

Computer Aided Design (CAD)



Lecture 9

Introduction to Simulink (2)

Dr.Eng. Basem ElHalawany

Schedule (Updated 28-10)

Topics	Estimated Duration (# Lectures)
Introduction	1
Introduction to Matlab Environment	1
Matlab Programing (m-files) (1)	5
Modeling using Matlab Simulink Tool	4 (2/4)
Midterm	7 th Week
Communication Systems Simulation (Applications)	3
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**[®]



Arthur A. Giordano • Allen H. Levesque



1.8 SENDING DATA TO WORKSPACE

- By adding the “**To Workspace**” block from Simulink **Sinks**
- The To Workspace block causes the output data from the Sine Wave block to be saved and examined for subsequent use such as plotting.

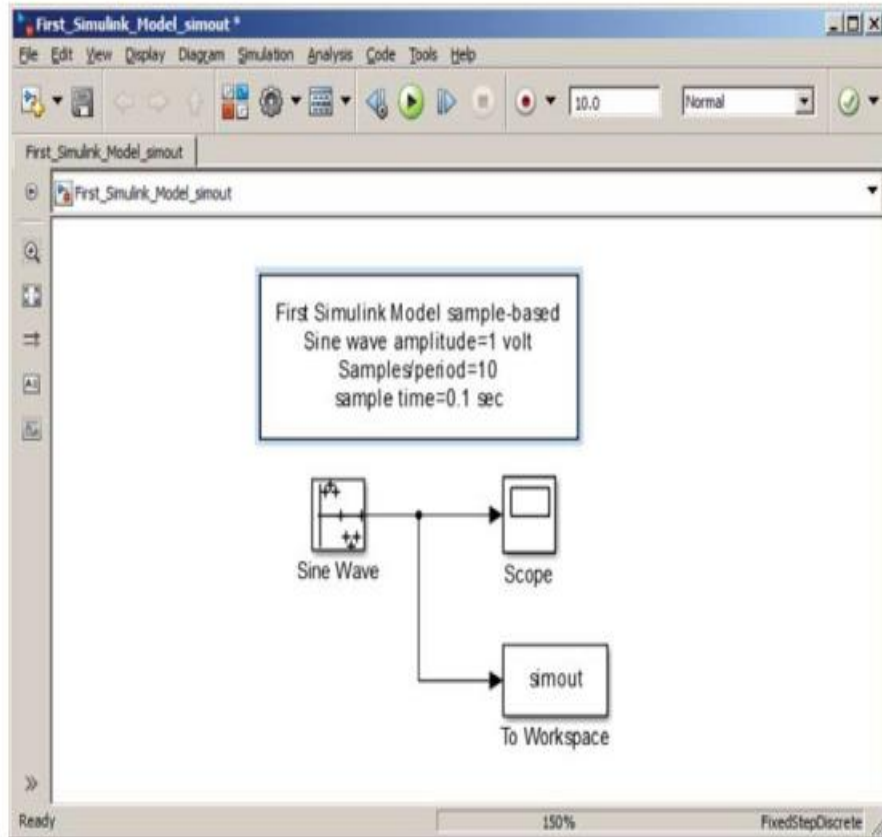
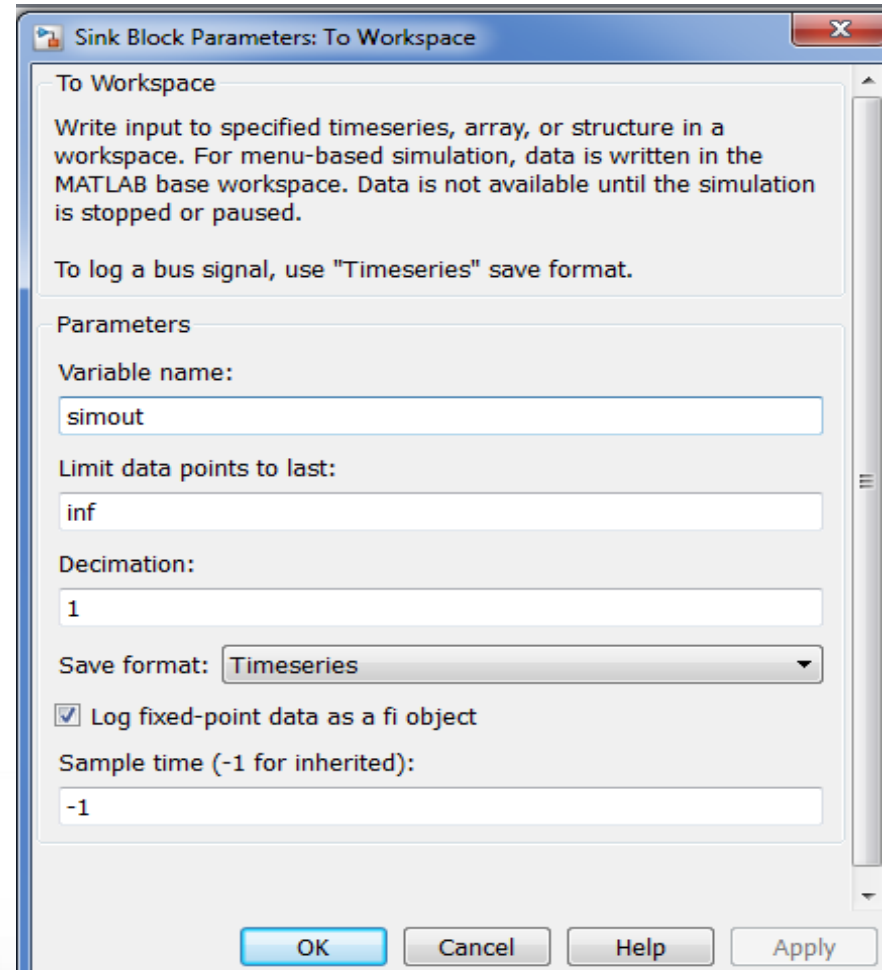
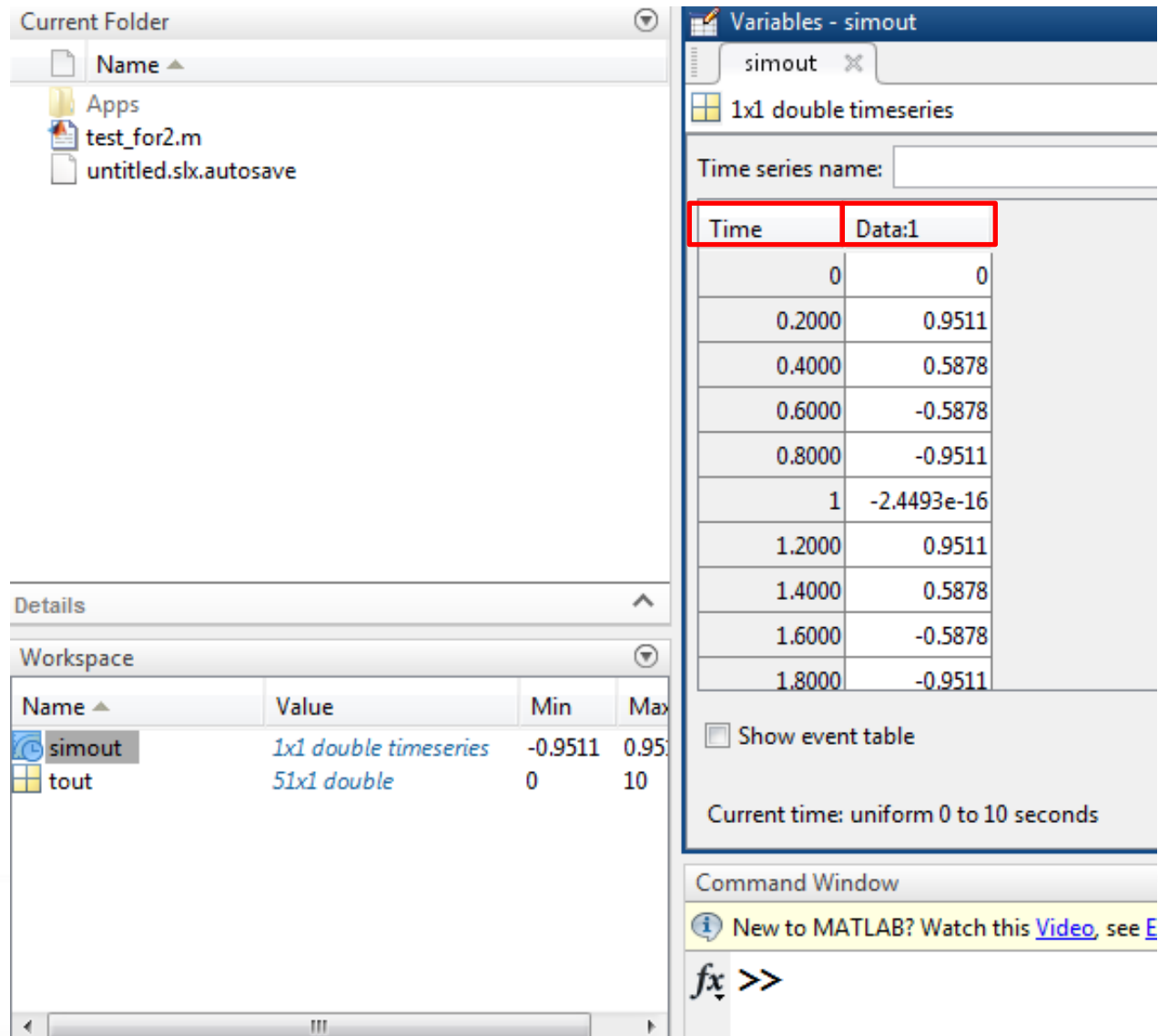


