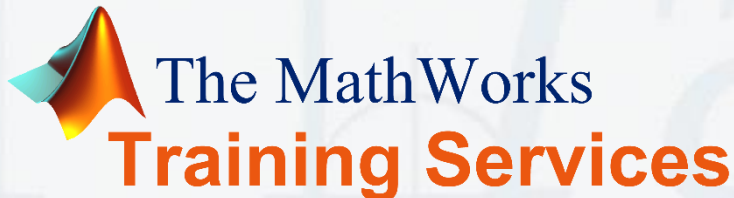


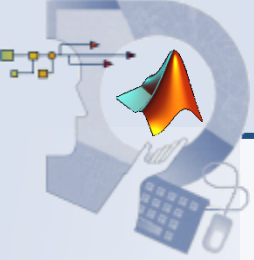
# Simulink® for System and Algorithm Modeling

## Modeling Algebraic Systems



The MathWorks

**Training Services**



# Outline

- Defining the system and identifying its components
- Modeling the system with equations
- Starting Simulink
- Building a block diagram for the model
- Defining the model parameters
- Defining the model I/O
- Simulating the system
- Creating signal viewers
- Modifying solver settings
- Validating the simulation results

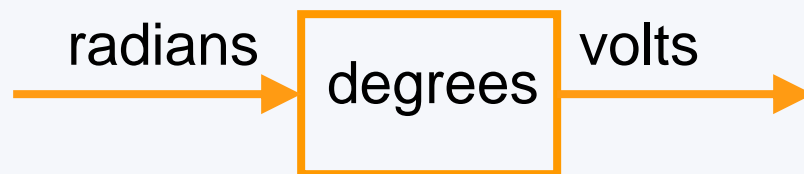


# Defining the System and Identifying Its Components

One of the outputs of the throttle subsystem is its angle. This is computed in radians and needs to be translated to degrees for analysis, and then translated to voltage for use in the controller by a potentiometer.

Before modeling the system with equations, answer the following questions:

- How many inputs?
- How many outputs?
- How many states?
- What are the parameters?
- Are there any intermediate signals?



# Modeling the System with Equations


- The following equation describes the relationship between the angle in radians,  $u$ , and the position in volts,  $y$ .

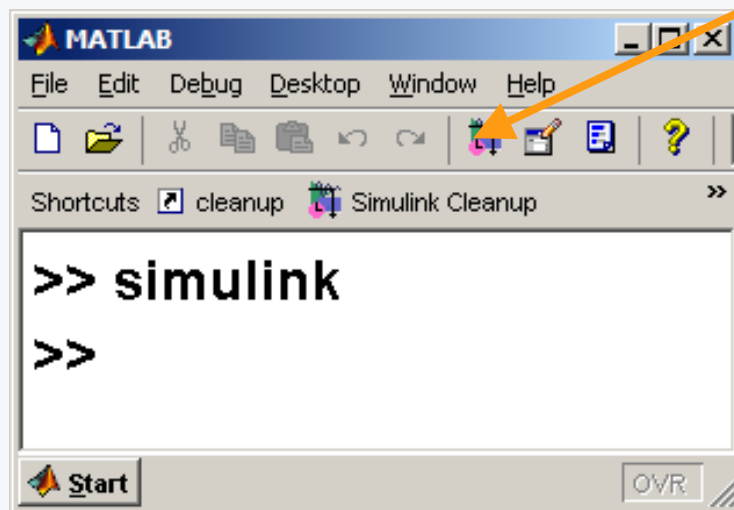
$$\angle^\circ = 180/\Pi * u$$

$$y = \begin{cases} 0.5V & \text{if } \angle^\circ = 0^\circ \text{ (closed throttle)} \\ 4.5V & \text{if } \angle^\circ = 90^\circ \text{ (open throttle)} \end{cases}$$

- Compute  $y$  using a lookup table that linearly interpolates between points to determine voltages for angles that fall between 0 and 90 degrees.

# Starting Simulink

- Open the Simulink Library Browser by typing `simulink` at the MATLAB command line or by selecting the  icon.



# Using the Simulink Library Browser

**Block Search**

**Block Description**

**Blockset**

**Library**

**Block**

**Divide:** Multiply or divide inputs. Choose element-wise or matrix product and specify one of the following:  
 a) \* or / for each input port (e.g., \*\*/)  
 b) scalar specifies the number of input ports to be multiplied  
 Scalar value of '1' for element-wise product causes all elements of a single input vector to be multiplied

