MATLAB/Simulink tutorial

ECEN 2060

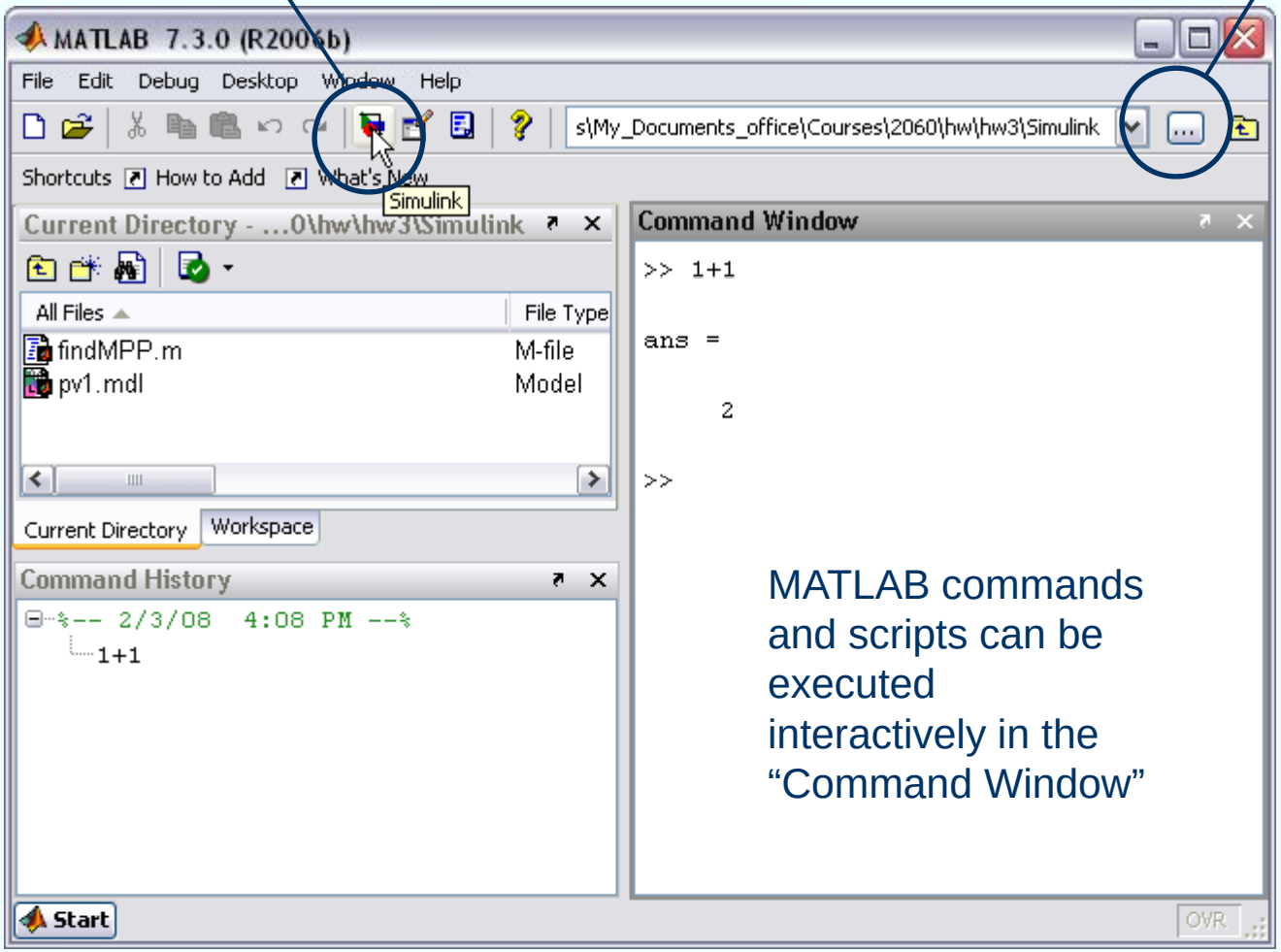
MATLAB/Simulink

- MathWorks tools for technical computing and simulations, widely used across various engineering and science disciplines
- MATLAB
  - Programming language and interactive environment well suited for computing, algorithms, data processing and visualization
- Simulink
  - Environment for graphical, model-based simulation of dynamic systems
- Available in all computer labs in the Engineering building
- Personal copy (full version, but for students only) can be purchased at www,mathworks.com for $99. This is not required for ECEN2060
- Tutorial objectives: very basic introduction to the tools at the level sufficient to understand ECEN2060 simulation models and do homework assignments