Figure 1.22 Sending Simulation Data to Workspace.



1.8 SENDING DATA TO WORKSPACE



The screenshot displays the MATLAB interface with the following components:

- Current Folder:** Shows files 'Apps', 'test_for2.m', and 'untitled.slx.autosave'.
- Workspace:** Lists variables 'simout' (1x1 double timeseries) and 'tout' (51x1 double).
- Variables - simout:** Shows a table of data for the 'simout' variable.
- Command Window:** Displays the MATLAB prompt 'fx >>'.

Time	Data:1
0	0
0.2000	0.9511
0.4000	0.5878
0.6000	-0.5878
0.8000	-0.9511
1	-2.4493e-16
1.2000	0.9511
1.4000	0.5878
1.6000	-0.5878
1.8000	-0.9511

Option: Timeseries



1.8 SENDING DATA TO WORKSPACE

Option: Array

The image displays the MATLAB environment. On the left, the 'Workspace' window shows two variables: 'simout' and 'tout', both of type '51x1 double'. The 'Command Window' at the bottom contains the command `>> plot(tout, simout)` and a cursor `fx >>`. The main workspace area shows a table with 16 rows and 3 columns, representing the data for 'simout'. The values in the first column are: 0, 0.1253, 0.2487, 0.3681, 0.4818, 0.5878, 0.6845, 0.7705, 0.8443, 0.9048, 0.9511, 0.9823, 0.9980, 0.9980, 0.9823, 0.9511. On the right, a window titled 'Figure 1' displays a plot of a sine wave. The x-axis ranges from 0 to 1, and the y-axis ranges from -1 to 1. The plot shows a smooth curve starting at (0,0), peaking at approximately (0.25, 1), crossing the x-axis at approximately (0.5, 0), reaching a trough at approximately (0.75, -1), and ending at (1,0).