Commonly Used Blocks

Continuous

Discontinuities

Discrete

Logic and Bit Operations

Lookup Tables

Math Operations

Model Verification

Model-Wide Utilities

Ports & Subsystems

Signal Attributes

Signal Routing

Sinks

Sources

User-Defined Functions

Additional Math & Discrete

Aerospace Blockset

Abs

Add

Algebraic Constraint

Assignment

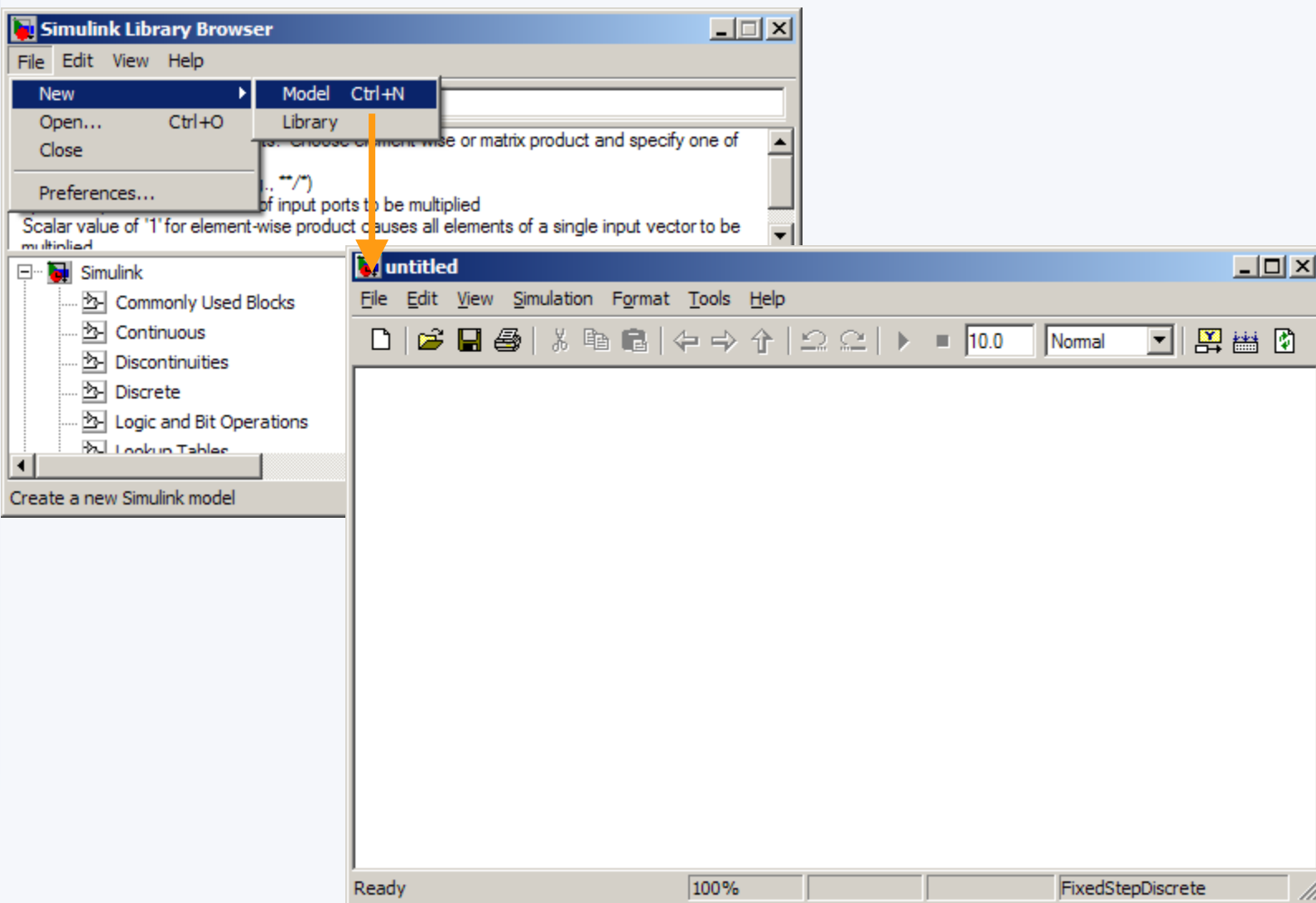
Bias

Complex to Magnitude-Angle

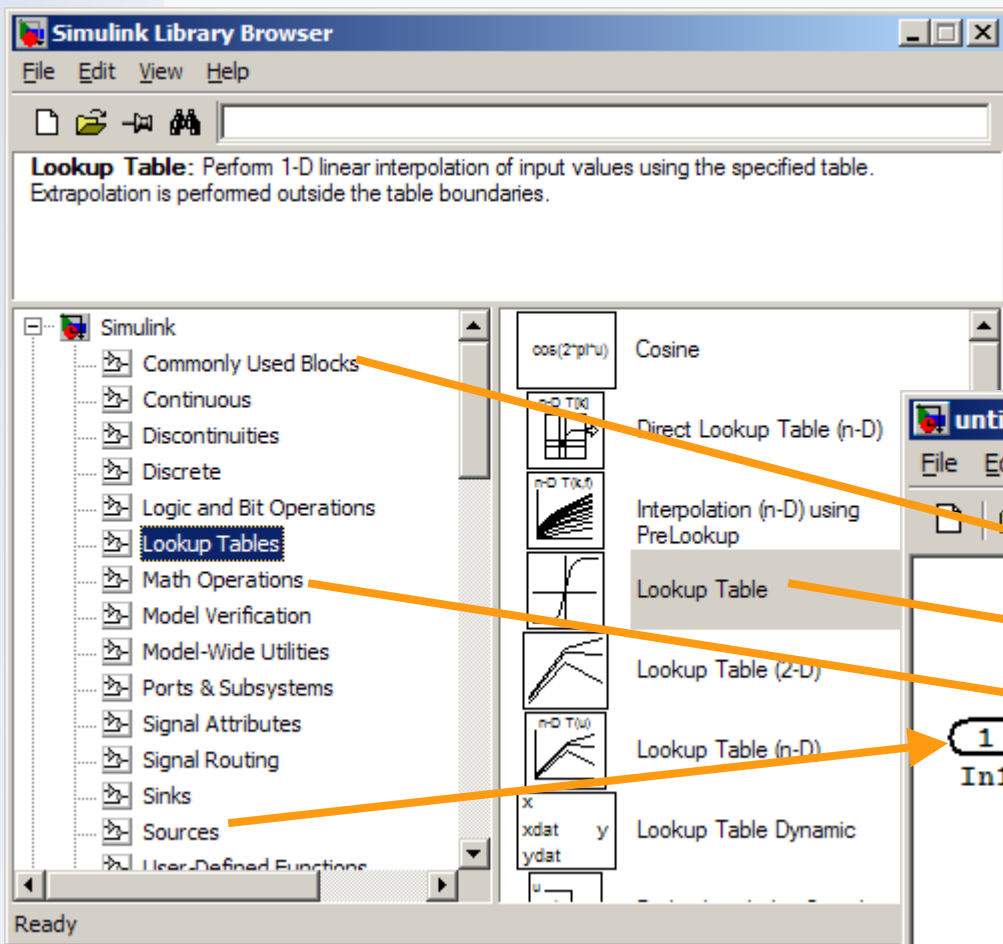
Complex to Real-Imag

Divide

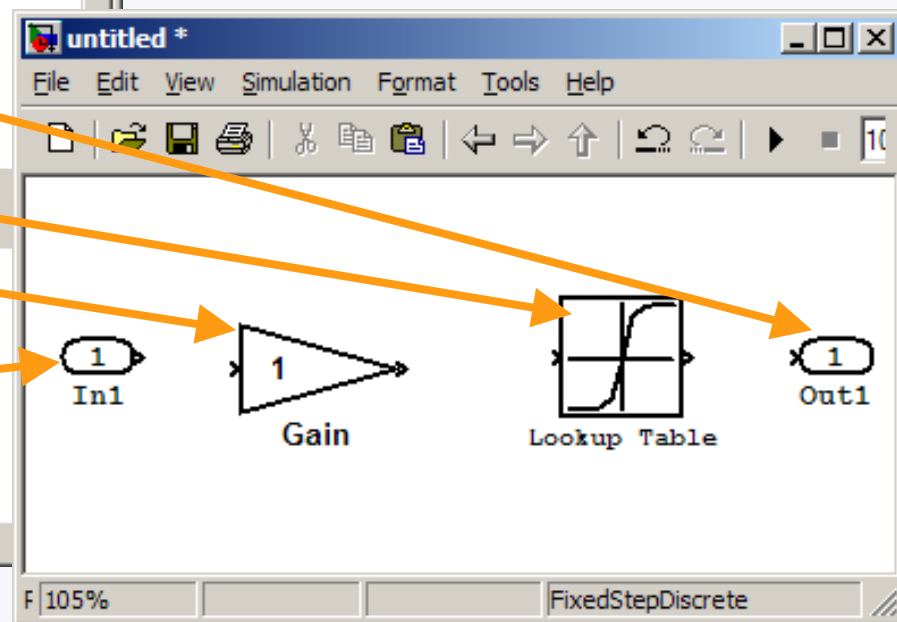
# Building a Block Diagram for the Model



# Adding Blocks



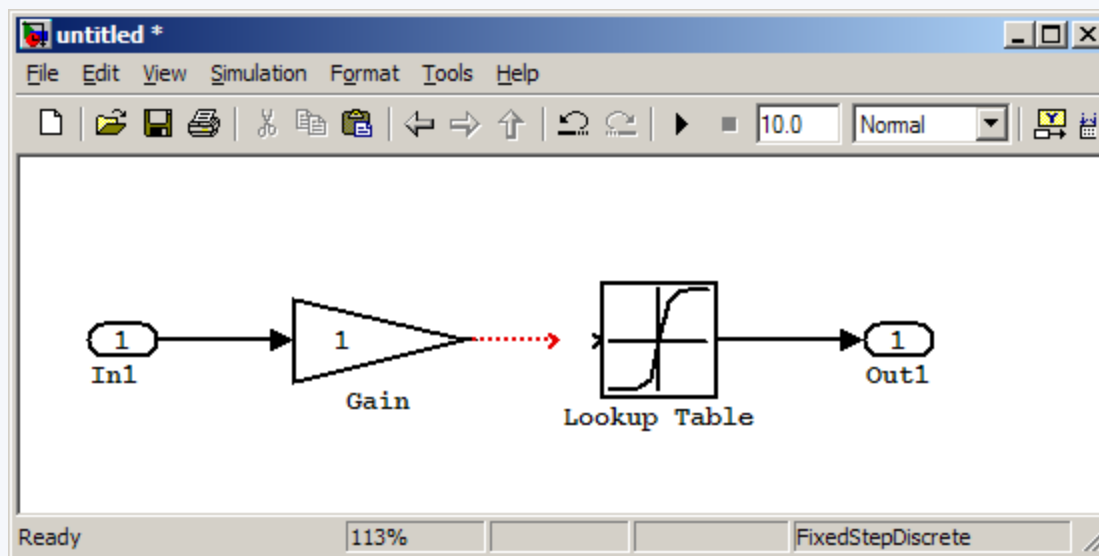
To add blocks, drag and drop them from the Simulink Library Browser into the model.





