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Ohio Supercomputer Center

Simulink Basics for Engineering Applications

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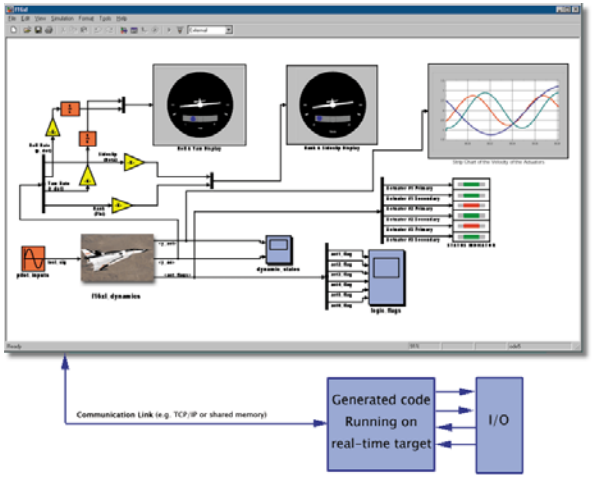
SC 09 Education Program, Saturday 11/14/09

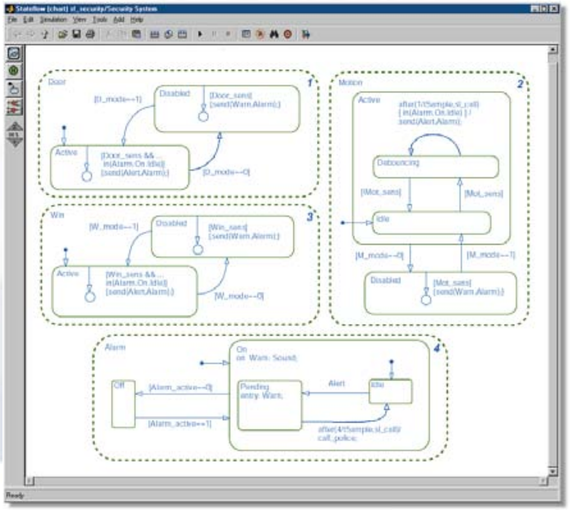
Basic concepts

- Simulink provides a graphical user interface (GUI) for building models as block diagrams, using click-and-drag mouse operations.
- Why use Simulink?
  - You can draw the models as you would with pencil and paper.
  - Designs are hierarchical, so that levels of details can be hidden or made explicit.
  - Simulations are interactive, so you can change parameters “on the fly”.
  - Simulink includes a comprehensive block library of sinks, sources, linear and nonlinear components, and connectors.
  - C code or executables can be generated from a Simulink model by using Real-Time Workshop.

Associated Products - 1

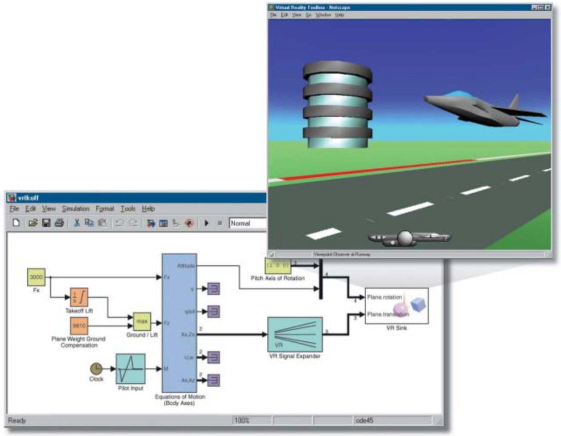


- Stateflow
- Simulink Performance Tools
- Sateflow Coder
- Real-time Workshop
- Real-time Workshop Embedded Coder
- Real-time Workshop ADA Coder
- Real-time Windows Target



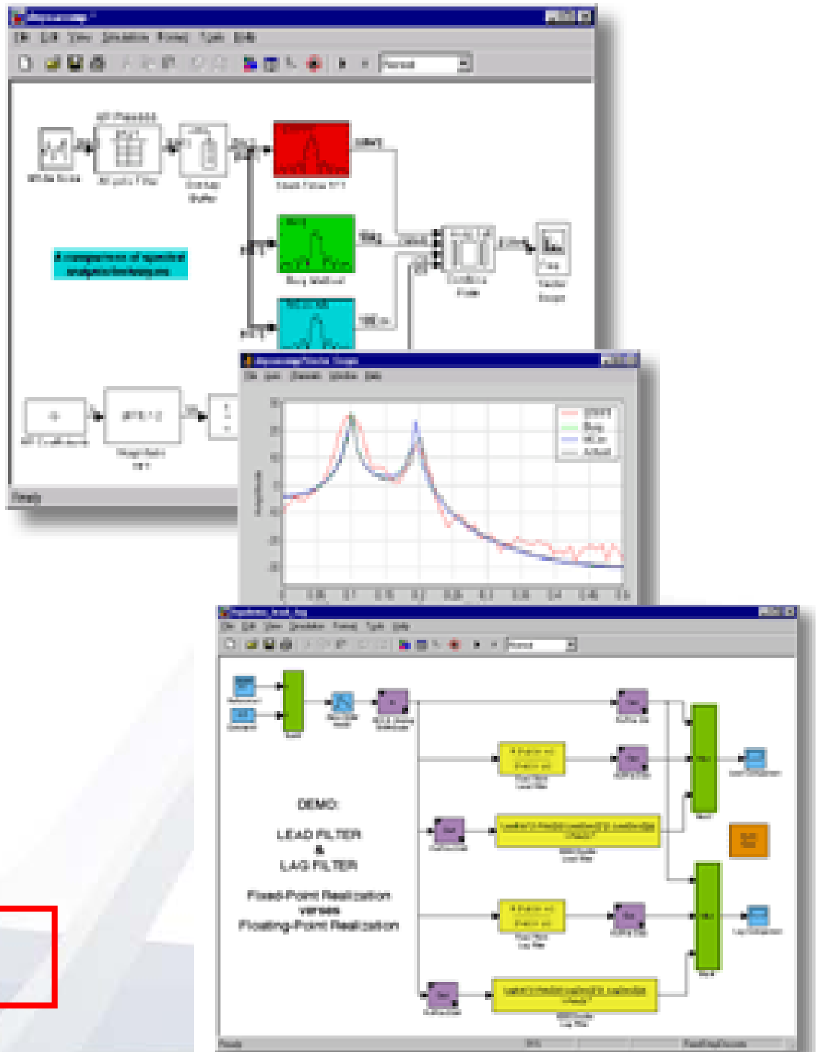
Associated Products - 2

- xPC Target
- xPC Targetbox
- xPC Target Embedded Option
- Simulink Report Generator
- Requirements Management Interface
- Virtual Reality
- SimMechanics
- Embedded Target MPC555



Simulink Blocksets

- Aerospace
- CDMA Reference
- Communications
- Dials and Gauges
- DSP
- Fixed Point
- Nonlinear Control Design
- Power Systems



A blockset is a library of blocks

A Typical Simulink Model

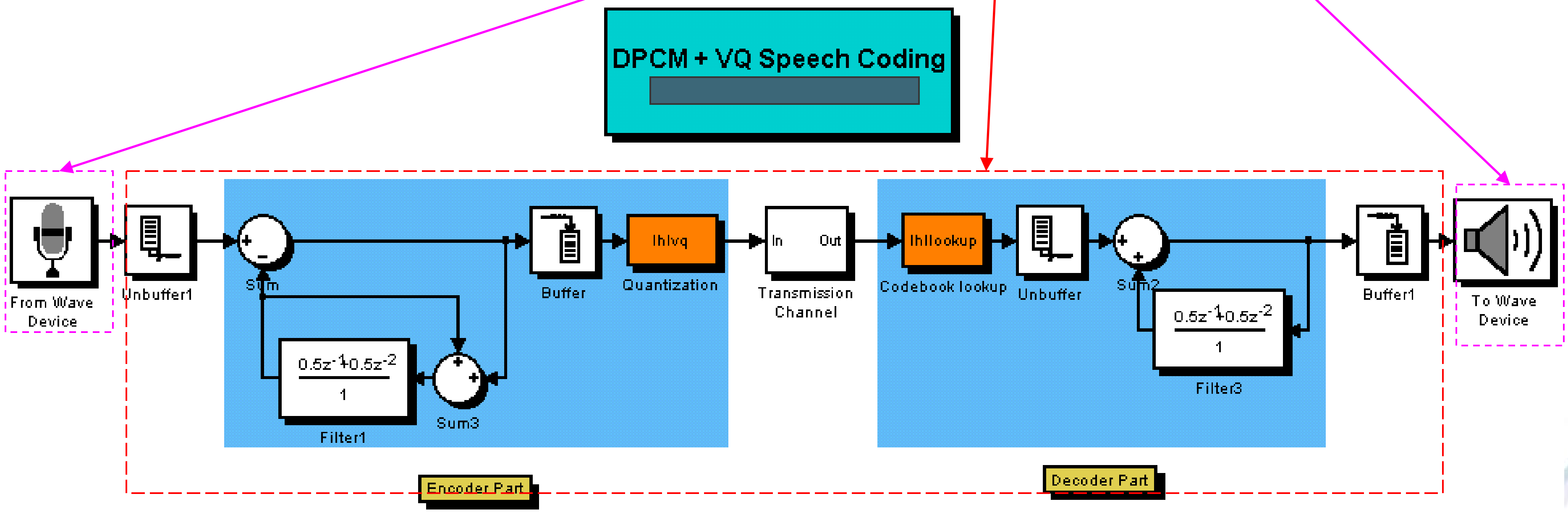
- Includes Sources, Systems and Sinks.

Sources → Systems → Sinks

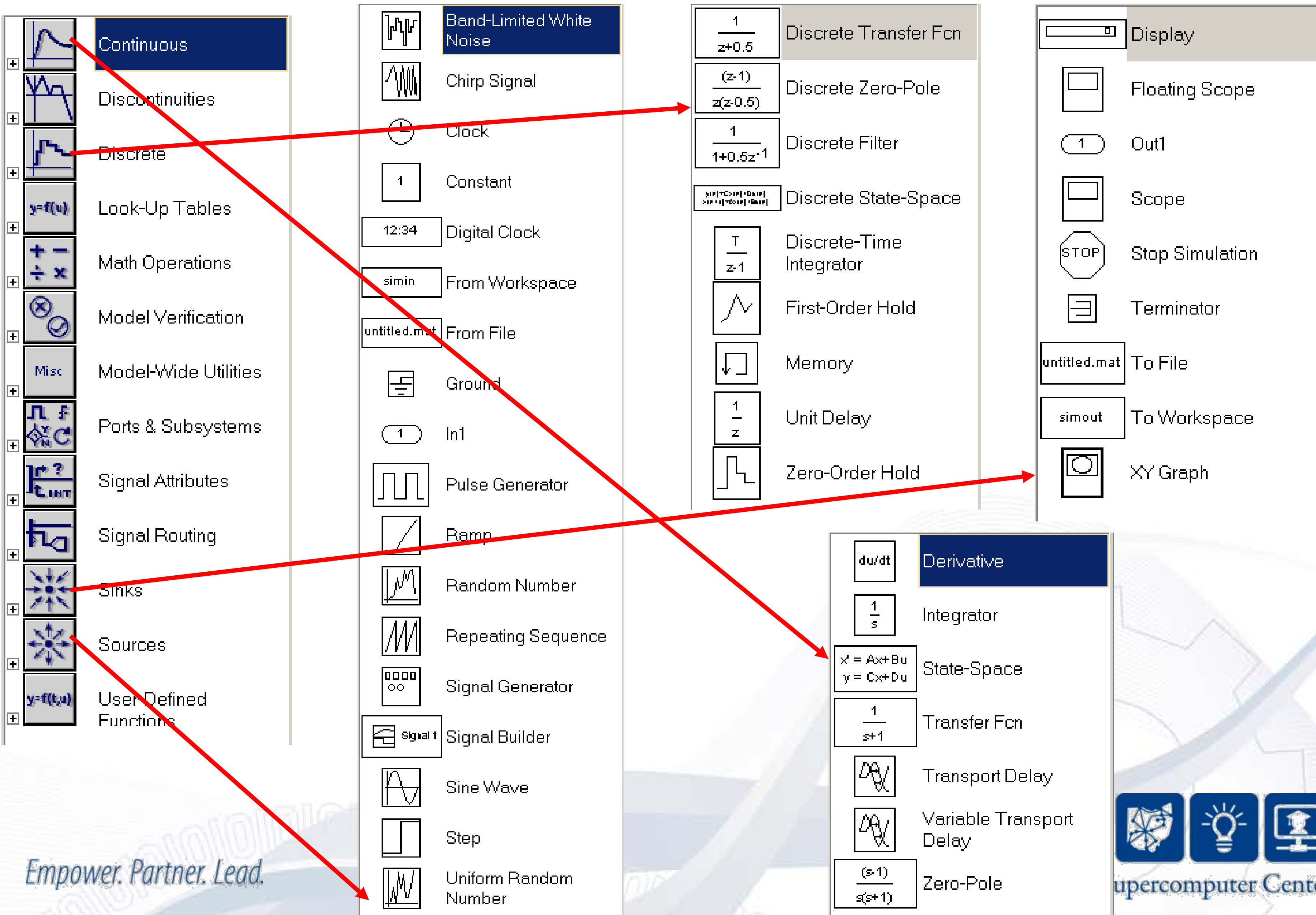
Sources	Systems	Sinks
Random Signals Function Generators From MATLAB Workspace From Disk Files	Interconnection of Linear and Nonlinear blocks	Displays Scopes FFT Scopes To MATLAB Workspace To Disk Files

A Typical Simulink Model

A typical Simulink model includes Source, System and Sink.