Start MATLAB, then start Simulink

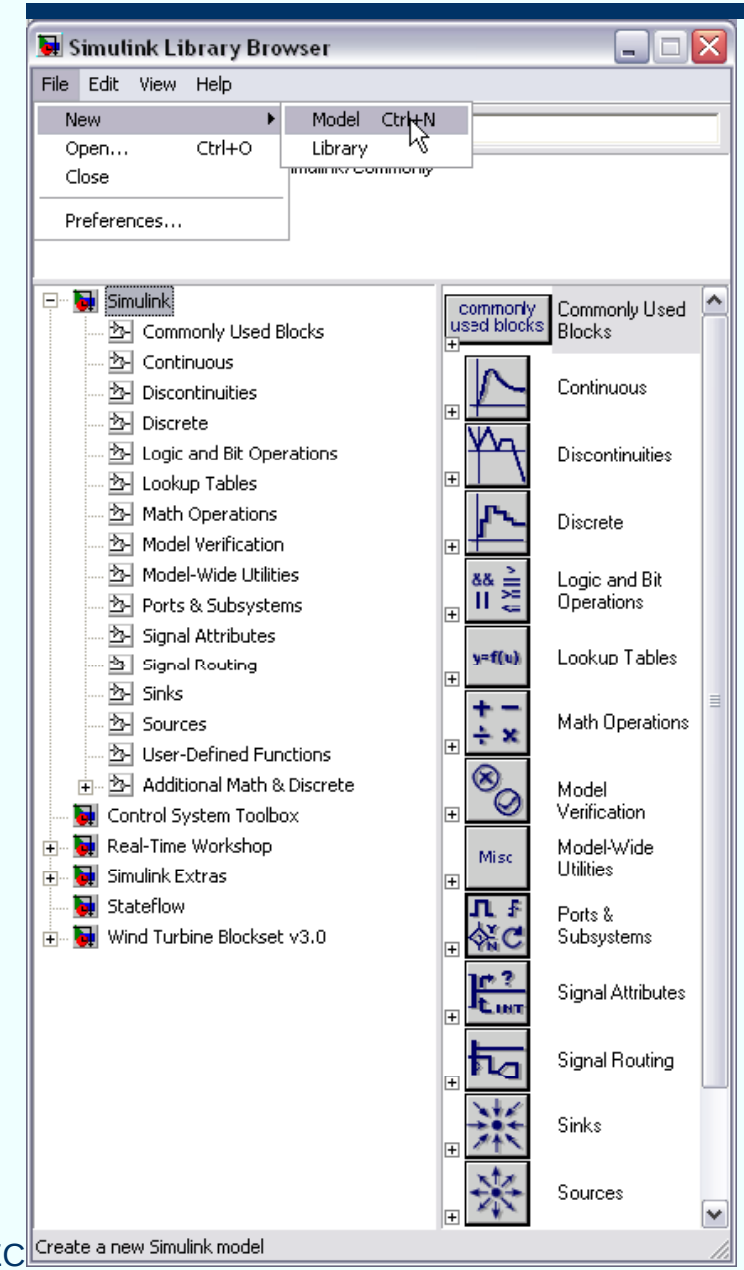
Click here to start Simulink

Choose Current Directory

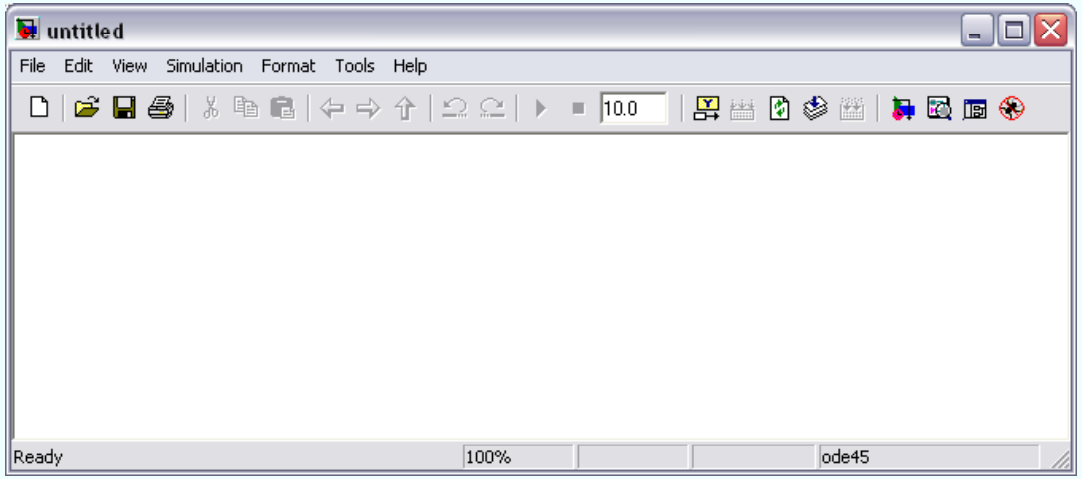


MATLAB commands and scripts can be executed interactively in the "Command Window"

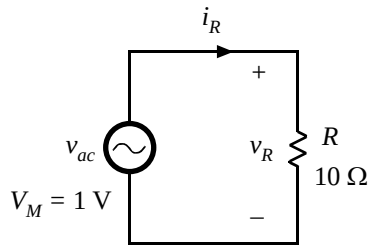
Simulink Library Browser