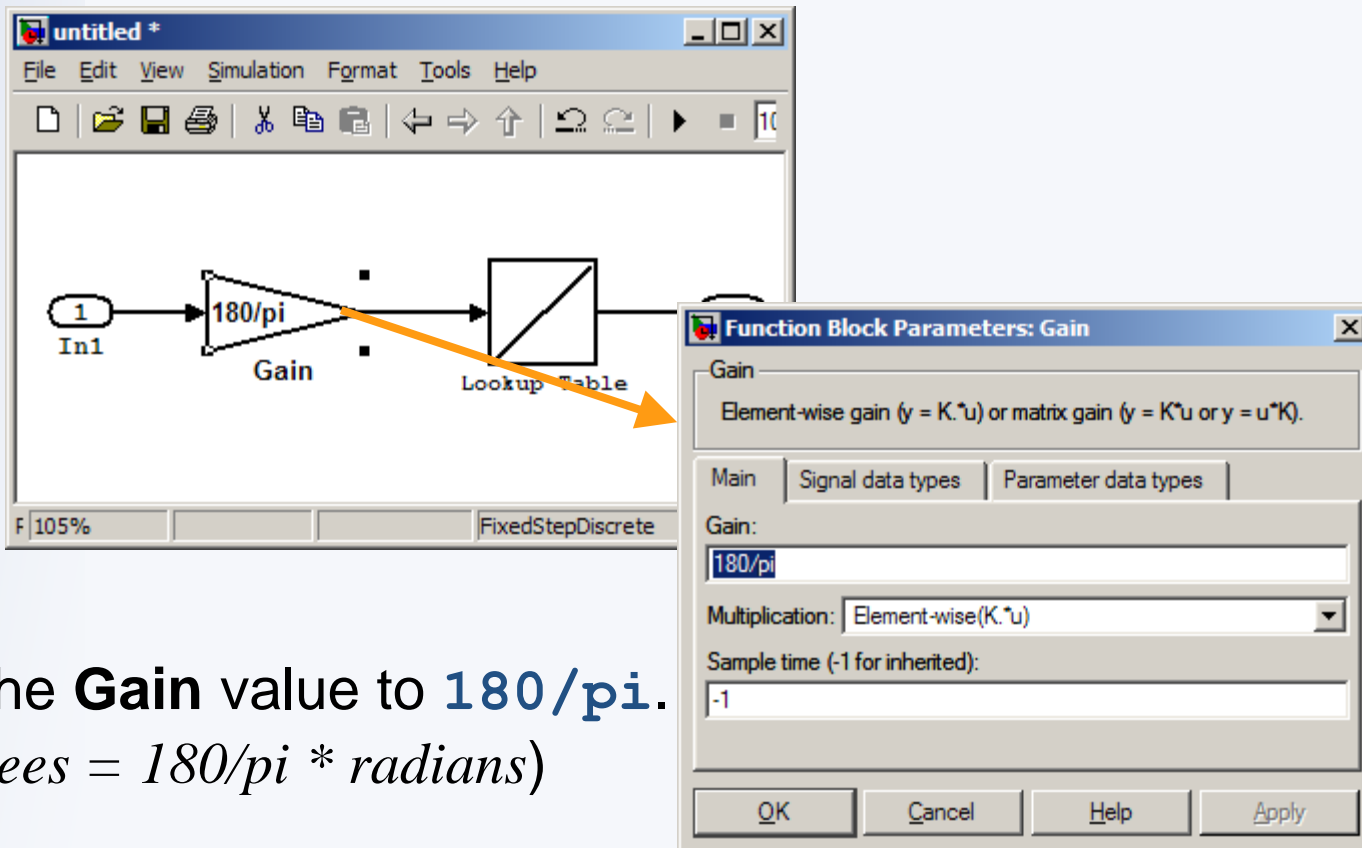
# Connecting Blocks

- To connect blocks, select the output port of the source block, and then left-click and drag a line to the destination block.



# Defining the Block Parameters

- To view and modify block parameters, double-click the block icon.

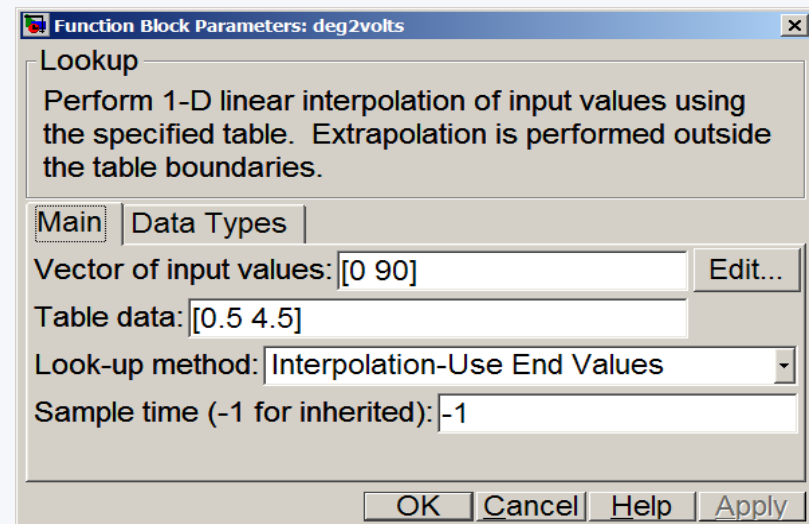


The screenshot shows a Simulink model window titled "untitled\*" with a menu bar (File, Edit, View, Simulation, Format, Tools, Help) and a toolbar. The model contains an input block "In1" with the value "1", a "Gain" block with the value "180/pi", and a "Lookup Table" block. An orange arrow points from the "Gain" block to the "Function Block Parameters: Gain" dialog box. The dialog box has tabs for "Main", "Signal data types", and "Parameter data types". The "Main" tab is active, showing the "Gain" parameter set to "180/pi", the "Multiplication" method set to "Element-wise(K.\*u)", and the "Sample time" set to "-1".