Block Choices in Simulink



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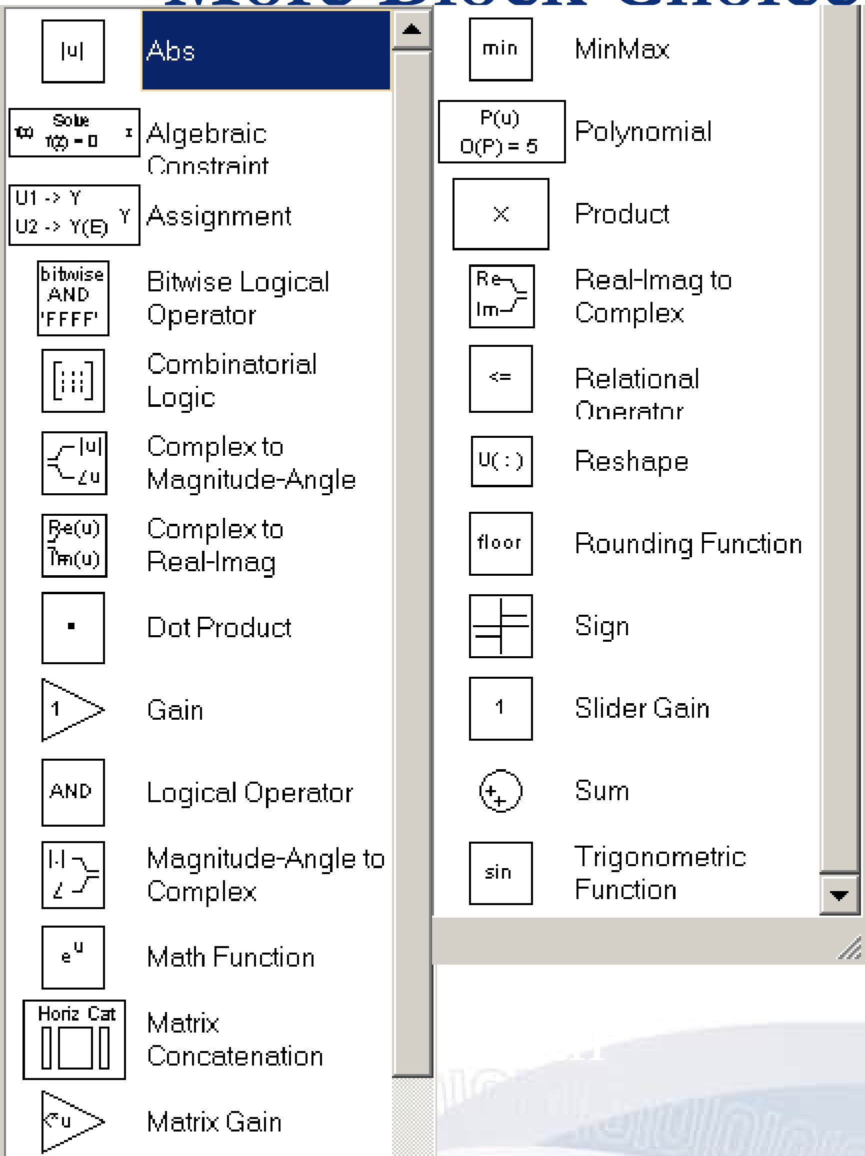
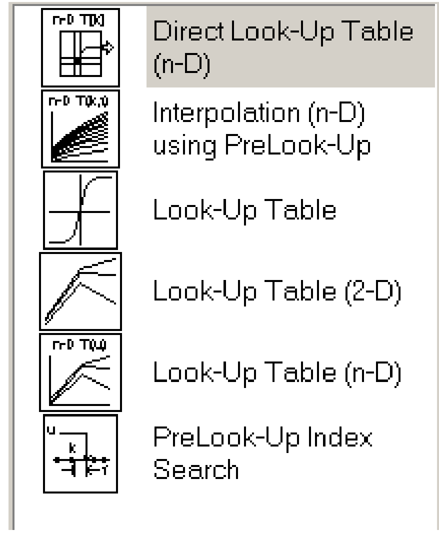
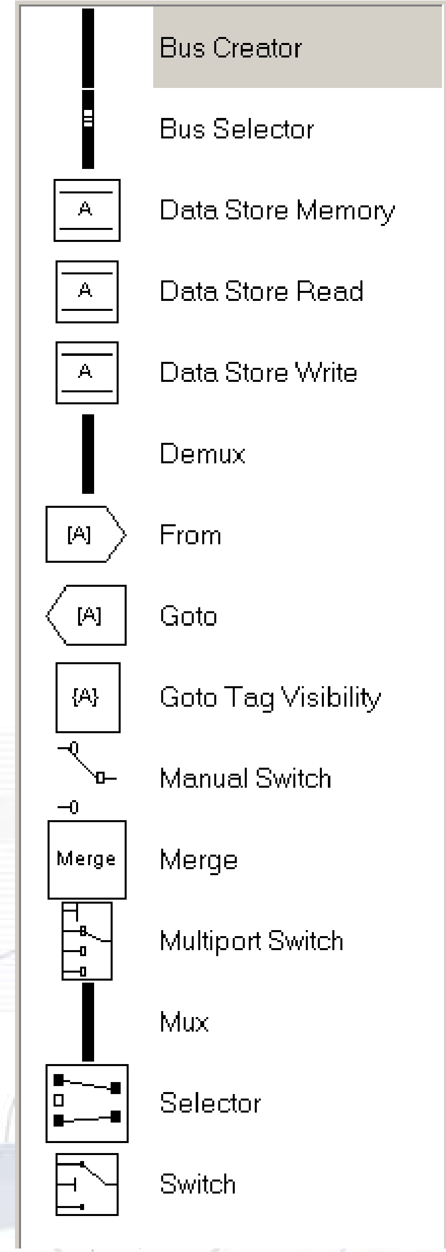
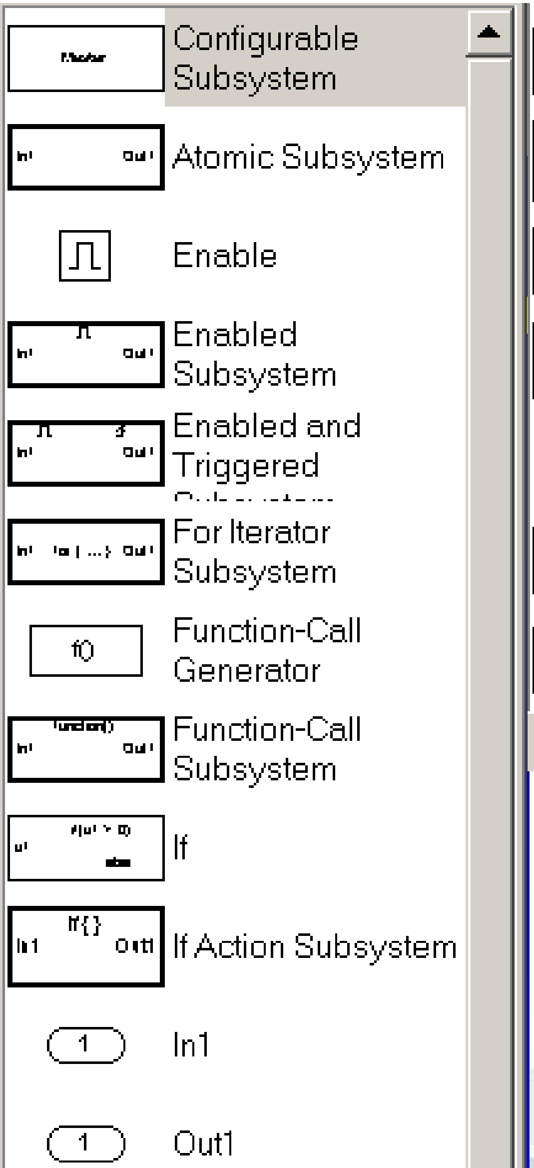
More Block Choices

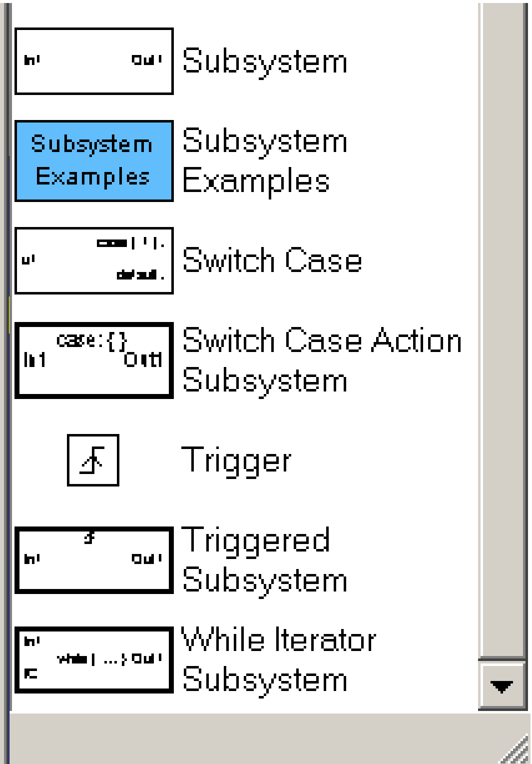


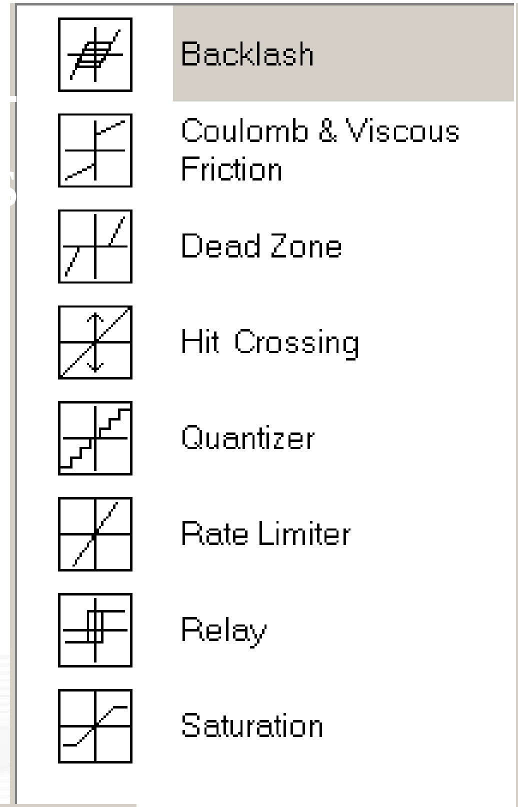


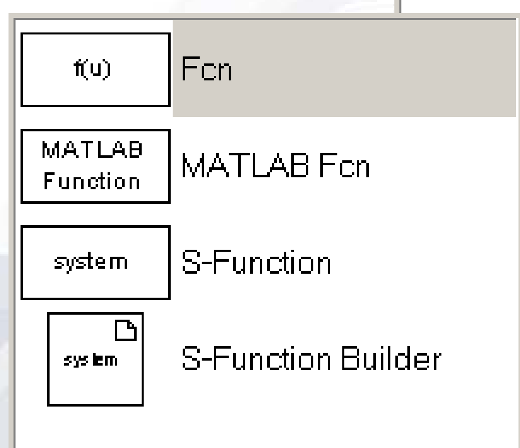


Yet More Simulink Blocks



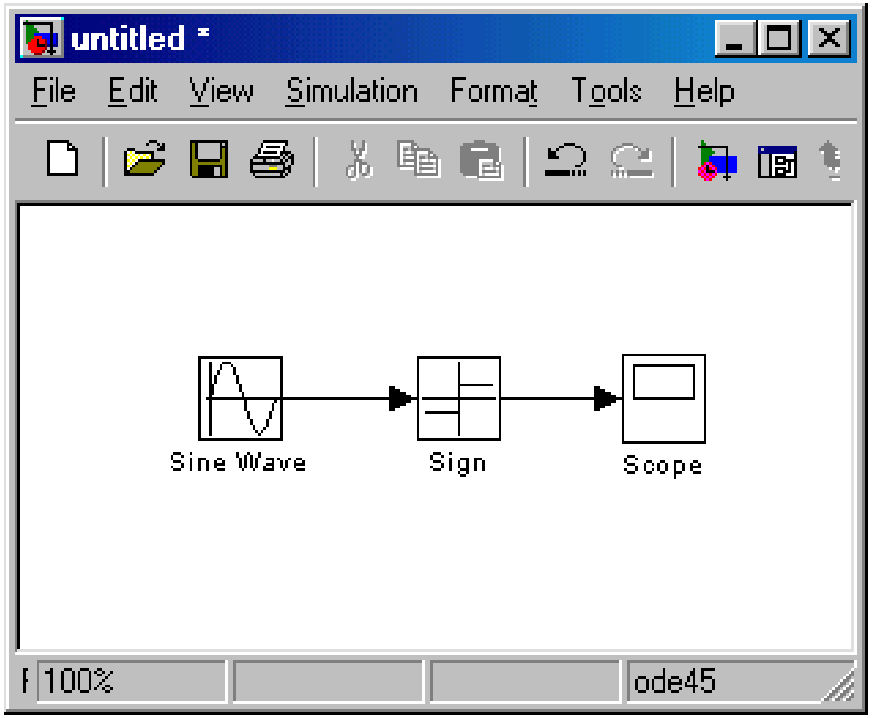


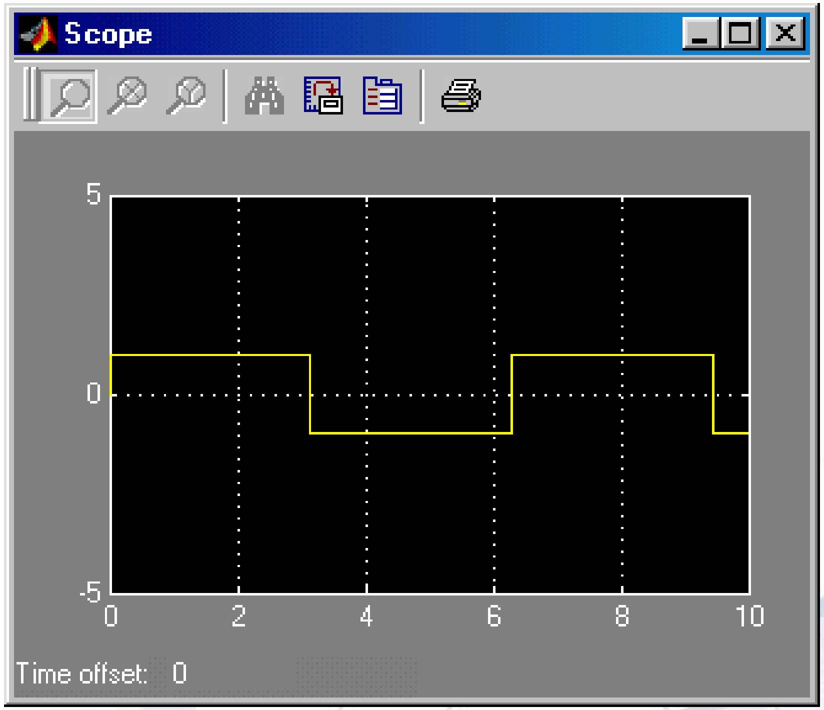




Now, let's build a simple model!