- Library Browser gives access to various standard or additional blocks that are used to build more complicated models
- ECEN2060 models will be constructed using standard Simulink blocks from the Simulink library
- Click File - New – Model (or Ctrl-N) to start a new model window



Constructing and simulating a simple circuit model



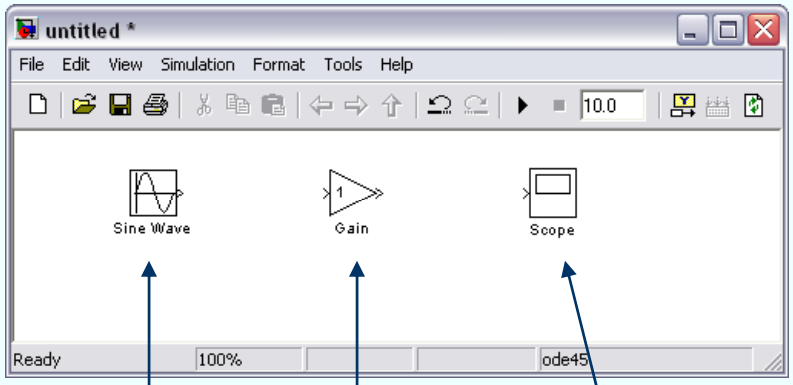
Circuit equation: $i_R = (1/R)\, v_{ac}$

Simulink:

output

"Gain" Block from Math Operations

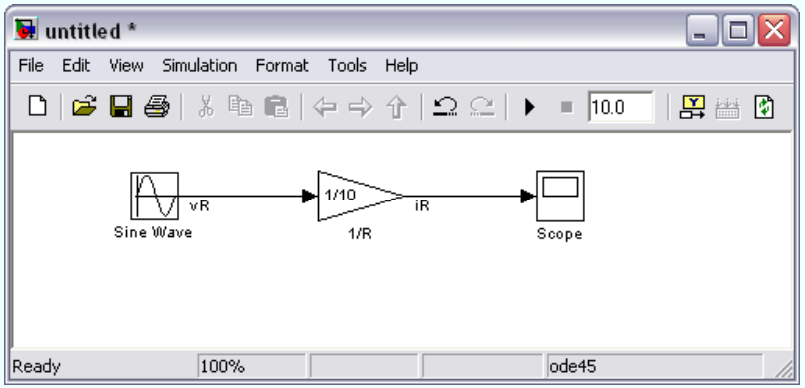
"Sine Wave" block from Sources



Drag an drop Sine Wave block from Sources in the Library

Drag an drop Gain block from Math Operations in the Library

Drag an drop Scope block from Sinks in the Library



Connect block inputs and outputs according to the circuit equation

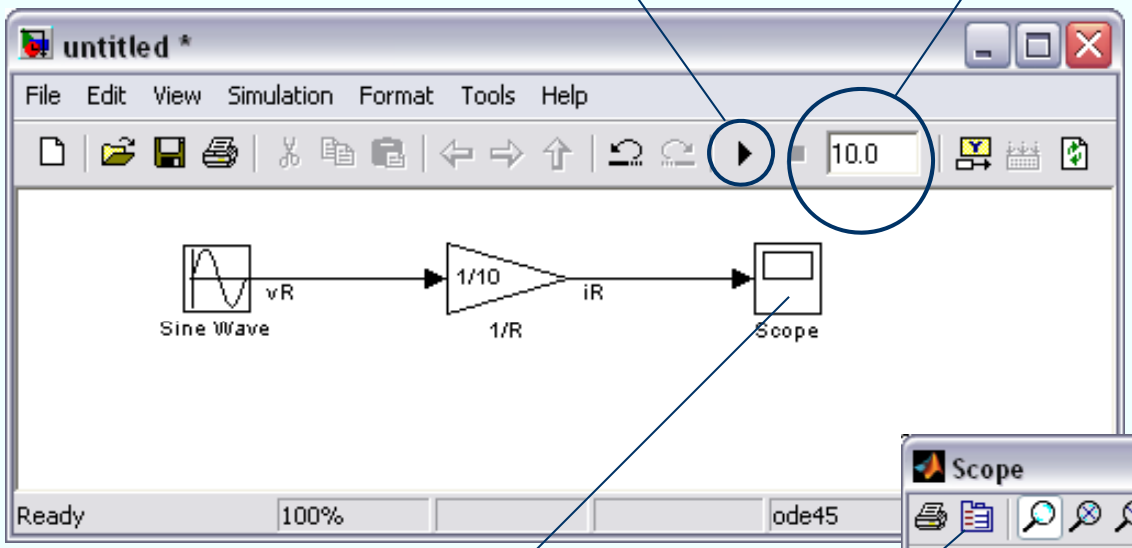
Double-click a block to change parameter values

To better document the model, double-click on the block name or on the connection line to change block and signal names as desired

Constructing and simulating a simple circuit model

Click here to start simulation

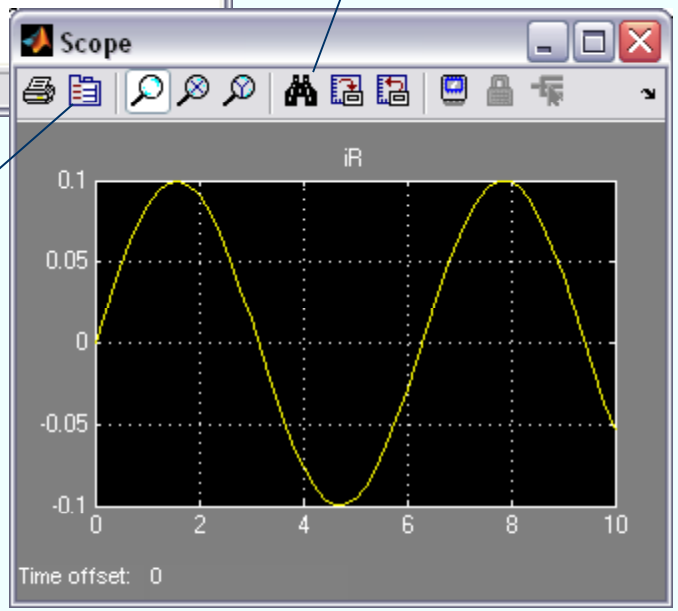
Total simulation time (10 seconds in this example) can be changed here



Autoscale

Double-click on the Scope block to display the output waveform (current i_R)

Scope parameters



Explore various menu options, block properties, etc. For example:

- Add another axis to the Scope and display both i_R and v_R
- Repeat simulations for different values of the sinewave amplitude or frequency, or different R