Set the **Gain** value to  $180/\pi$ .  
(*degrees =  $180/\pi$  \* radians*)

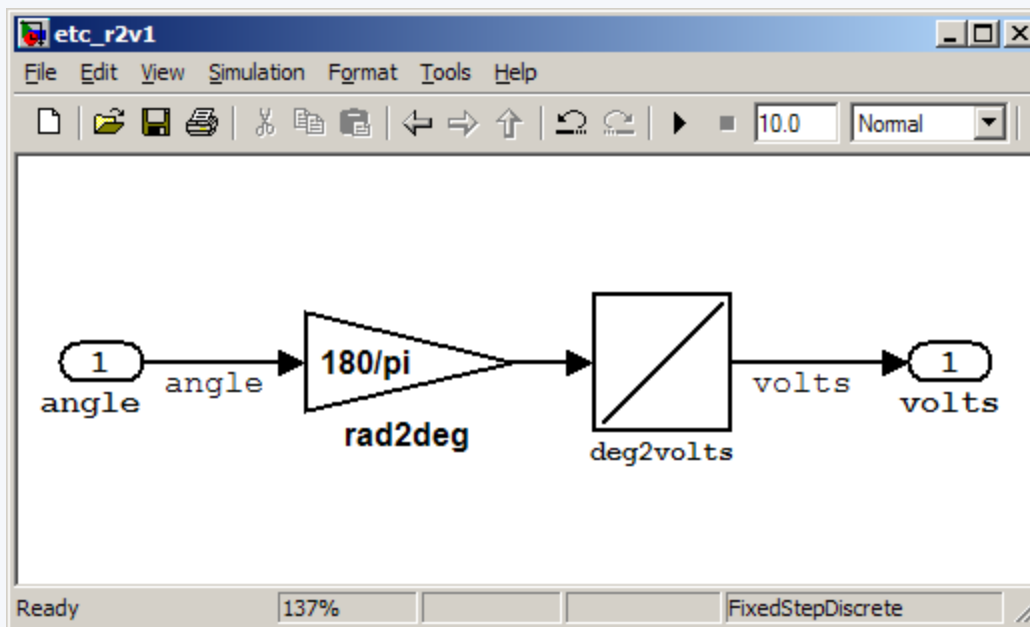
# Defining the Lookup Table Parameters

- To compute  $y$  from the throttle angle in degrees using the Lookup Table block, define the following parameters:
  - The **Vector of input values** are  $[0 \ 90]$
  - The **Vector of output values** are  $[.5 \ 4.5]$
  - Select **Interpolation-Use End Values** as the **Look-up method**.



# Labeling Blocks and Signals

- To rename a block, click the block label and edit.
- Block labels must be unique.
- To label a signal, double-click the signal line and enter text.



>> etc\_r2v1

# Defining the System Input

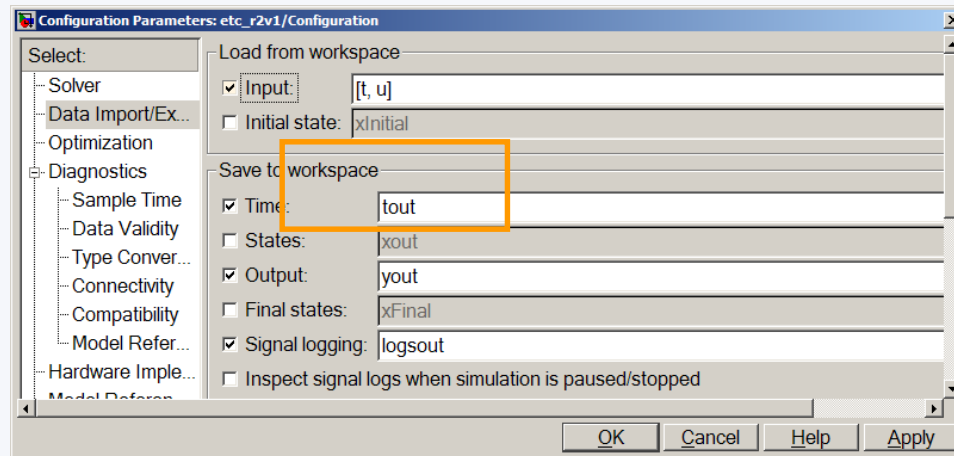
- Signals fed in from root-level Inports can be loaded from the MATLAB workspace.
- Select the **Data Import/Export** option from the **Configuration Parameters** dialog box.