1	2	3
1	0	
2	0.1253	
3	0.2487	
4	0.3681	
5	0.4818	
6	0.5878	
7	0.6845	
8	0.7705	
9	0.8443	
10	0.9048	
11	0.9511	
12	0.9823	
13	0.9980	
14	0.9980	
15	0.9823	
16	0.9511	



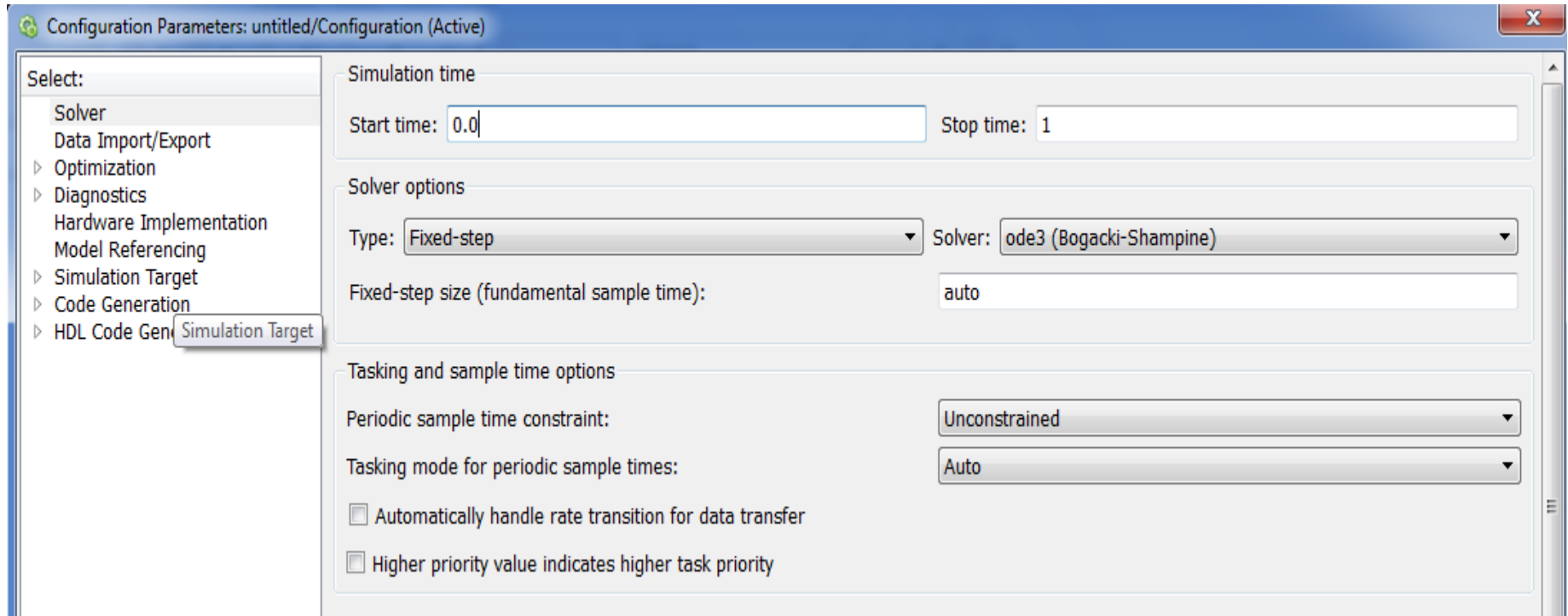
- Model Explorer is a tool available to provide the user with the ability to view, modify or add elements in the Simulink model and workspace variables.
- To open the Model Explorer, select Model Explorer under the View tab in the Simulink model window.

The screenshot shows the Model Explorer window with the following components:

- Model Hierarchy:** A tree view on the left showing the Simulink Root, Base Workspace, and the selected 'untitled*' model.
- Contents of: untitled* (only):** A table listing the contents of the selected model.
- Table:** A table with columns 'Name', 'BlockType', and 'OutDataTypeStr'. The 'To Workspace' block is selected.
- Sink Block Parameters: To Workspace:** A configuration panel on the right with the following settings:
 - To Workspace:** Write input to specified timeseries, array, or structure in a workspace. For menu-based simulation, data is written in the MATLAB base workspace. Data is not available until the simulation is stopped or paused. To log a bus signal, use "Timeseries" save format.
 - Parameters:**
 - Variable name:
 - Limit data points to last:
 - Decimation:
 - Save format:
 - Log fixed-point data as a fi object
 - Sample time (-1 for inherited):

1.11 Selecting Model Configuration Parameters

- In the Simulink model window, pulling down the Simulation tab and selecting Model Configuration Parameters



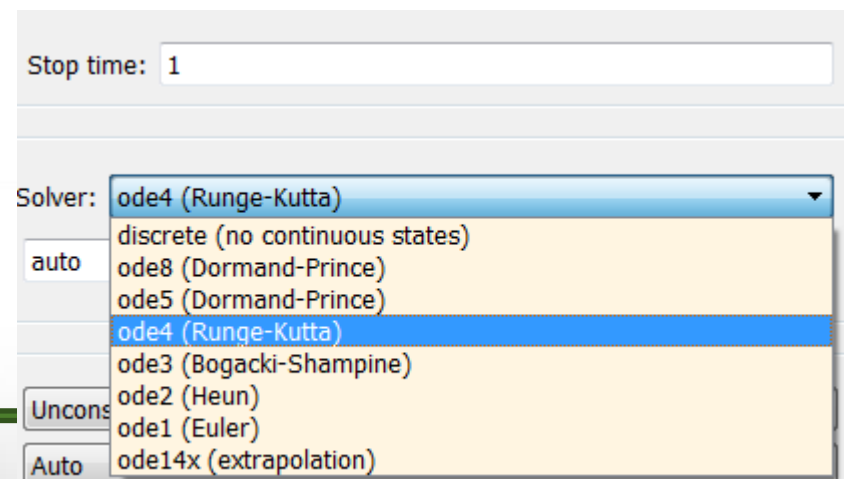
- User can specify the:
 - ✓ simulation start and stop time and
 - ✓ choose the solver for the simulation