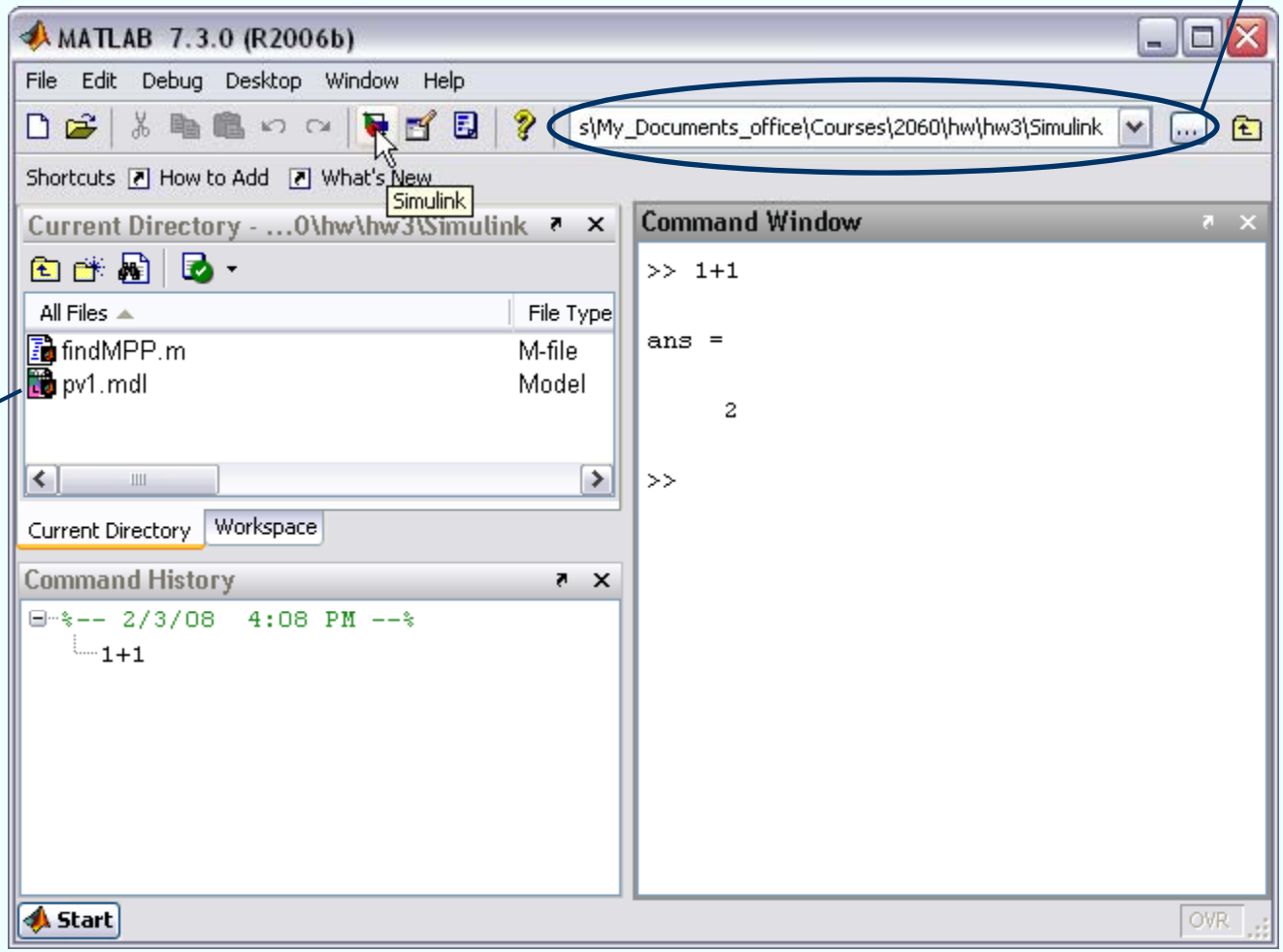
Notes

- Simulink blocks have zero, one or more inputs and zero, one or more outputs
- Inputs and outputs are all considered “signals”
- Unlike circuit-oriented simulators (e.g. Spice), Simulink has no knowledge of whether a signal is voltage, current, power, torque, speed, …, which
  - makes it a very general tool for simulations of various dynamical systems, but
  - requires a user to decide which signals are inputs and which signals are outputs, and make block connections to correctly model system equations; as a result, Simulink block diagrams may not be as intuitive as circuit diagrams

Another example

Make sure you have downloaded **pv1.mdl** and **findMPP.m** to a working folder (files are available on the course website, MATLAB/Simulink page)