The screenshot shows the Simulink environment with the 'Configuration Parameters' dialog box open. The 'Data Import/Export' option is selected in the 'Select:' list. The 'Load from workspace' checkbox is checked, and the 'Input' field is set to '[t, u]'. The 'Save to workspace' section has several options checked, including 'Time', 'Output', and 'Signal logging'. The background shows a Simulink block diagram with an input block '1' labeled 'angle', a 'rad2deg' block, and an output block 'deg2r'.

```
>> t = linspace(0,10,100)';
>> u = linspace(0,pi/2,100)';
```

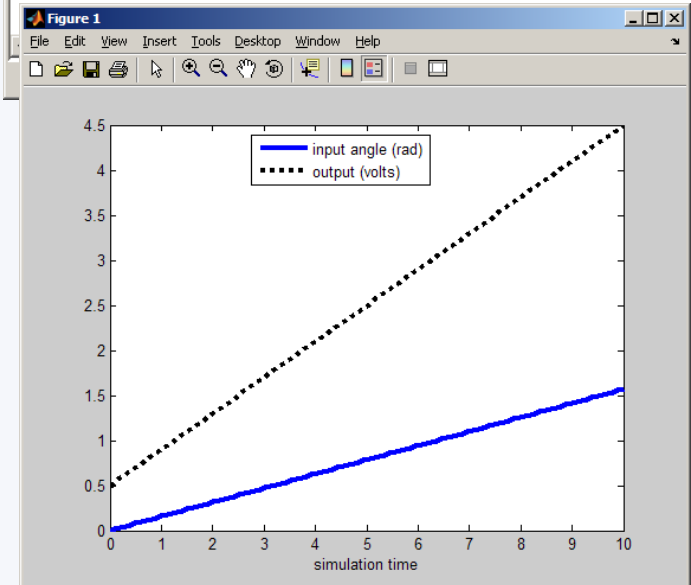
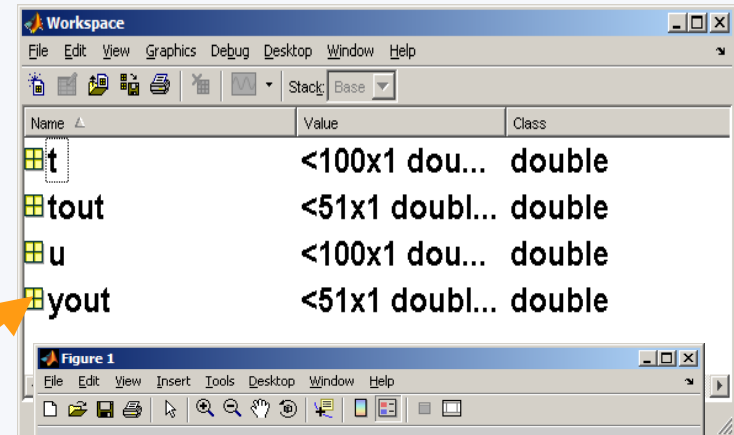
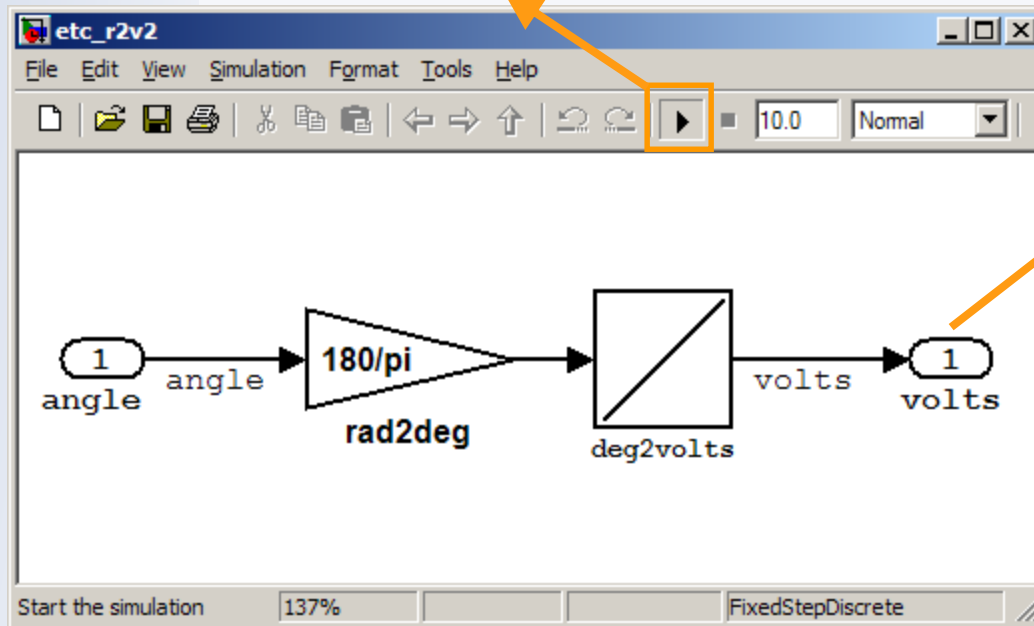
# Defining the System Output

- Signals fed to root-level Outport blocks can be saved to the MATLAB workspace.
- Signals are written to the workspace when the simulation is stopped or paused.
- Select the **Data Import/Export** option from the Configuration Parameters dialog box.
- Select **Output** and **Time** from **Save to workspace**. The voltage signal is written to the variable **yout**.