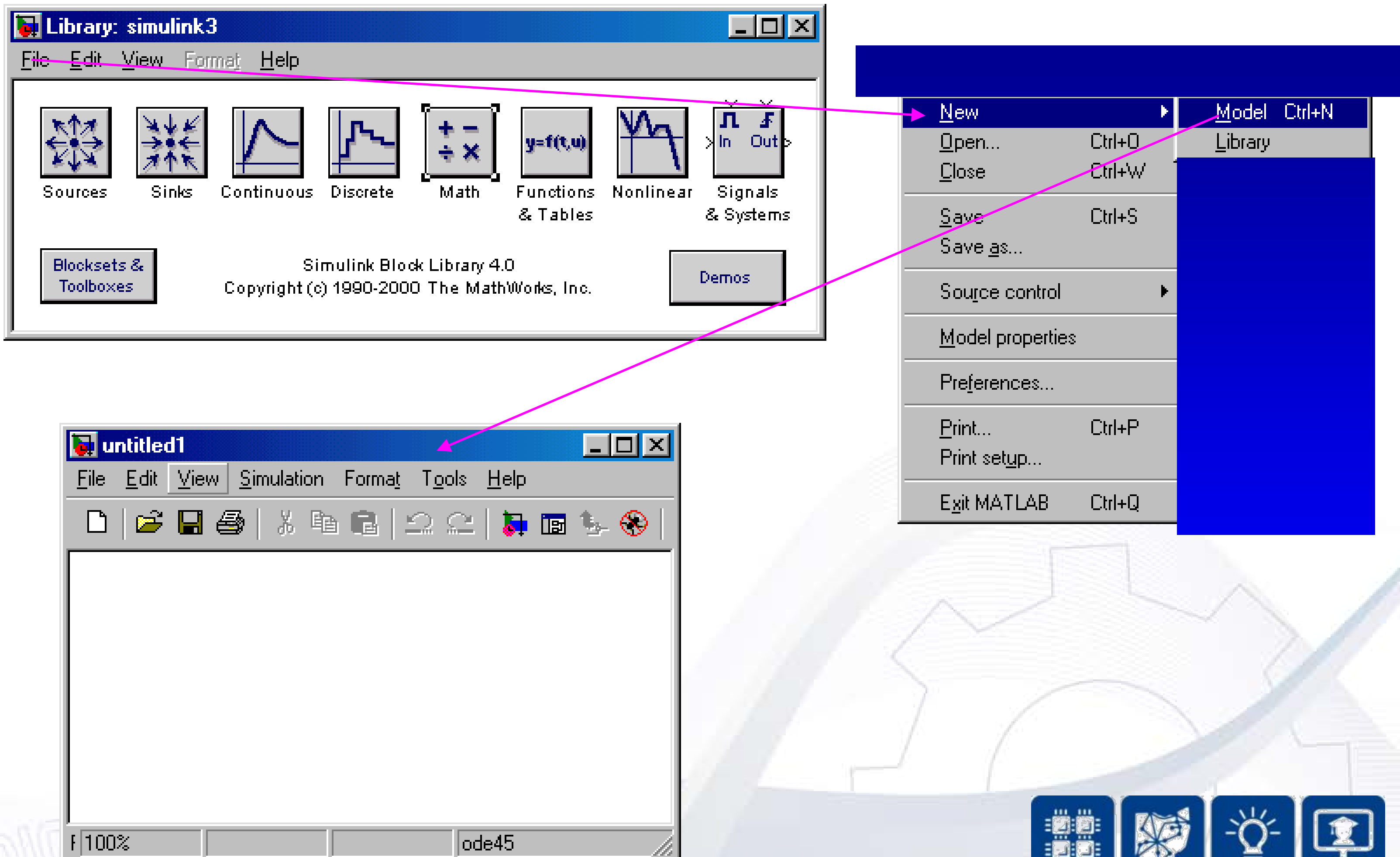
This model plots the sign of the input signal.





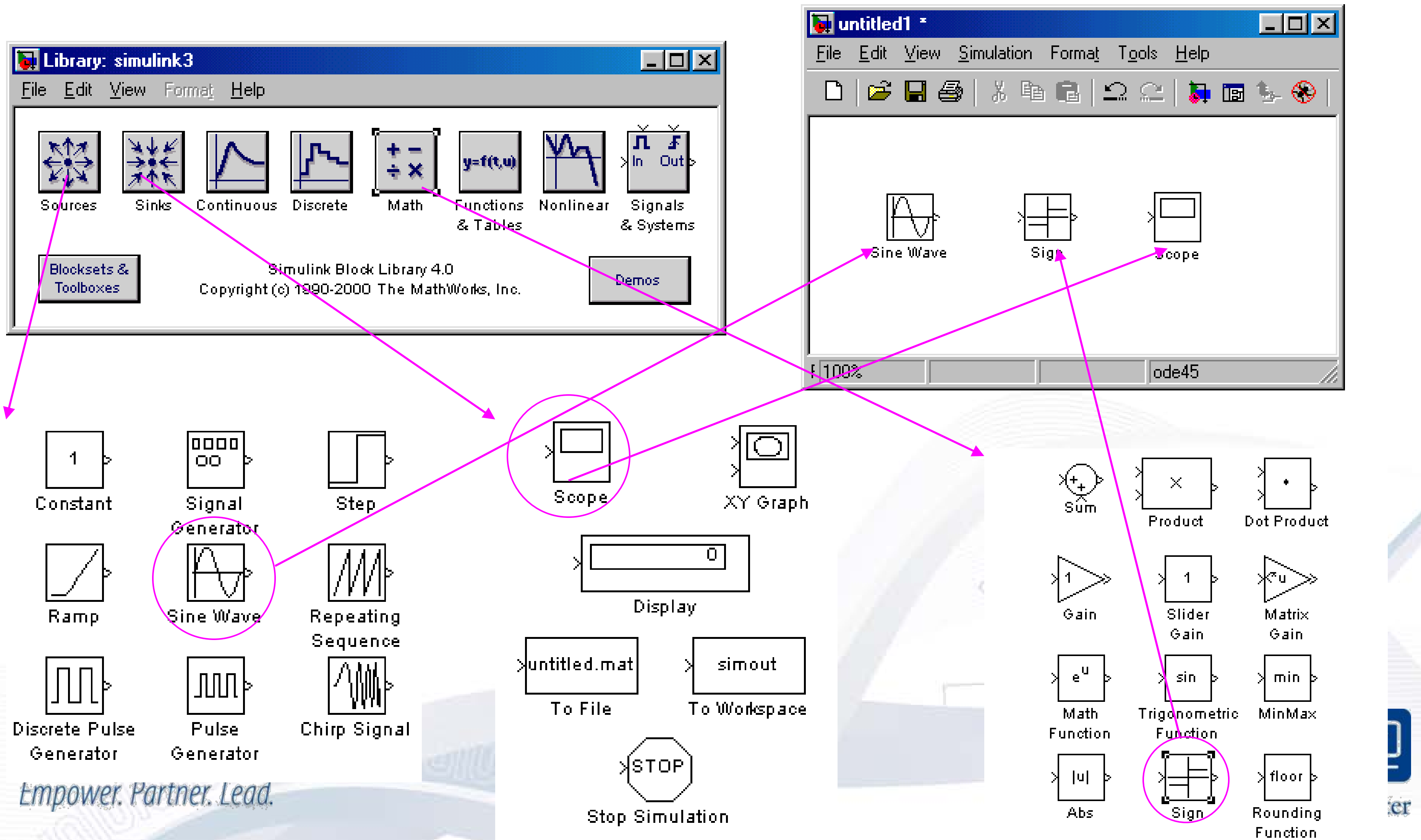
Example -- Step 1

Step1: Start Simulink and choose New then Model from the File menu.



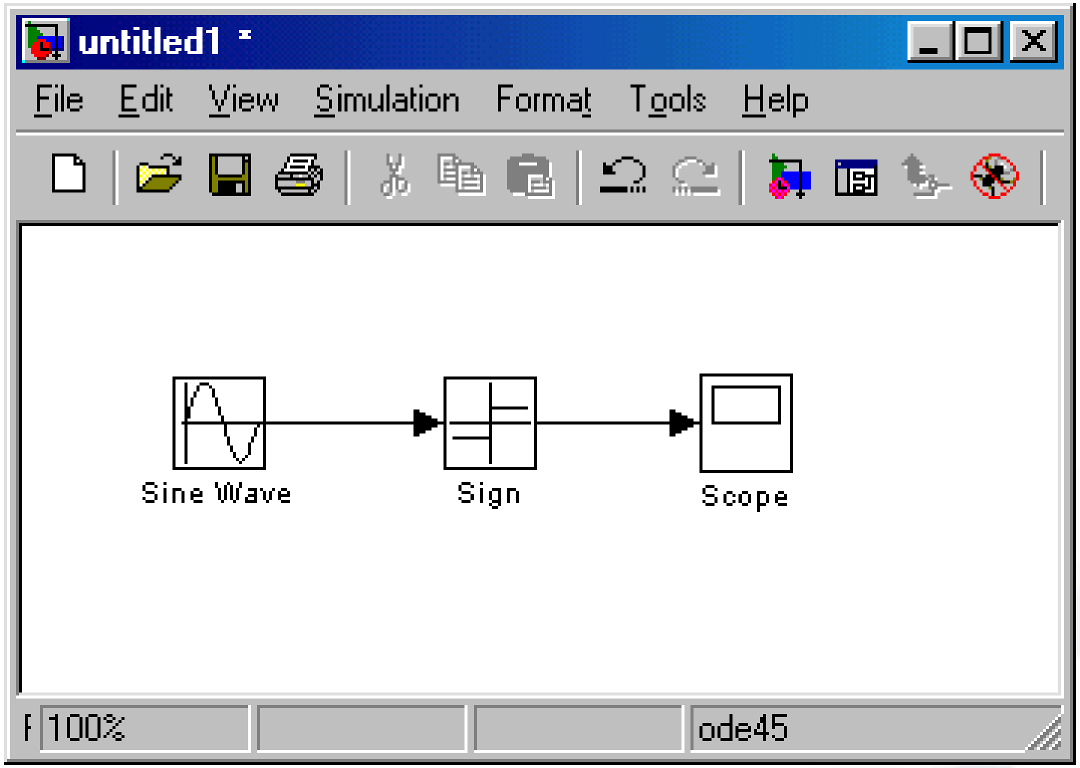
Example -- Step 2

Step2: Copy the needed blocks by using Drag and Drop.



Example -- Step 3

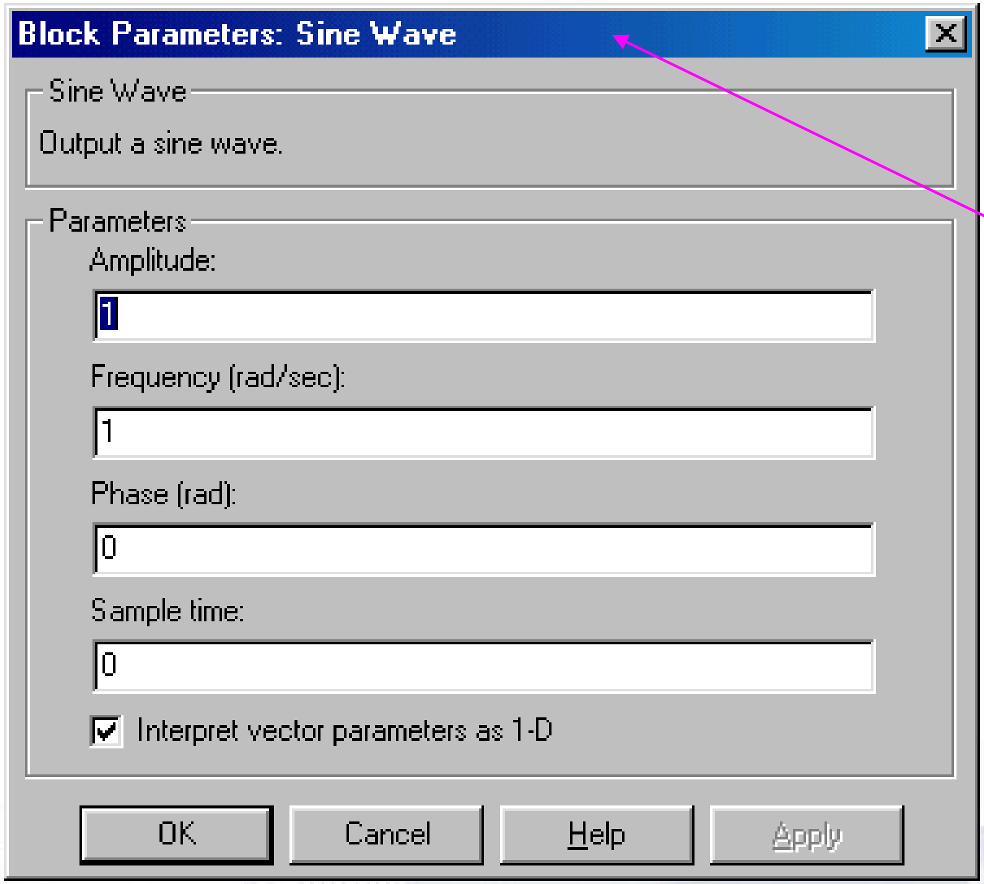
Step3: Complete the connection.