Simulation: Simulink Solvers

- A dynamic system is simulated by computing its states at successive time steps over a specified time span, using information provided by the model
- This entails repeatedly solving a set of difference or differential equations describing component blocks in the model of the system being simulated
- The process of solving the model at successive time steps is referred to as **simulating** the system that the model represents
- Simulink provides an assortment of solvers, each geared to solving a specific type of model

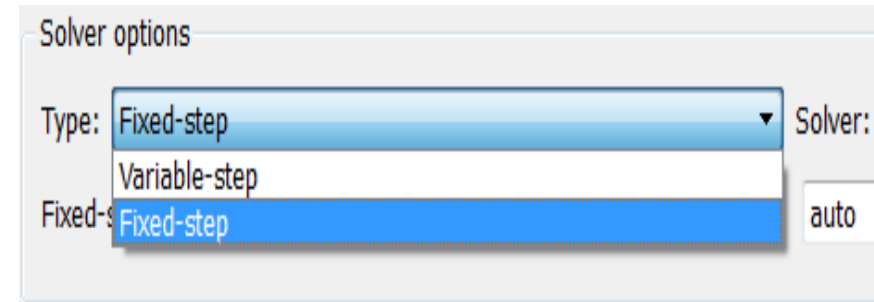
✓ The Solver is selected as ode-45, which, in general is the best first choice as a solver for most Simulink models.



1.11 Selecting Model Configuration Parameters

➤ Solver Options:

➤ For both fixed-step and variable-step solvers, the next simulation time is the sum of the current simulation time and the step size.

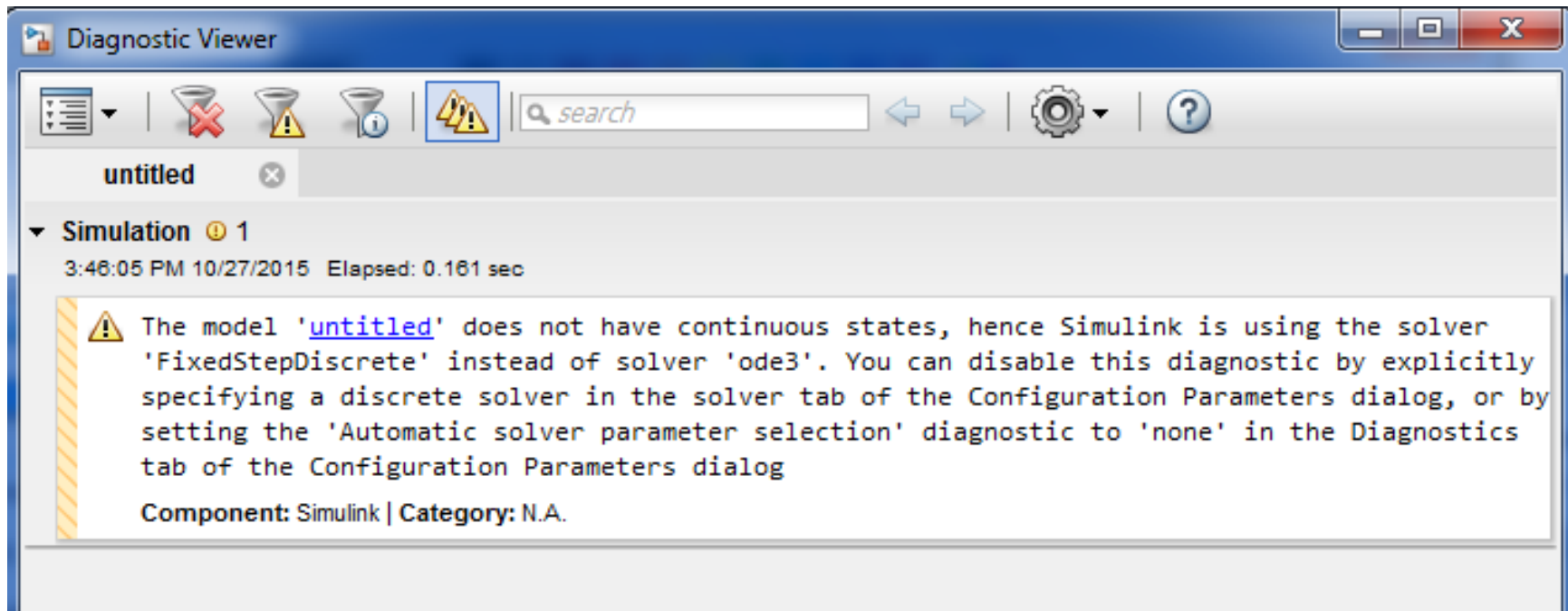


- With a fixed-step solver, the step size remains constant throughout the simulation
- With a variable-step solver, the step size can vary in an adaptive fashion from step to step to maximize efficiency, while meeting specified error tolerances
- Simulink also provides the choice of **continuous** versus **discrete** solvers
 - Continuous solvers use numerical integration to compute a model's continuous states at the current time step
 - Discrete solvers exist primarily to solve purely discrete models. They compute the next simulation time step for a model and each block in the model updates its individual discrete states



➤ Solver Warning Example (1)