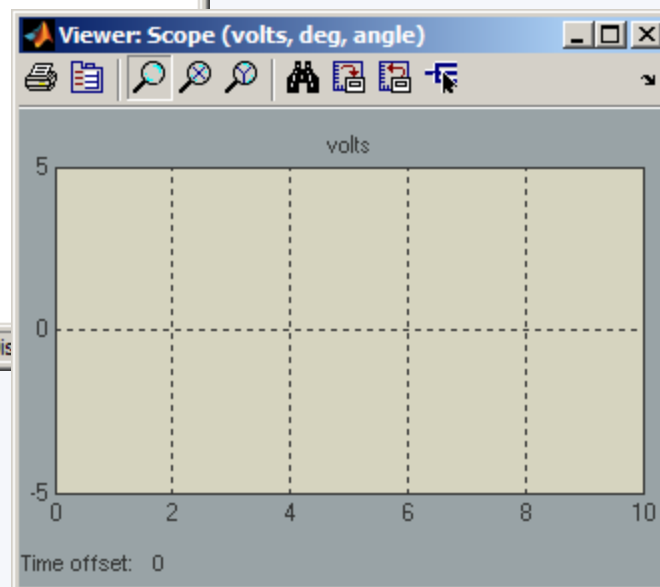
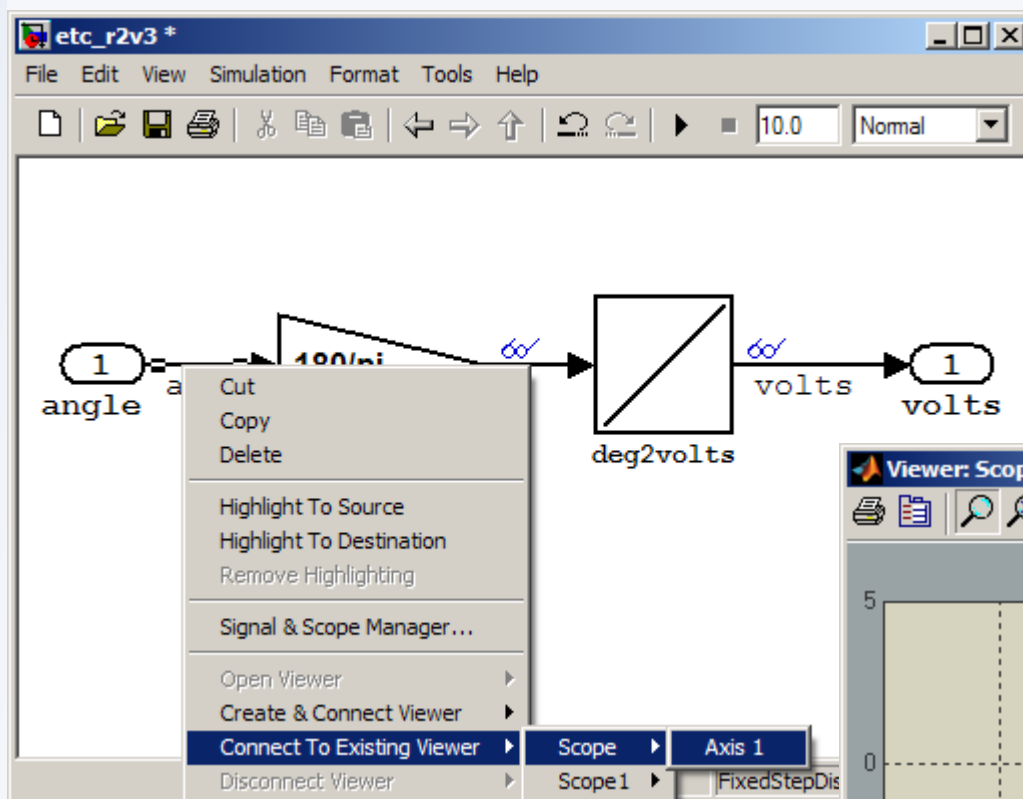
# Simulating the Model and Visualizing the Response

Start Simulation



```
>> plot(t,u,tout,yout,'k:')
>> xlabel('simulation time')
>> legend('input angle (rad)', 'output (volts)')
```