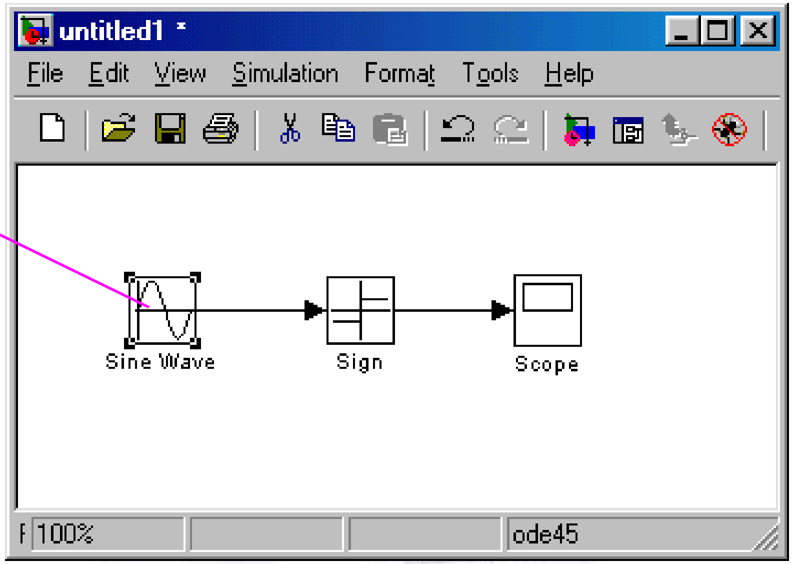


- Move the mouse to the location of output port of the source block.
- Hold down the mouse button and move the cursor to the input port of the destination block.
- Release the mouse button.

Example -- Step 4

Step4: Set the block parameters.

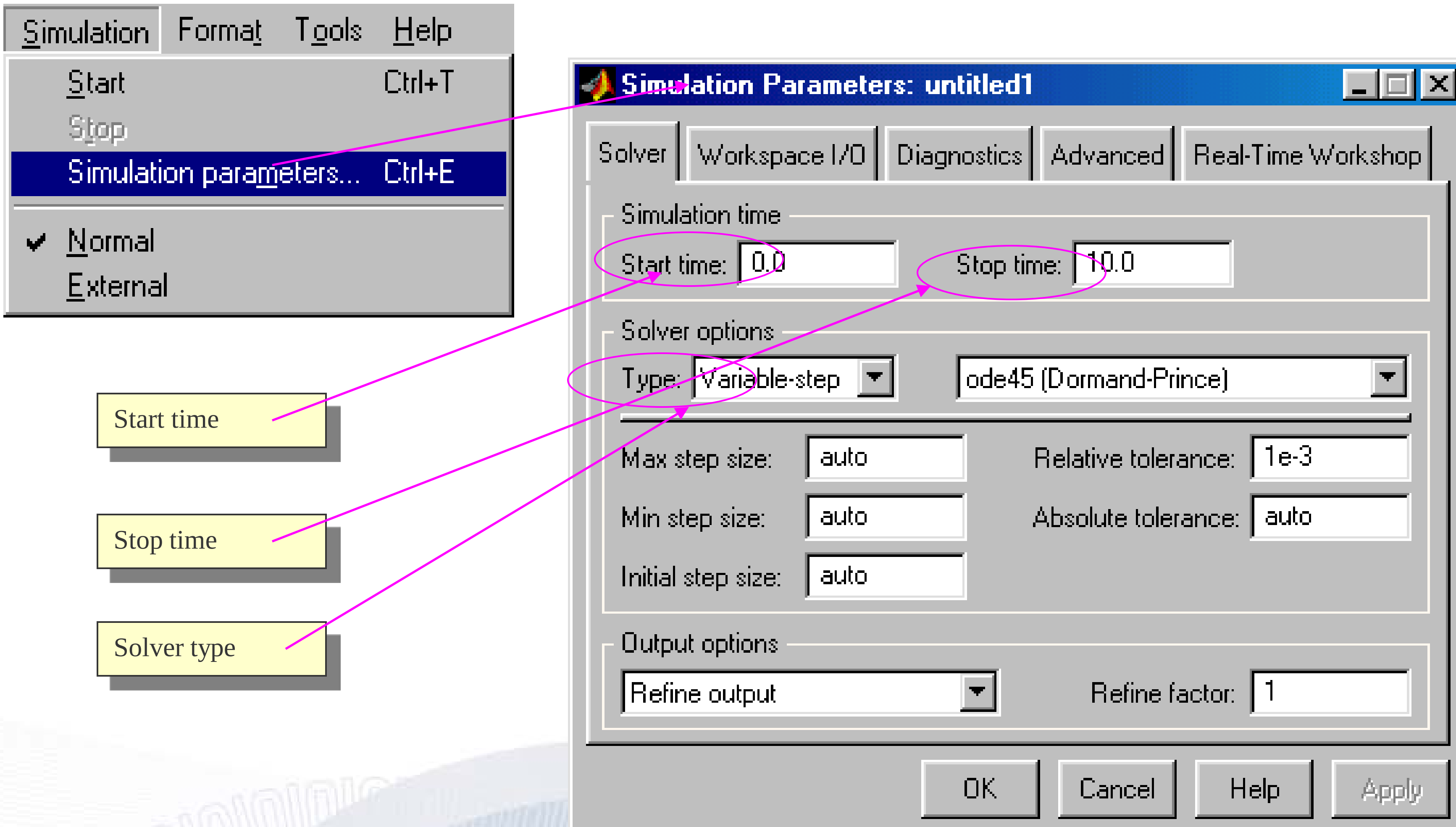




Double click a block to open its block parameters.

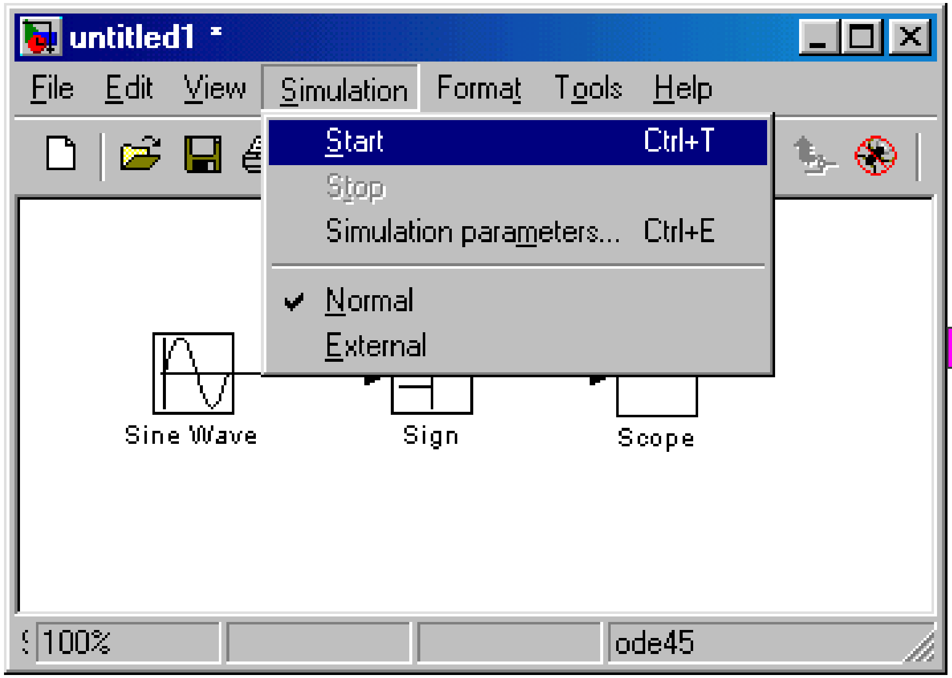
Example -- Step 5

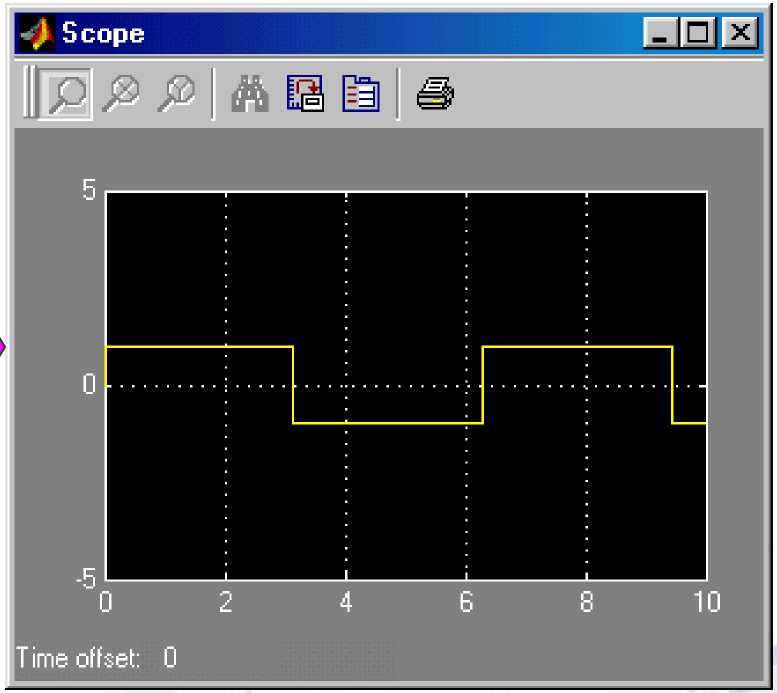
Step5: Setup the simulation parameters.



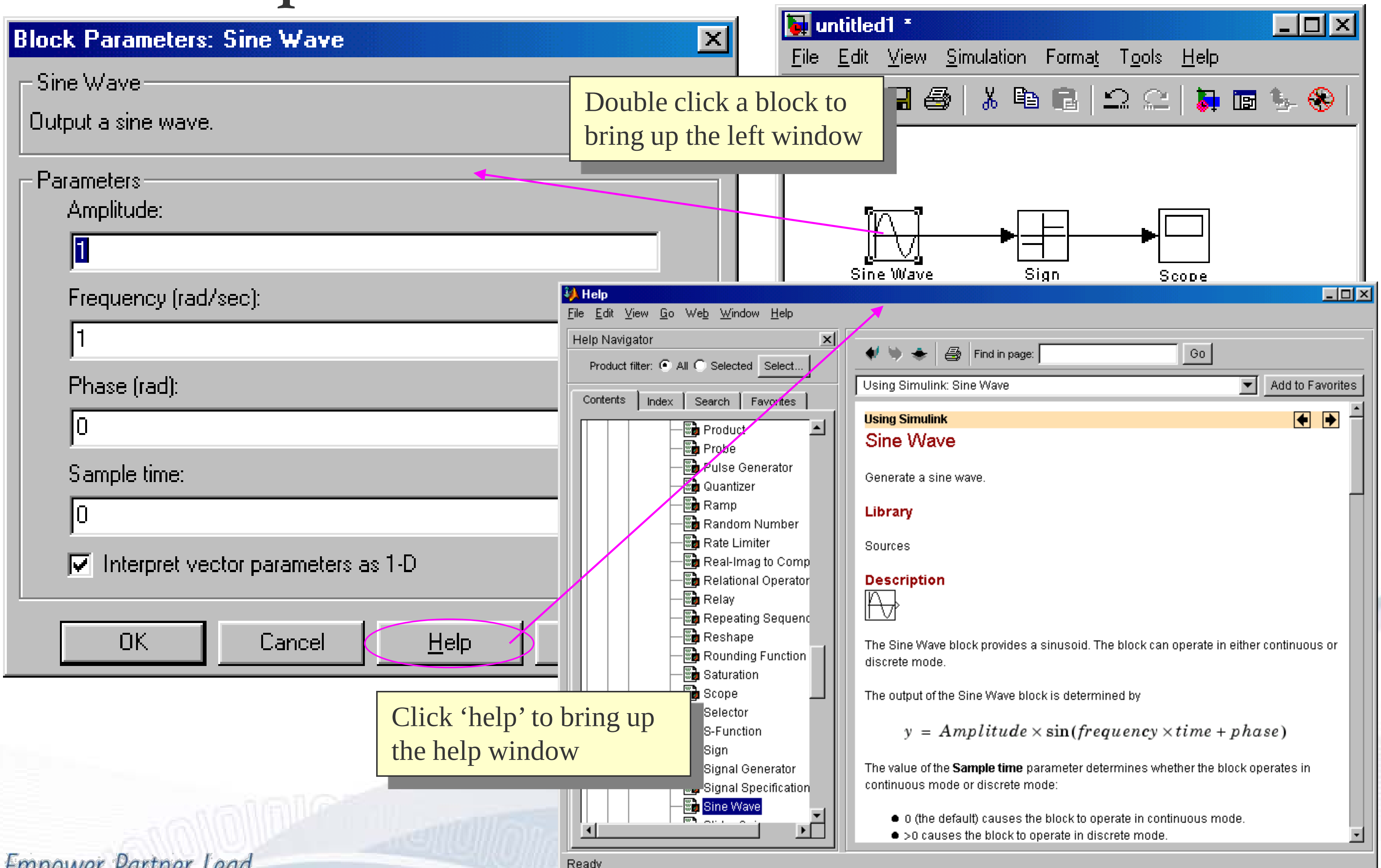
Example -- Step 6

Step6: Start simulation.