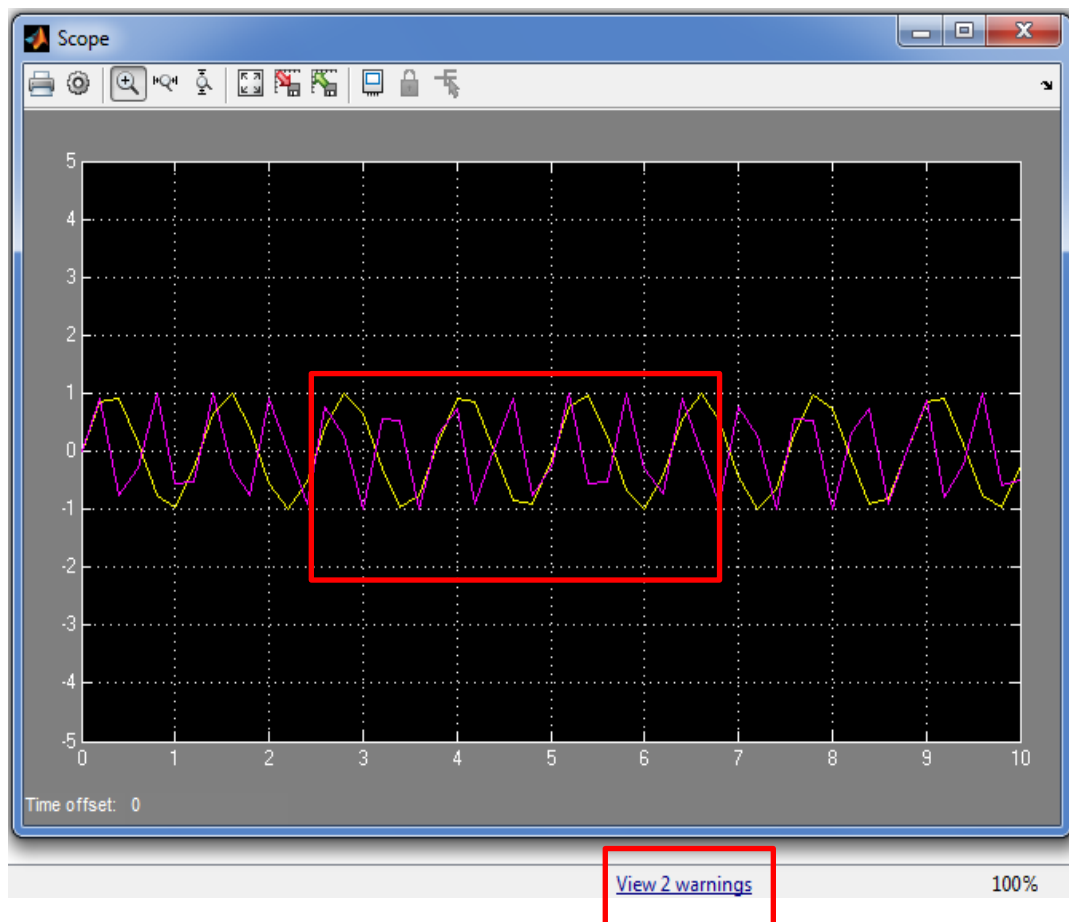
- If the model is **modified** where the Sine Wave block is chosen to have a **Sample-based Sine** type and a 0.1 s Sample time is entered,
- The model execution will **produce a warning message** seen at the bottom of the Simulink model.



- The model 'untitled' does not have continuous states, hence Simulink is using the solver 'FixedStepDiscrete' instead of solver 'ode3'.

➤ Solver Warning Example (2)

➤ Bad resolution



⚠ Unable to determine a fixed step size based on the sample times in the model 'untitled', because the model does not have any discrete sample times. Picking a fixed step size of (0.2) based on simulation start and stop times. You can disable this diagnostic by explicitly specifying a fixed step size in the Solver pane of the Configuration Parameters dialog box, or setting the 'Automatic solver parameter selection' diagnostic to 'none' in the Solver group on the Diagnostics pane of the Configuration Parameters dialog box.

➤ Solver Warning Example (1)

- Bad resolution can be solved by changing the step size to improve the resolution

Solver options

Type: Fixed-step

Solver: ode3 (Bogacki-Shampine)

Fixed-step size (fundamental sample time):