# Adding Signal Viewers

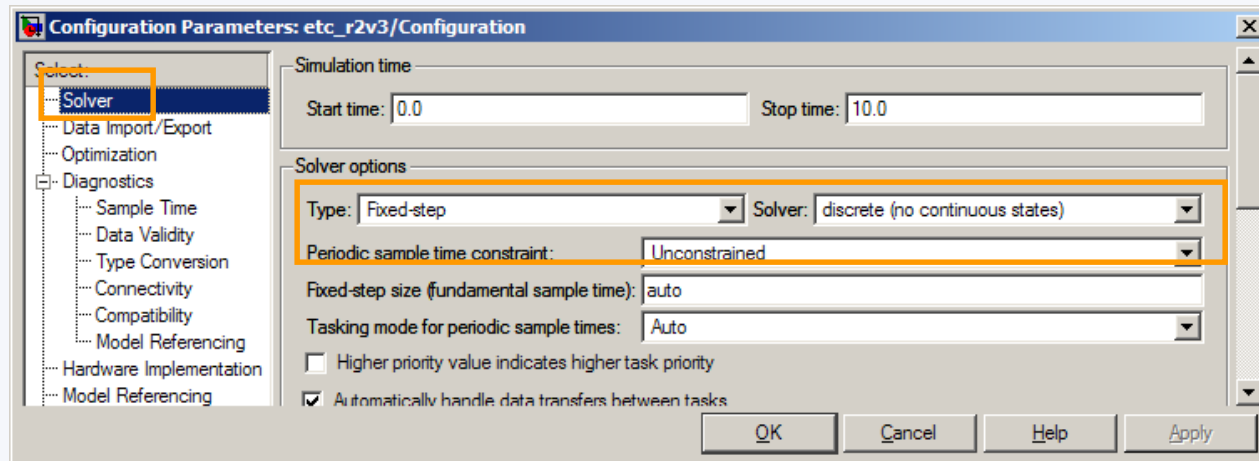




# Modifying Solver Settings

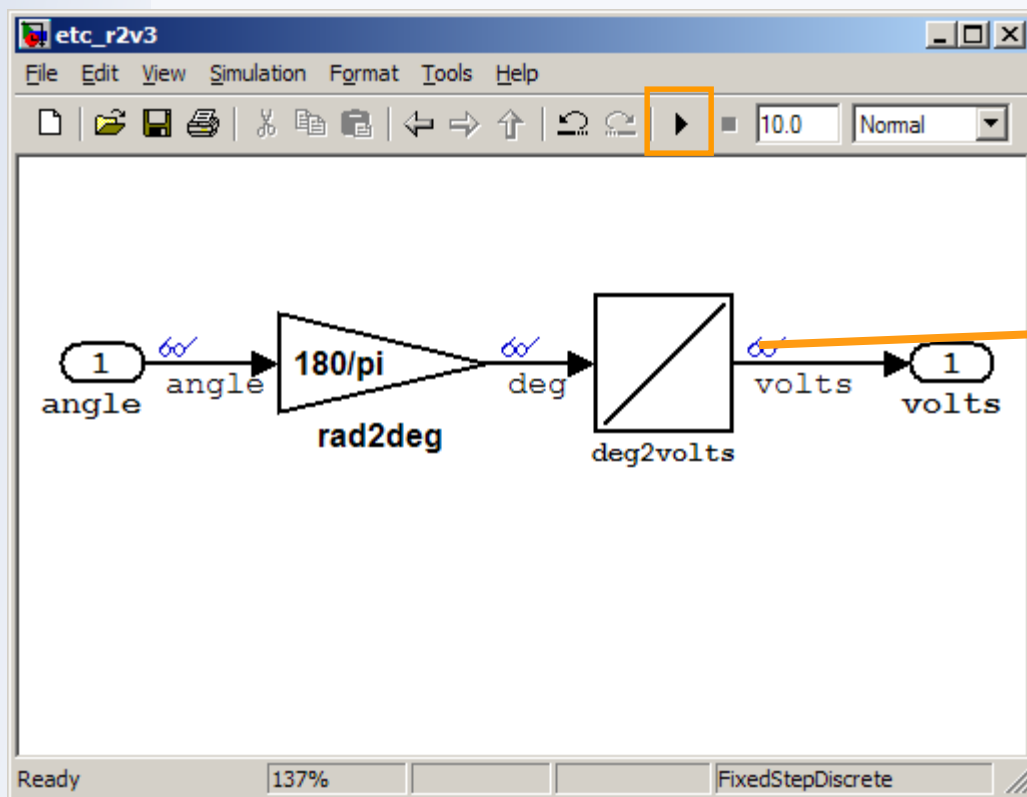
To select a solver,

- Select **Simulation** → **Configuration Parameters**.
- Select the **Solver** option at the left of the dialog.
- Set the **Type** to **Fixed-Step** and the **Solver** to **discrete (no continuous states)**
- Select **OK** to confirm settings.

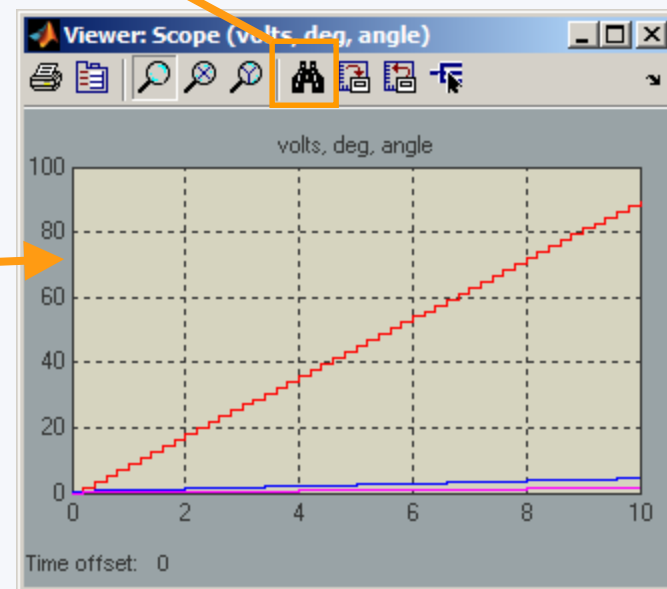


>> etc\_r2v3

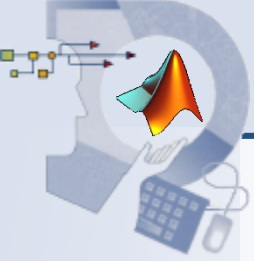
# Simulating and Analyzing the Response



Auto-scale scope axis



>> etc\_r2v3



# Summary

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