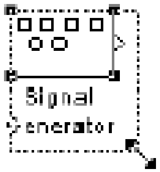
Need help?



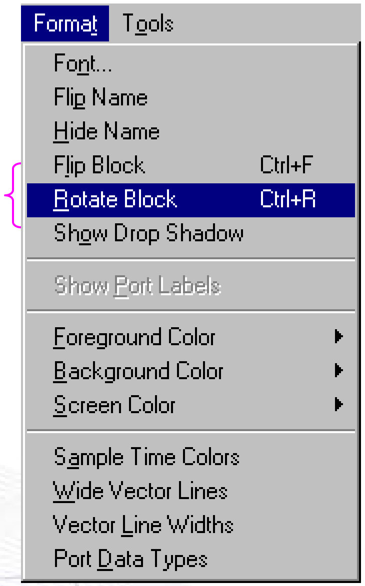
Double click a block to bring up the left window

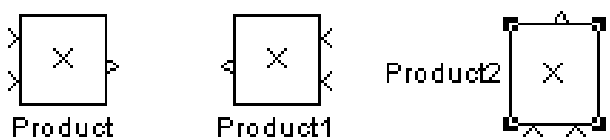
Click 'help' to bring up the help window

Manipulating blocks

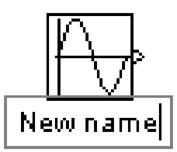


Select a corner and drag to resize a block



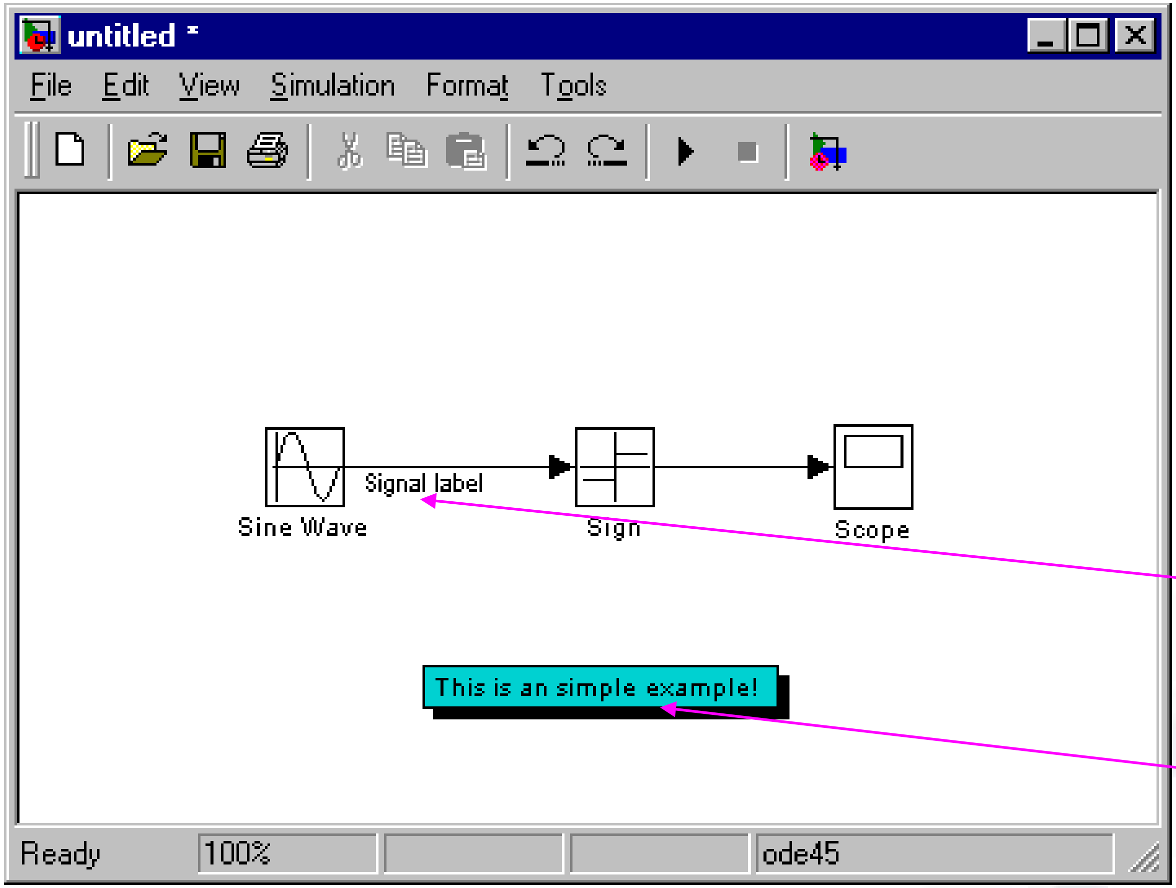


Rotating a block



Single click on the block label to change block name

Labels and Annotations

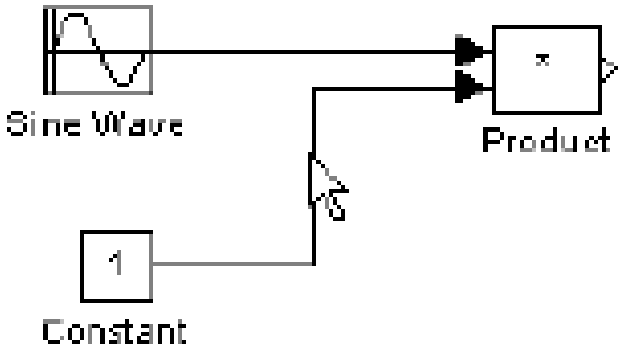


Double click a line to add line label

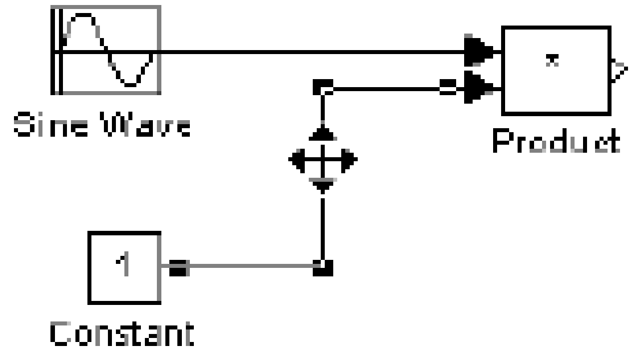
Double click an empty area to add annotation

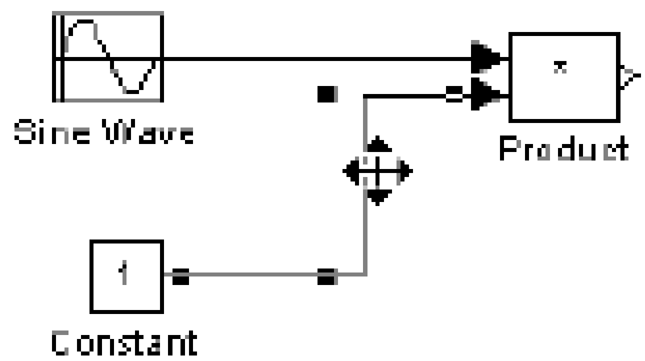
Moving a line segment

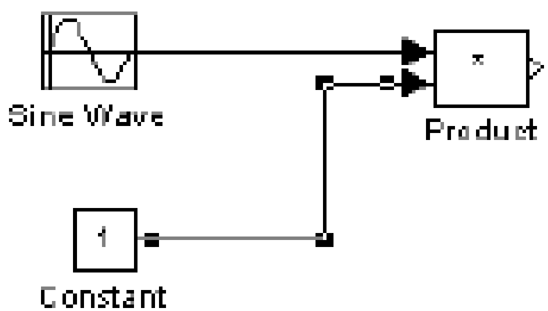
Step1: **Position the pointer on the segment you want to move.**



Step2: **Press and hold down the left mouse button.**



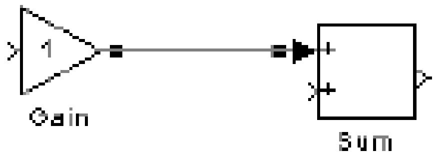




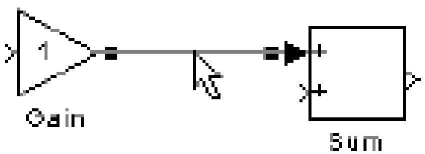
Step3: **Drag the pointer to the desired location.**

Step4: **Release the mouse button.**

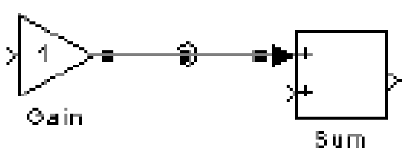
Dividing a line into segments



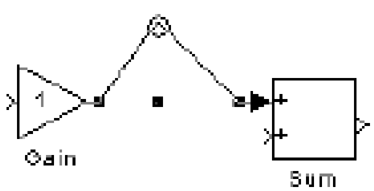
Step1: Select the line.



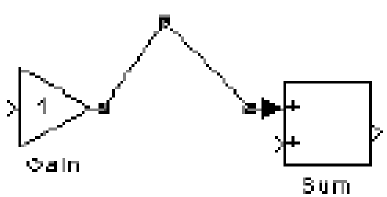
Step2: Position the pointer on the line where you want the vertex.



Step3: While holding down the Shift key, press and hold down the mouse button.

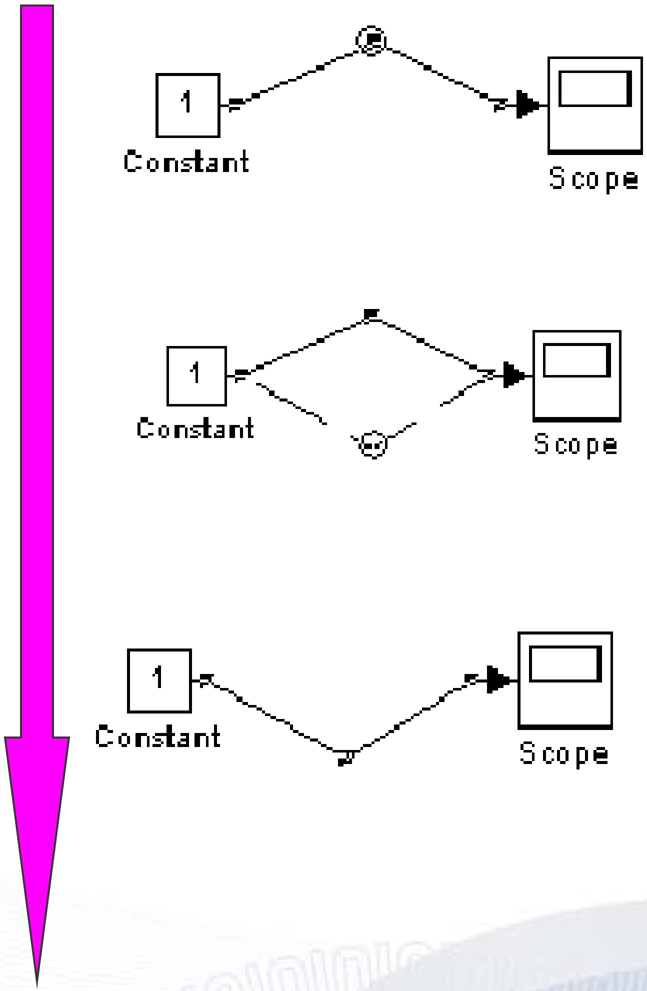


Step4: Drag the pointer to the desired location.



Step5: Release the mouse button and the Shift key.

Dividing a line into segments

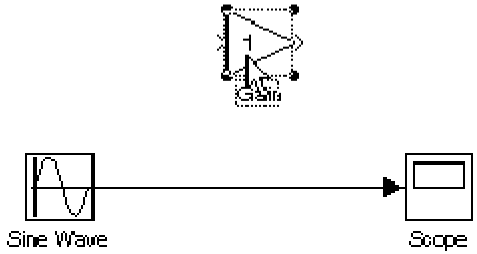


Step1: **Position the pointer on the vertex, then press and hold down the mouse button.**

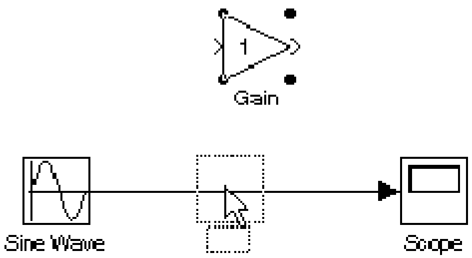
Step2: **Drag the pointer to the desired location.**

Step3: **Release the mouse button.**

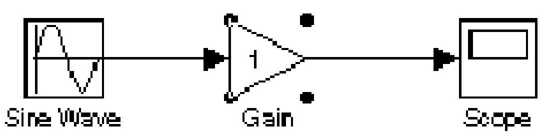
Inserting a block in a line



Step1: Position the pointer over the block and press the left mouse button.



Step2: Drag the block over the line in which you want to insert the block.



Step3: Release the mouse button to drop the block on the line.