auto

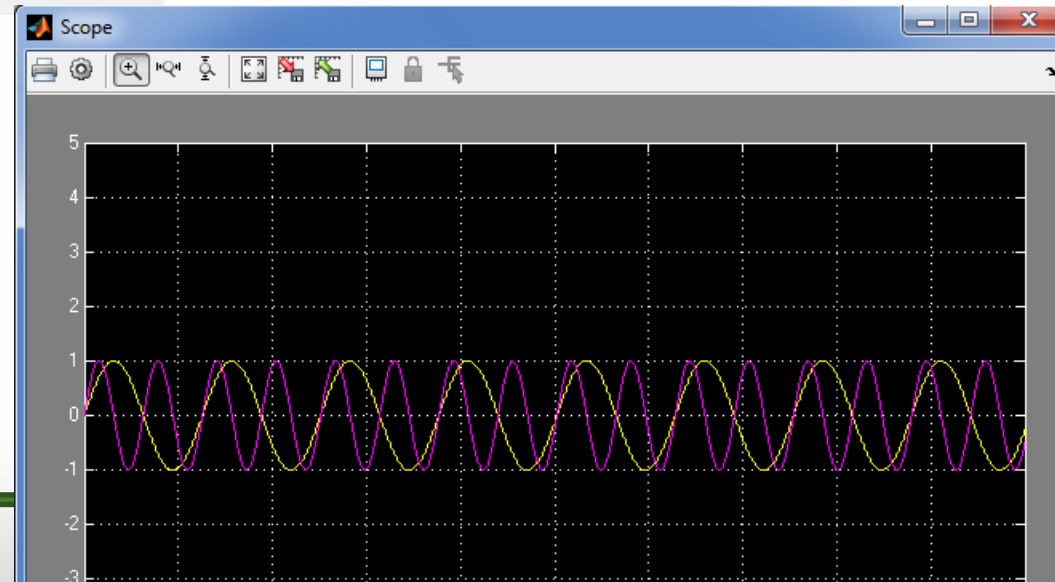
Solver options

Type: Fixed-step

Solver: ode3 (Bo

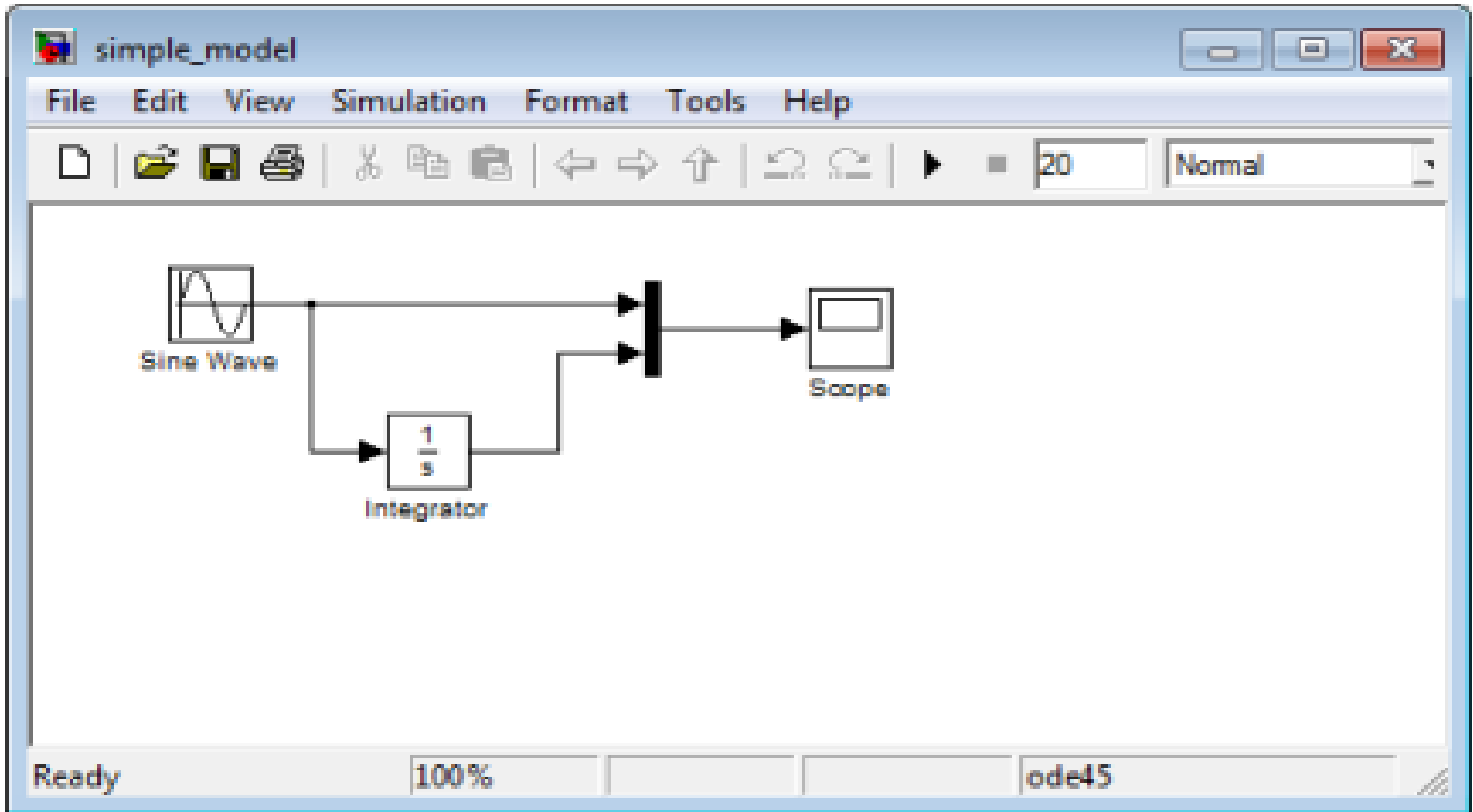
Fixed-step size (fundamental sample time):

1e-4



Examples

(1) Integration and Signals Multiplexing



- Integrator: Simulink- Continuous
- Integrator: Simulink – Commonly used Blocks

Examples: (2) Fourier Series

1.2 Let $x(t) = \frac{4}{\pi} \left[\sin(t) + \frac{1}{3} \sin(3t) + \frac{1}{5} \sin(5t) \right]$.

- a. Develop a Simulink model for $x(t)$ with an included information block. Assume a 10 s simulation time.

Parameters

Sine type: Time based

Time (t): Use simulation time

Amplitude: 4/pi

Bias: 0

Frequency (rad/sec): 1*2*pi

Amplitude: 4/(3*pi)

