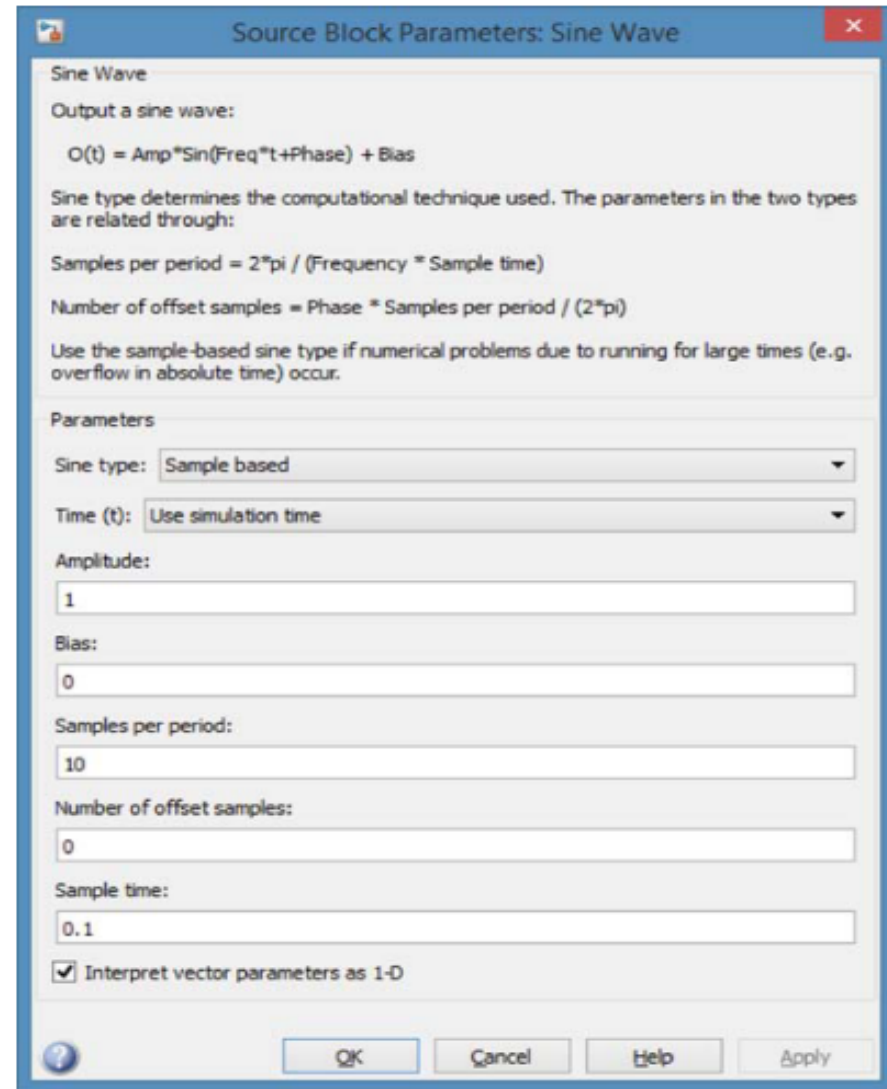
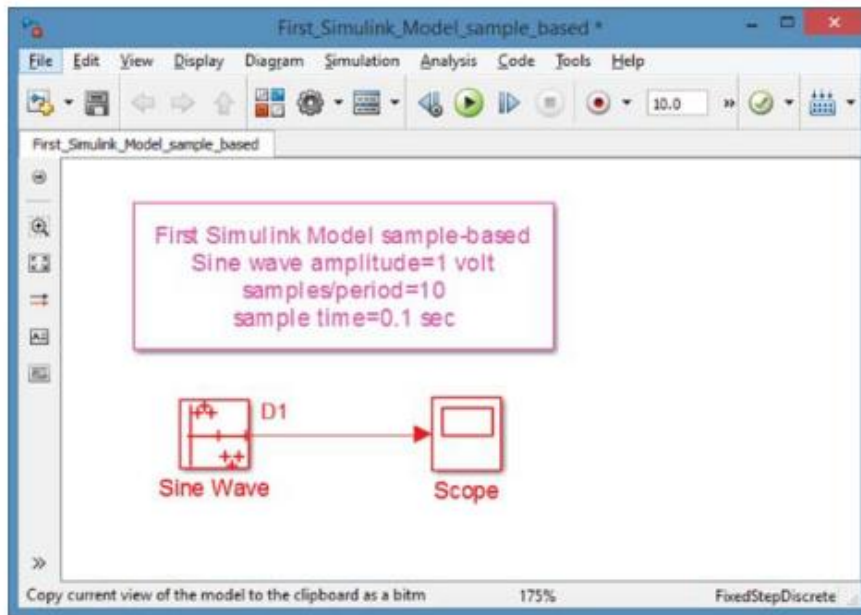


Figure 1.19 First Simulink Model Modified for Sample Based computation. Figure 1.18 Sample Based Selection in Sine Wave Block.

## 1.7 SAMPLE-BASED SIGNALS

- If the simulation model is changed by selecting **Sample based** in the Sine type Parameters
- the Sample time is set to 0.1 (seconds) and the number of samples per period is set to 10.

resulting sample values