Example 2: Revisit van der Pol's equation

- Recall that the equation is

$$d^2x/dt^2 - \mu(1-x^2)dx/dt + x = 0$$

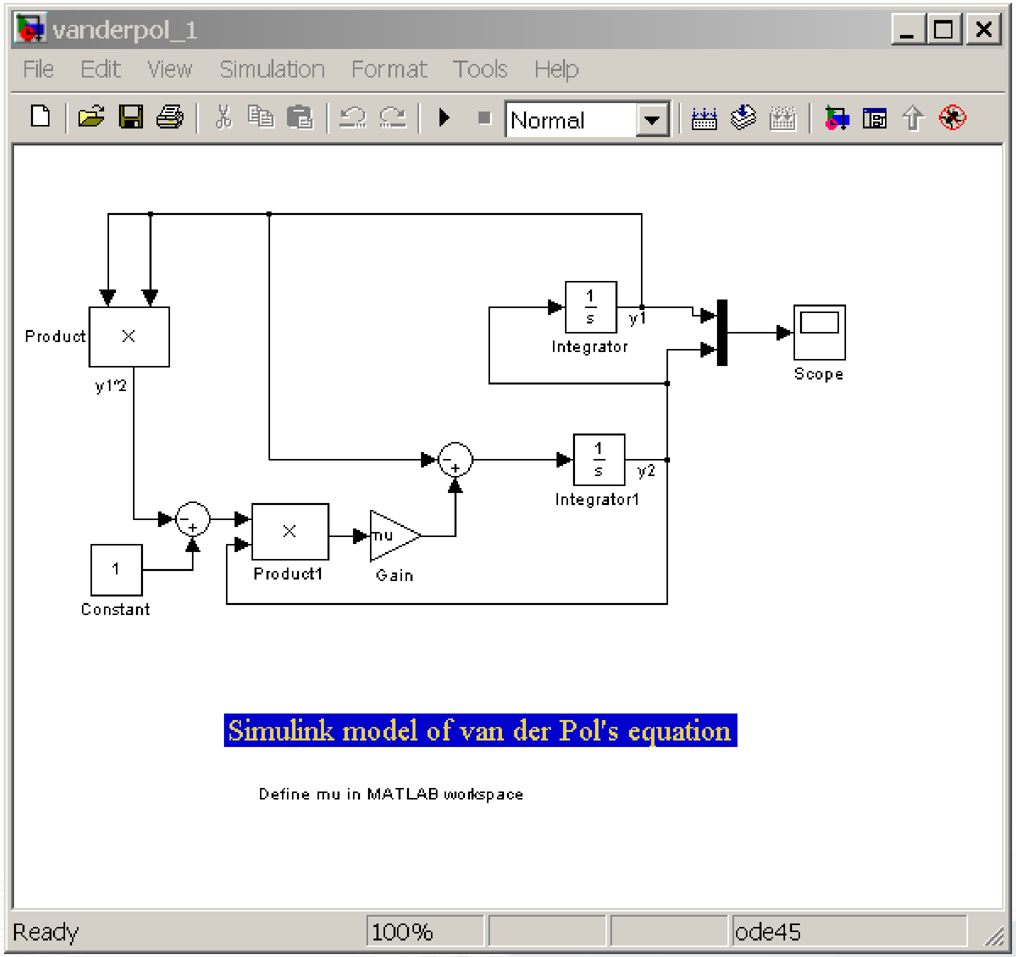
- Convert to first order ODEs using

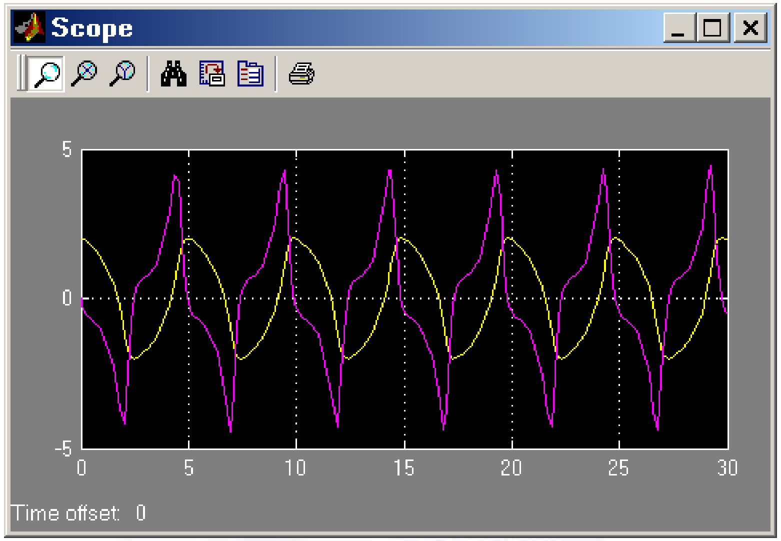
$$dy_1/dt = y_2$$

$$dy_2/dt=\mu(1-y_1^2)y_2-y_1$$

  where $y_1 = x$, and $y_2 = dx/dt$
- In Simulink, start with two integrator blocks, one for y_1, another for y_2.
- Then use Sum, Product and Gain blocks to create dy_1/dt and dy_2/dt as inputs to the integrator blocks.

Simulink model of van der Pol





Example 3: Leaky Integrator

- An ideal integrator is described by the equation

$$dy/dt = x(t),$$

where y(t) is the output and x(t) is the input.

- A leaky integrator is described by the equation

$$dy/dt = x(t) - \mu y(t), \mu > 0$$

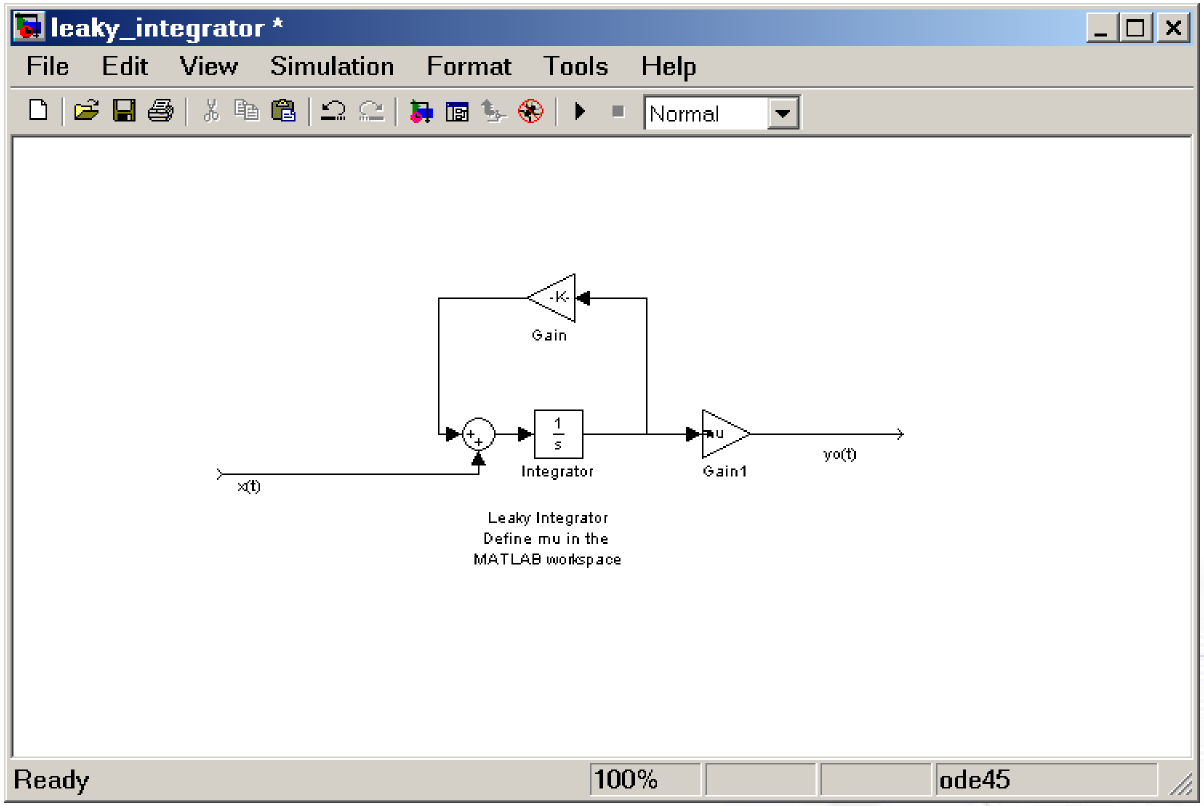
- The solution, for x(t) = Ku(t), is

$$y(t) = (K/\mu)\,(1 - e^{-\mu t})u(t)$$

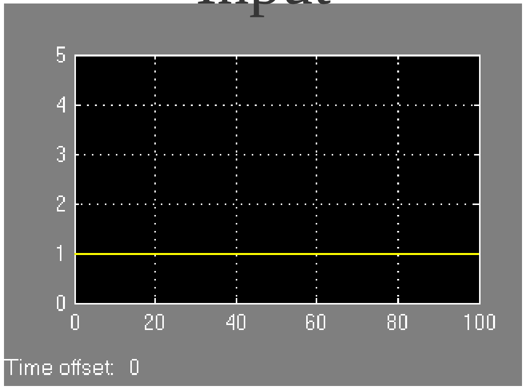
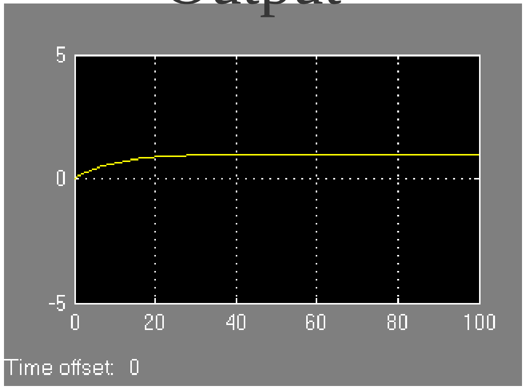
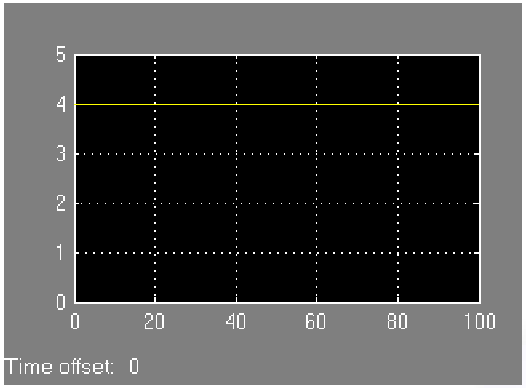
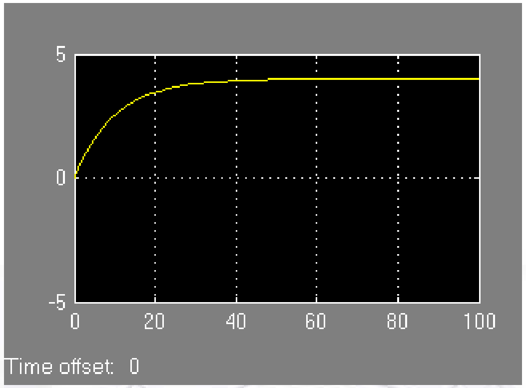
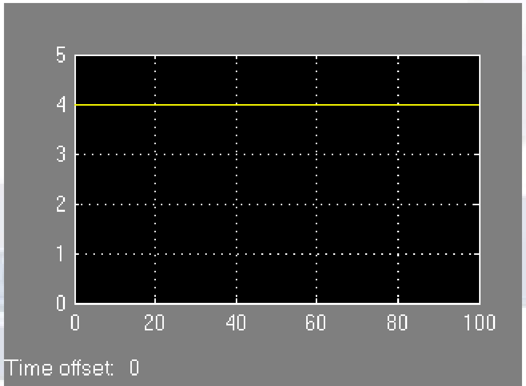
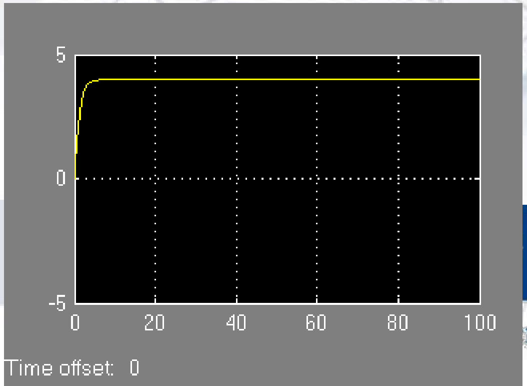
- If we want the steady state output for a constant input to be the same constant, we can add a gain term of μ at the output.