Bias: 0

Frequency (rad/sec): 3*2*pi

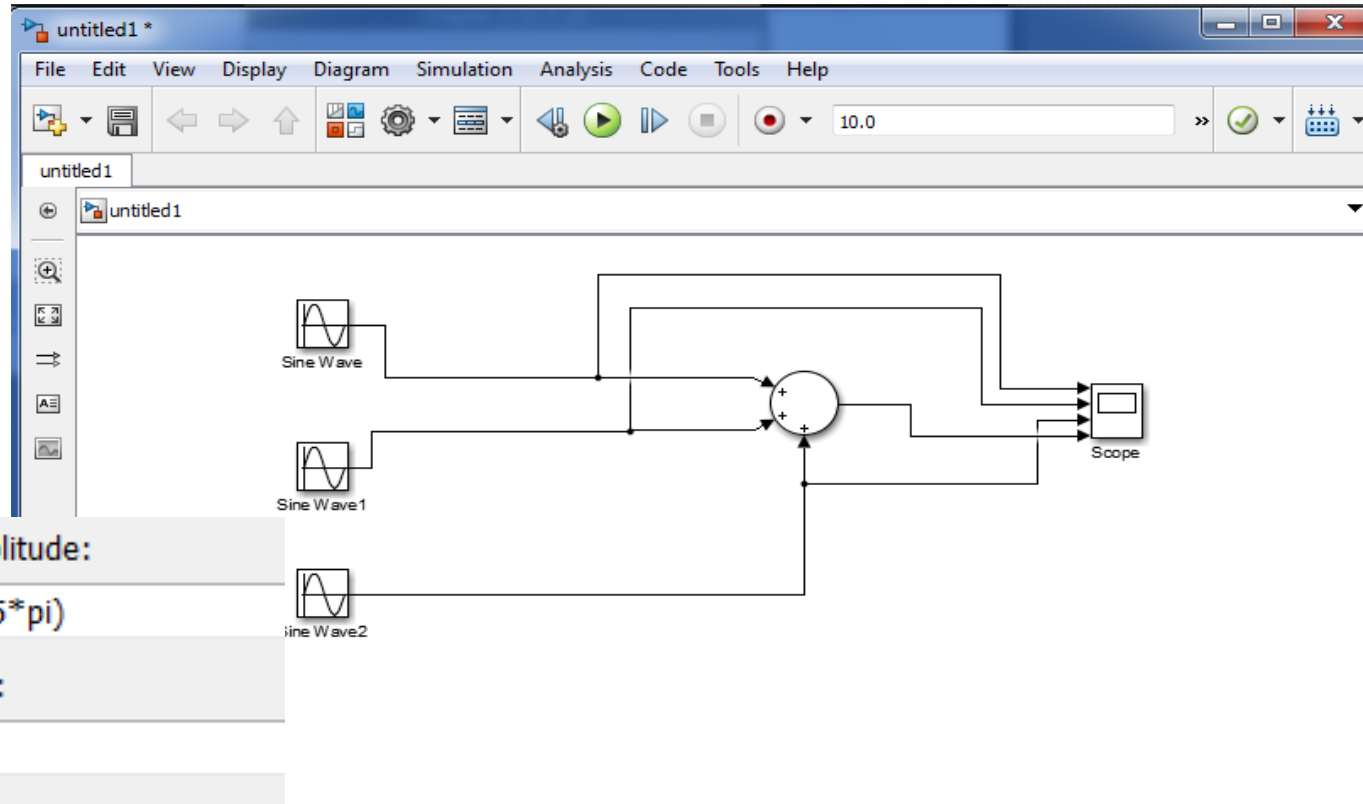
Phase (rad): 0

Amplitude: 4/(5*pi)

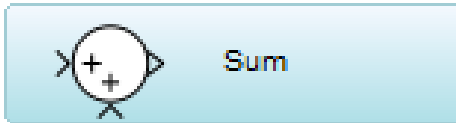
Bias: 0

Frequency (rad/sec): 5*2*pi

Phase (rad): 0



Examples: (2) Fourier Series



Function Block Parameters: Sum

Sum

Add or subtract inputs. Specify one of the following:

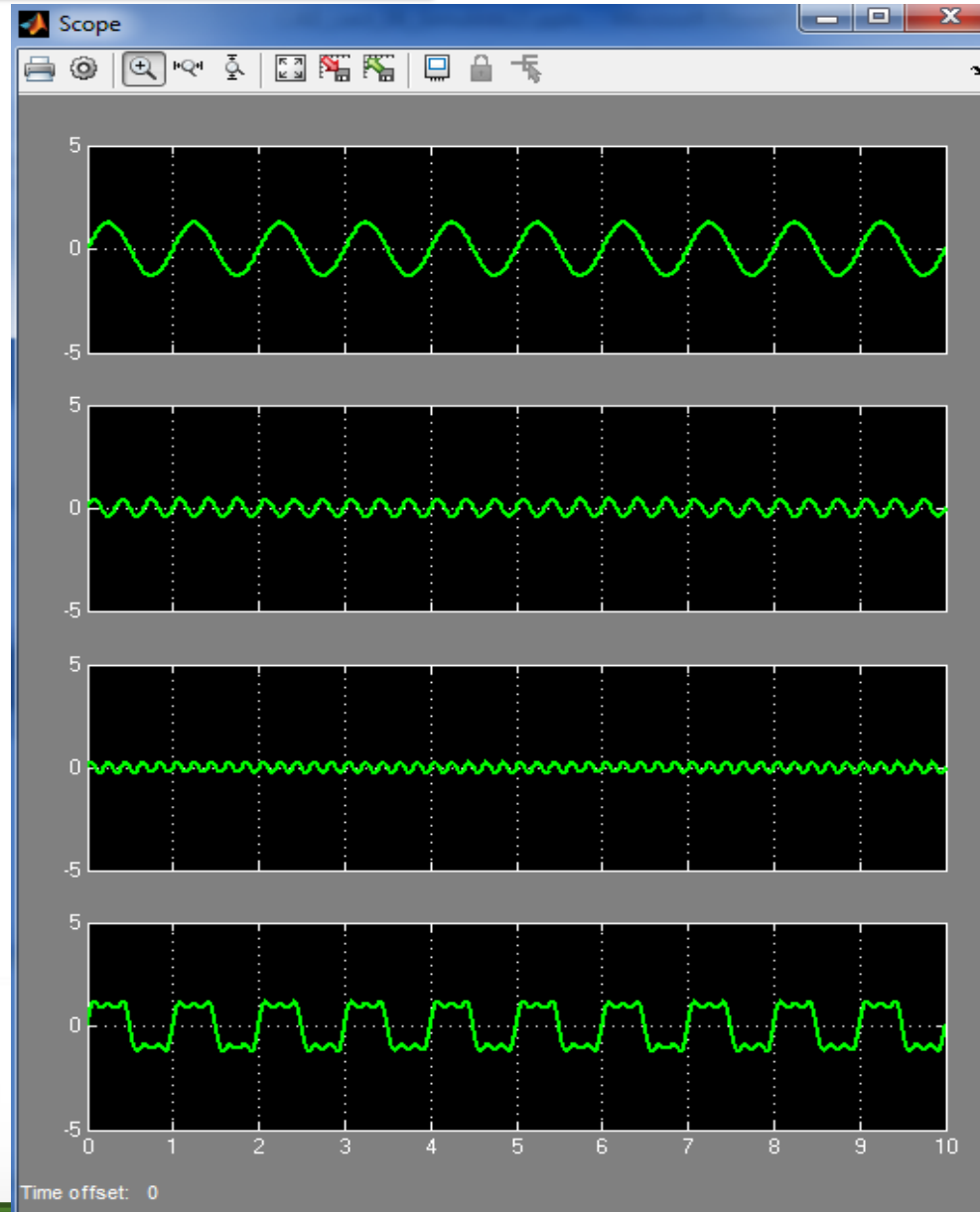
- a) string containing + or - for each input port, | for spacer between ports (e.g. ++|-|++)
- b) scalar, ≥ 1 , specifies the number of input ports to be summed. When there is only one input port, add or subtract elements over all dimensions or one specified dimension

