# 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 <b>(1/4)</b>
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





# Arthur A. Giordano • Allen H. Levesque

#### **CAD - Basem ElHalawany**

#### **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.



# **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.



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.

📑 Simulink Library Browser					
File Edit View Help					
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# 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.

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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

File       Edit       View       Help         Image: Search term       Image: Search Results: (none)       Frequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Frequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Frequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Frequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Trequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Trequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Trequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Trequently Used         Image: Simulation of the search term       Image: Search Results: (none)       Trequently Used         Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes         Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes         Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes       Image: Signal Attributes         Image: Signal Attributes       Image: Signal Attributes	📲 Simulink Library Browser	
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#### First Simulink Model

# 1.4.1 Inserting Signal Source and Scope

#### Model Info under Simulink Model-Wide Utilities.





#### **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.



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	📸 Source Block Parameters: Sine Wave 🗧
	Sine Wave
	Output a sine wave:
	O(t) = Amp*Sin(Freq*t+Phase) + Bias
	Sine type determines the computational technique used. The parameters in the two types are related through:
2	Samples per period = 2*pi / (Frequency * Sample time)
5	Number of offset samples = Phase * 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):
	1000
	Phase (rad):
	0
	Sample time:
	0
	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.

🛃 'Scope' parameters 📃 💷 💌	外 'Scope' parameters 📃 📼 💌	🚺 'Scope' parameters 📃 📼 💌
General History Style	General History Style	General History Style
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OK Cancel Help Apply	OK Cancel Help Apply	OK Cancel Help Apply

## **1.5 EXECUTING THE SIMULINK MODEL**



Figure 1.12 Executing the Simulink Model.



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### **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.

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#### 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 sinousoids, 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.



🔁 Source Block Parameters: Sine Wave	x
Sine Wave	
Output a sine wave:	
O(t) = Amp*Sin(Freq*t+Phase) + Bias	
Sine type determines the computational technique used. The parameters in the two types are related through:	
Samples per period = 2*pi / (Frequency * Sample time)	
Number of offset samples = Phase * 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.



2	Source Block Parameters: Sine Wave
Sine Wave	
Output a sir	wave:
O(t) = Am	p*Sin(Freq*t+Phase) + Bias
Sine type de are related	termines the computational technique used. The parameters in the two types through:
Samples per	period = 2*pi / (Frequency * Sample time)
Number of a	offset samples = Phase * Samples per period / (2*pi)
Use the sam overflow in	ple-based sine type if numerical problems due to running for large times (e.g. absolute time) occur.
Parameters	
Sine type:	Sample based 💌
Time (t):	Jse simulation time
Amplitude:	
1	
Bias:	
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Samples pe	r period:
10	
Number of	offset samples:
0	
Sample time	
0.1	

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



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#### 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