$$y_o(t) = \mu y(t)$$

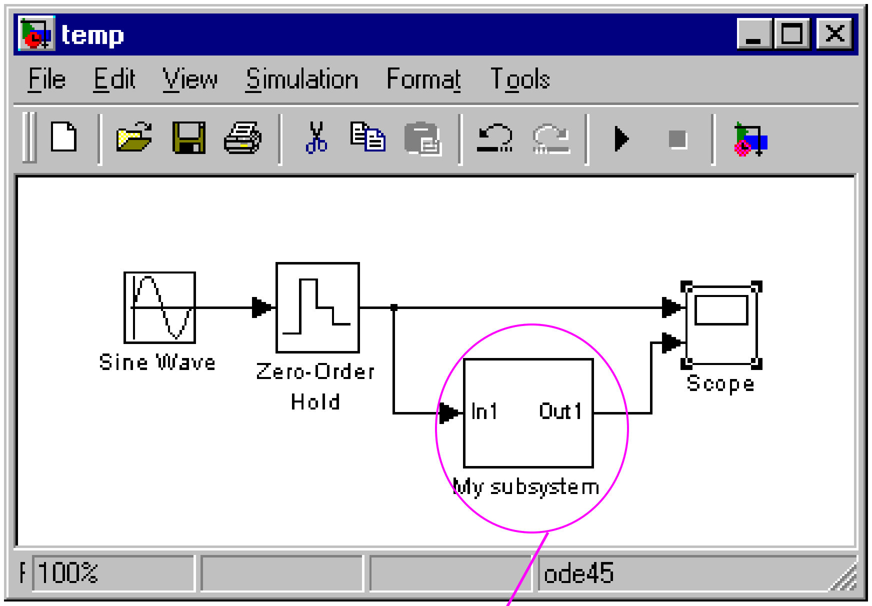
Simulink model for leaky integrator

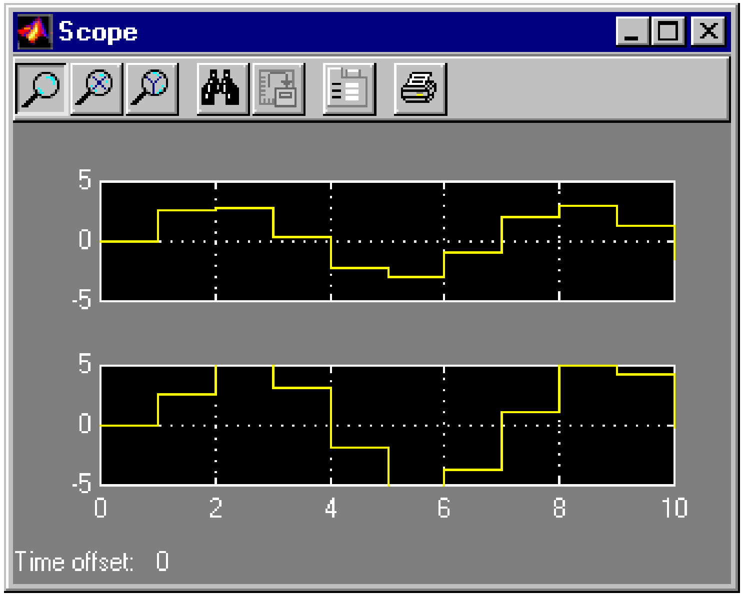


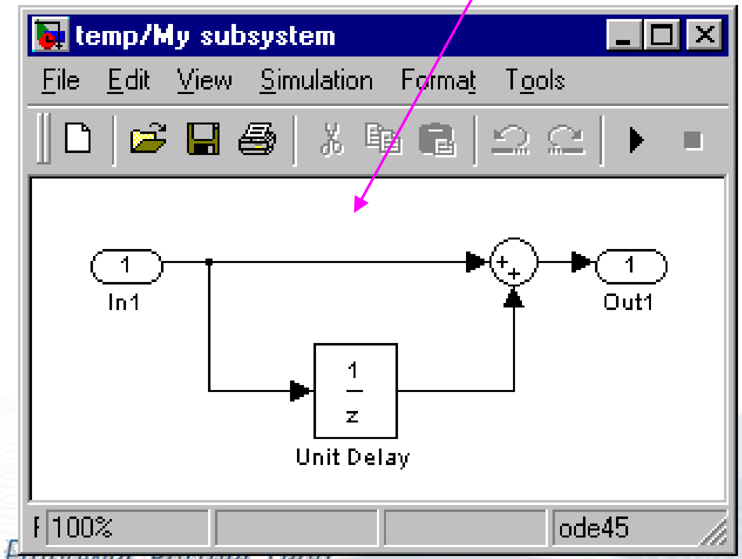
Output of leaky integrator

	Input	Output
μ= 0.1 K = 1		
μ= 0.1 K = 4		
μ= 0.9 K = 4		

Subsystems





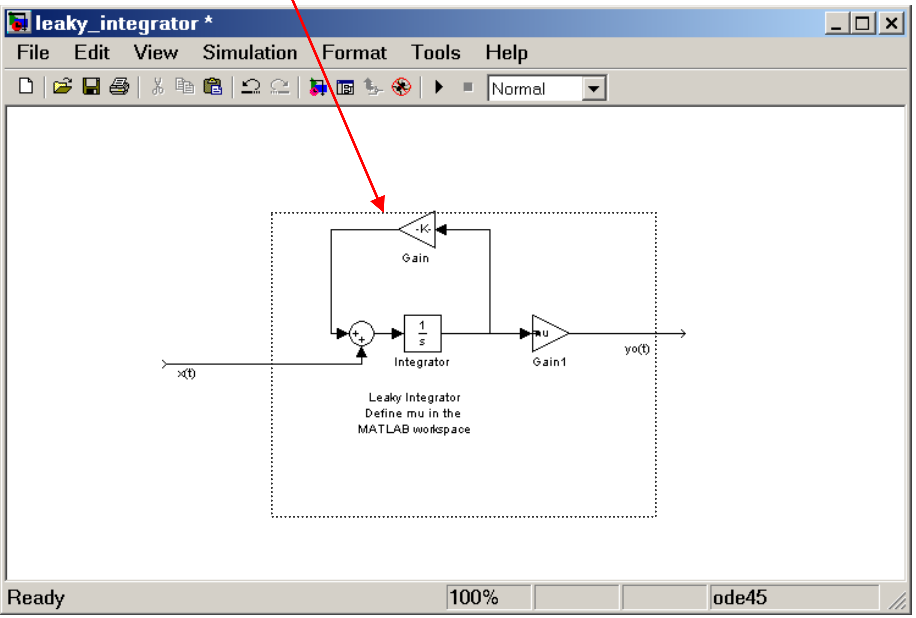


Subsystems can hide the complexity of the subsystems from the user, which can make your model clearer. There are two ways to create Subsystems.

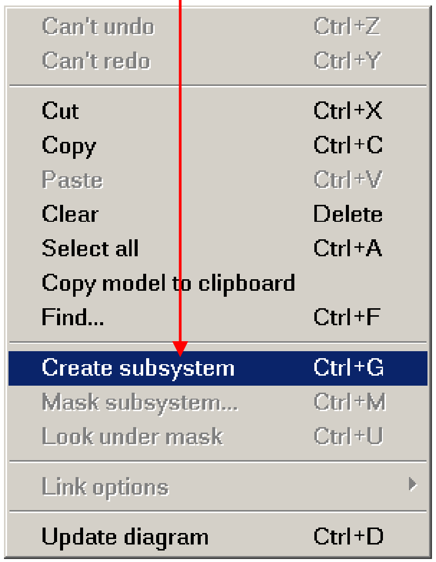
- You can create a Subsystem by adding the Subsystem block from Signals & Systems. Then you can edit the Subsystem by doubling clicking the Subsystem block.
- You can create create the subsystem by grouping blocks from an existing system.

Leaky integrator subsystem

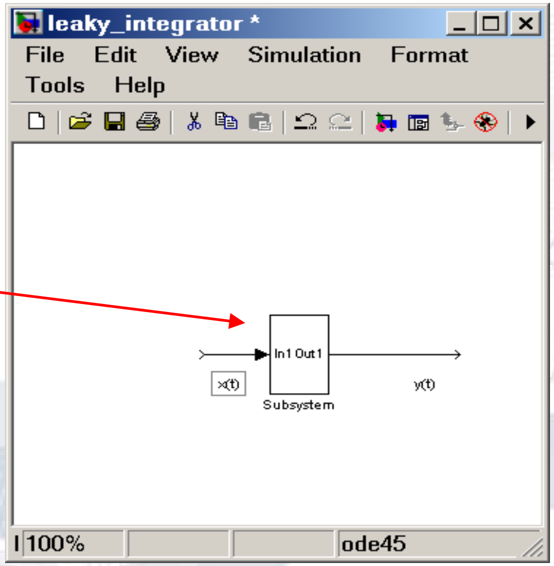
1. Use the mouse to select the blocks



2. Choose Create Subsystem from the Edit menu

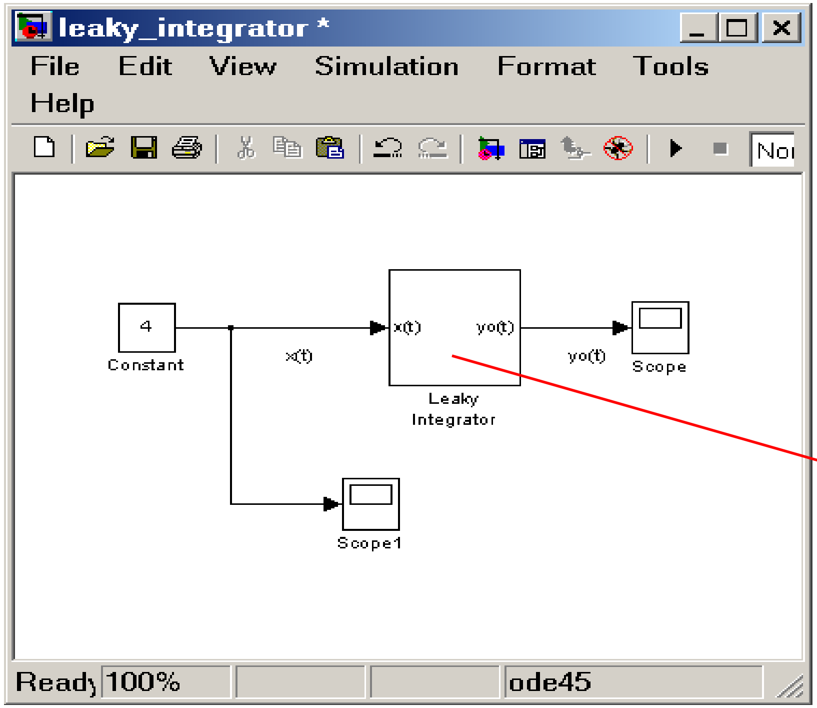


3. This replaces the selected blocks with a Subsystem block.

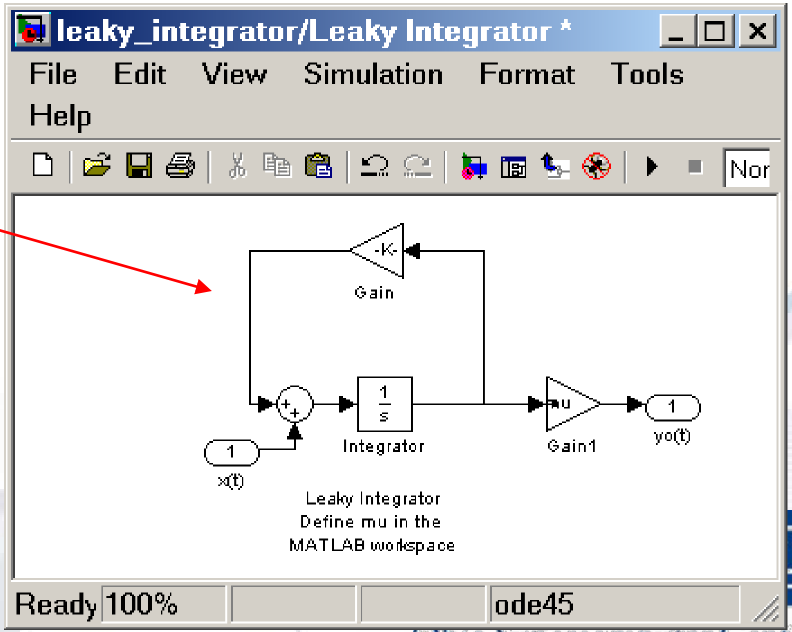


Using the leaky integrator subsystem

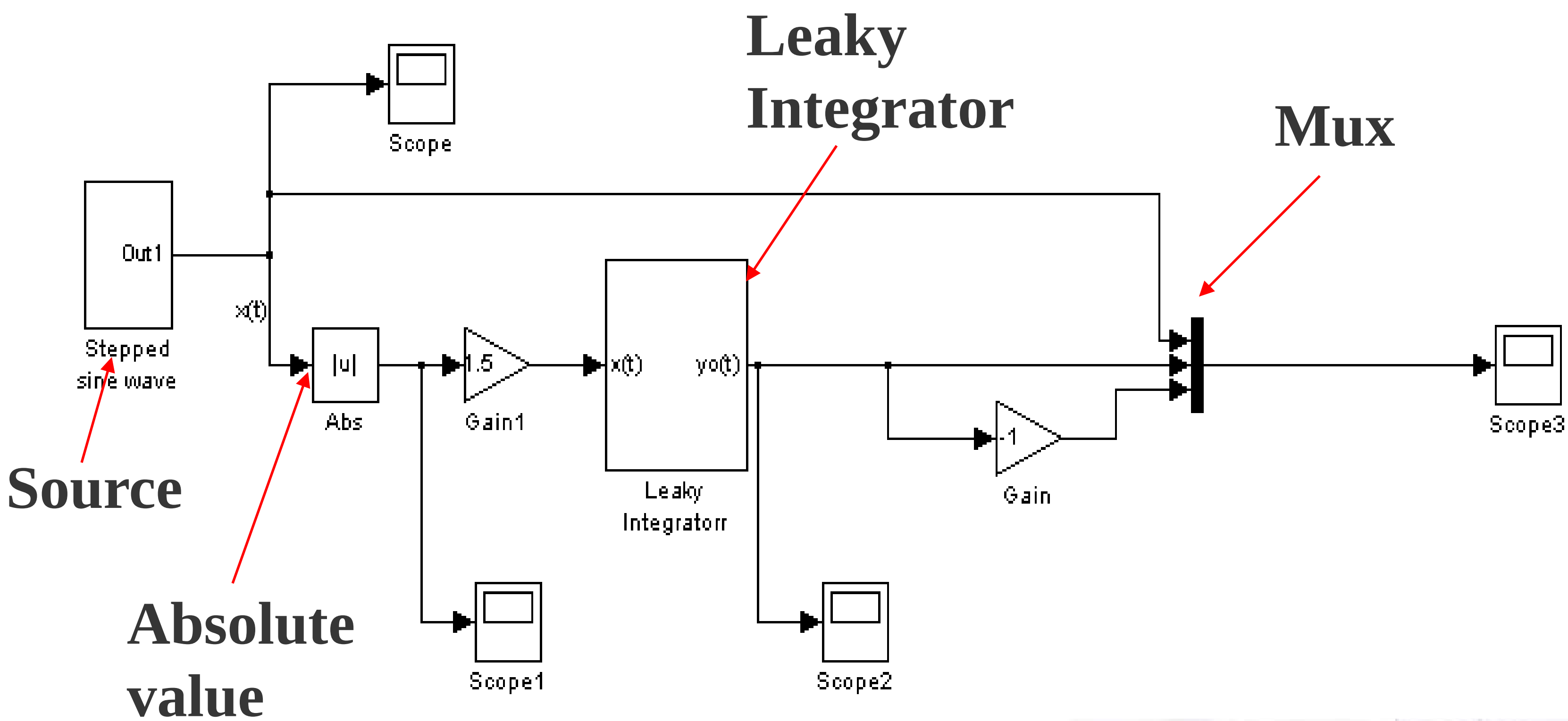
- You can now use the leaky integrator subsystem like any other block