Main | Signal Attributes

Icon shape: round

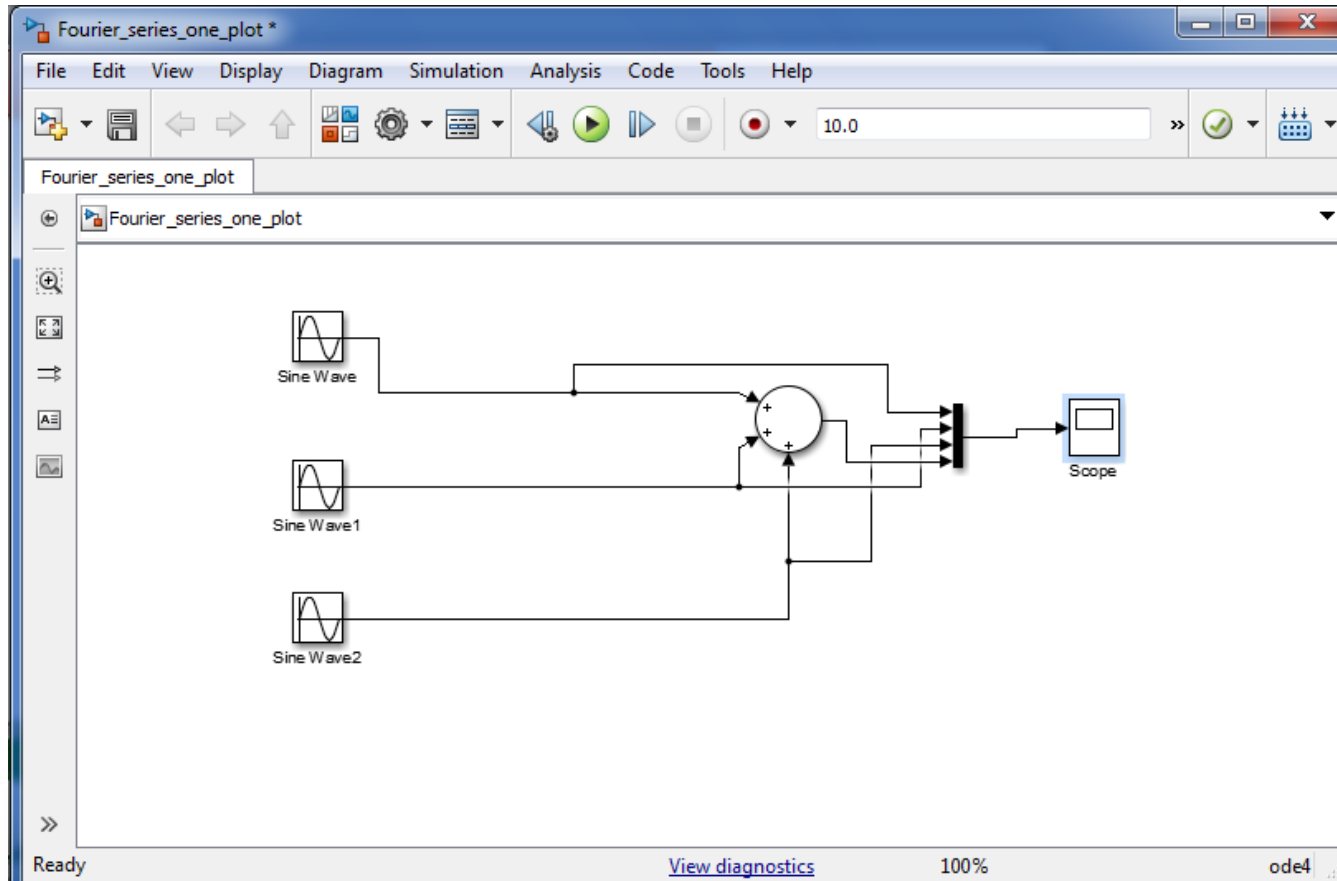
List of signs: +++

Sample time (-1 for inherited): -1



Examples: (2) Fourier Series

➤ Different Plotting



Examples: (2) Fourier Series

➤ Different Plotting