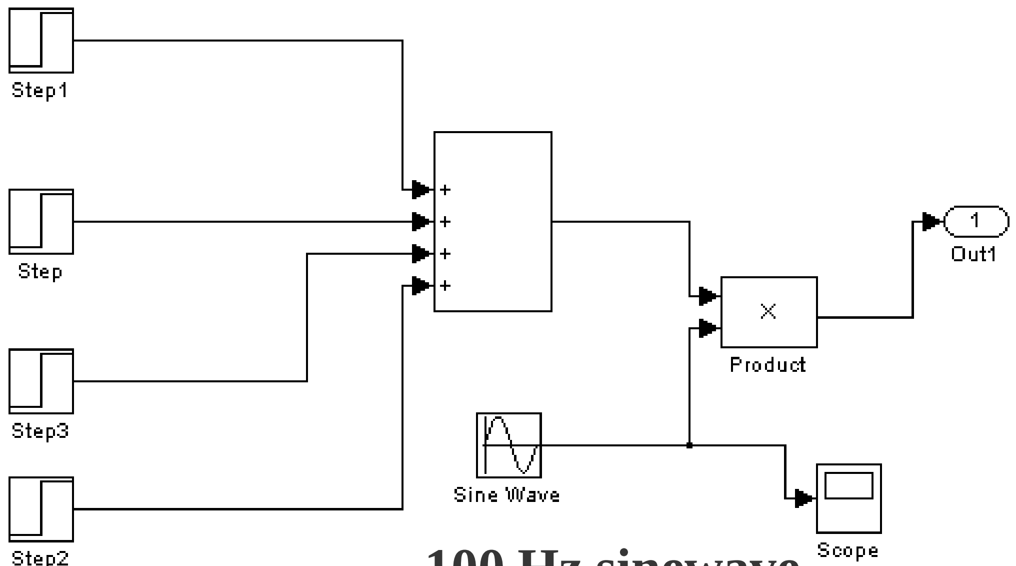
- Double clicking the subsystem opens the subsystem and shows the blocks inside



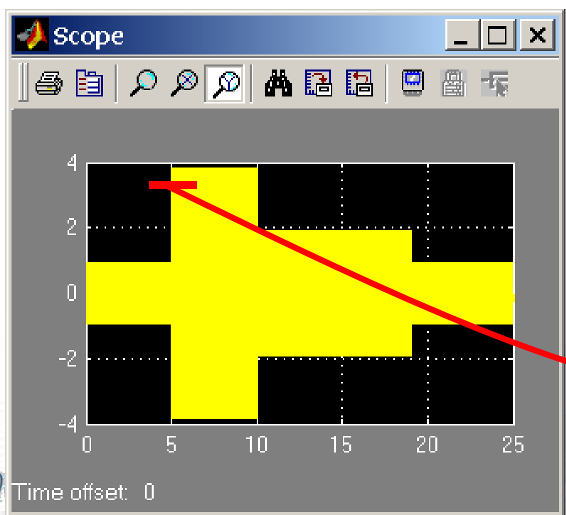
Example 4: Envelope Detection using Leaky Integrator



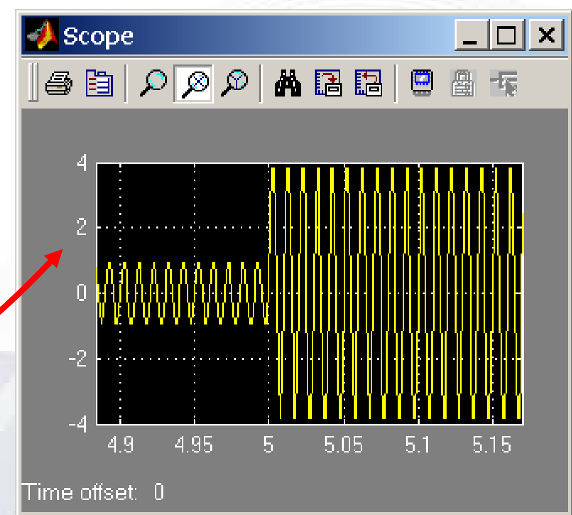
Stepped Sine Wave



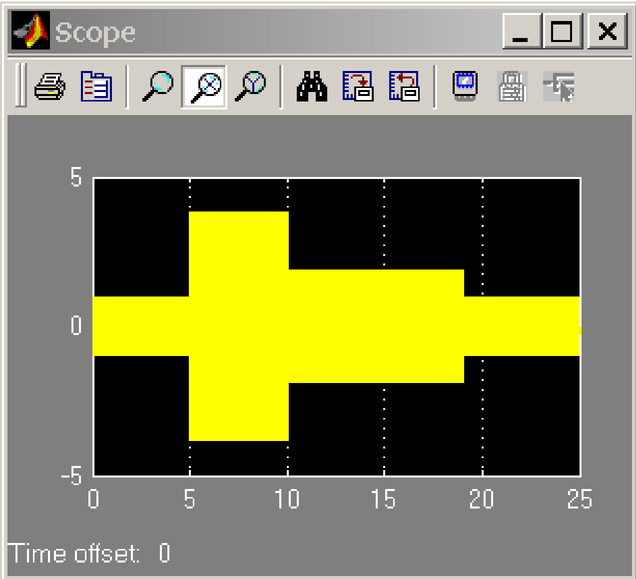
100 Hz sinewave



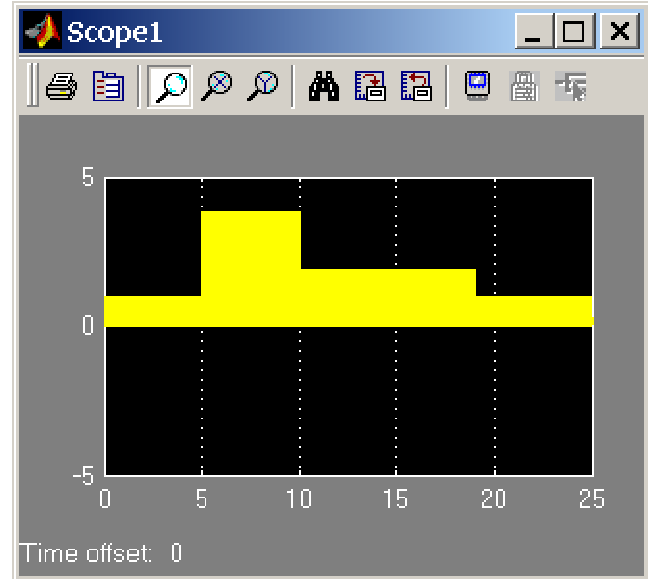
Blowup Around 5sec



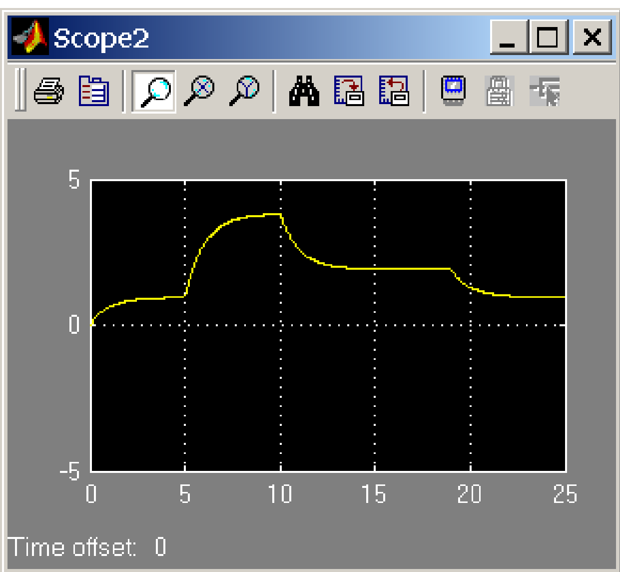
Results for mu =1 for Leaky Integrator



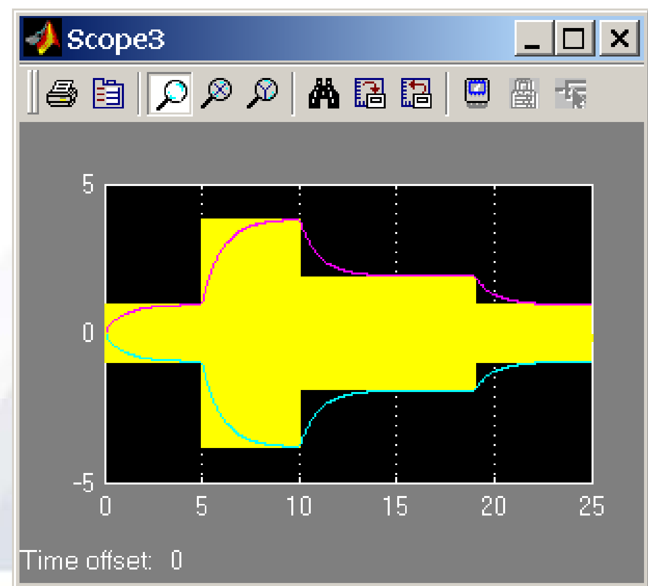
Stepped
Sine wave



After absolute
value

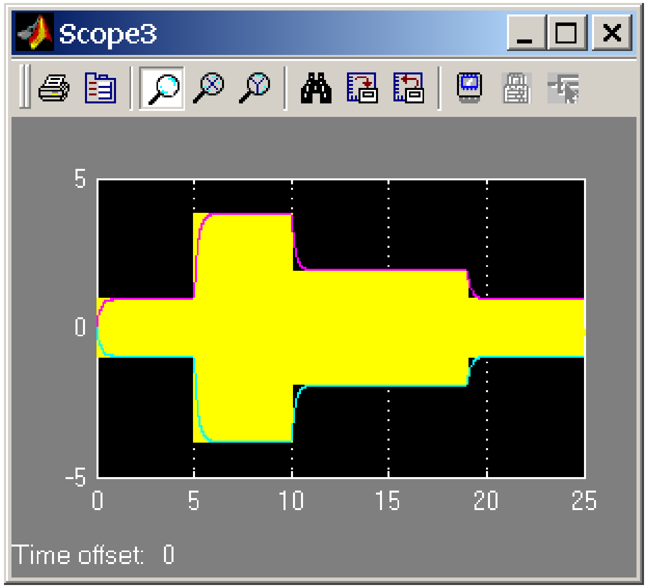


After leaky
integrator

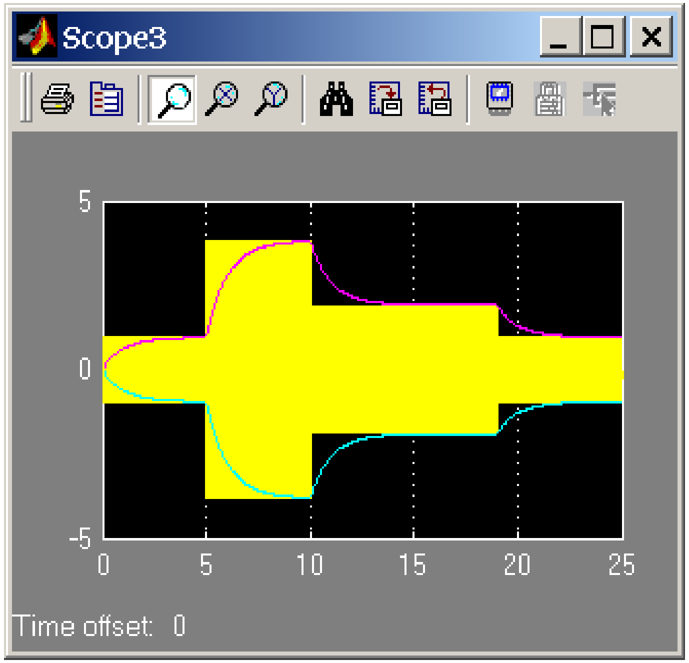


Envelope detector
output

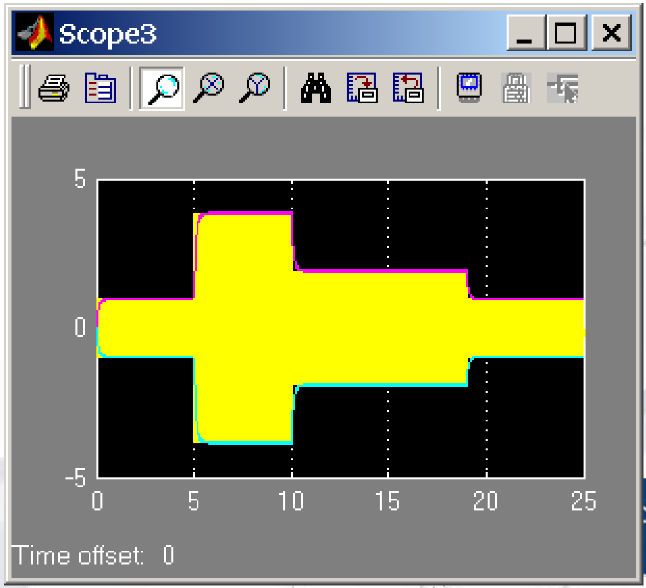
Comparing Results for different mu values



Mu = 5



Mu = 1



Mu = 10