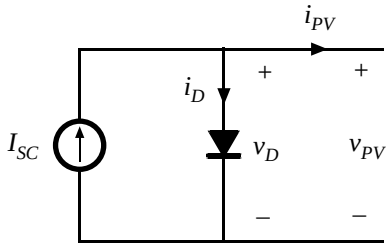
Set MATLAB Current Directory to the folder where you downloaded pv1.mdl and findMPP.m



Double-click pv1.mdl to open the PV cell Simulink model

Simple PV cell Simulink model pv1.mdl

Circuit model



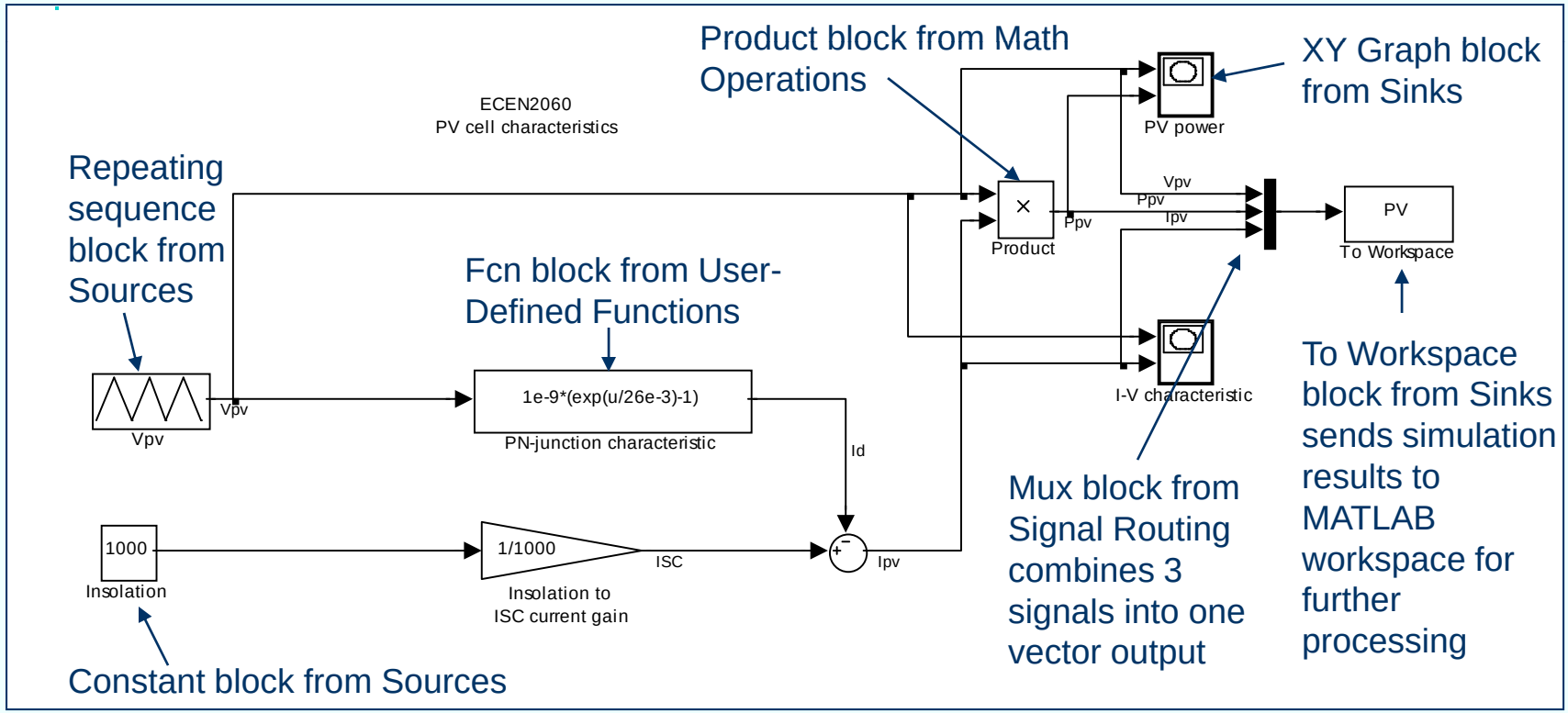
Model equations

input

$$i_D = I_o\left(e^{v_D/V_T} - 1\right), \quad v_D = v_{PV}$$

$$i_{PV} = I_{SC} - i_D$$

output

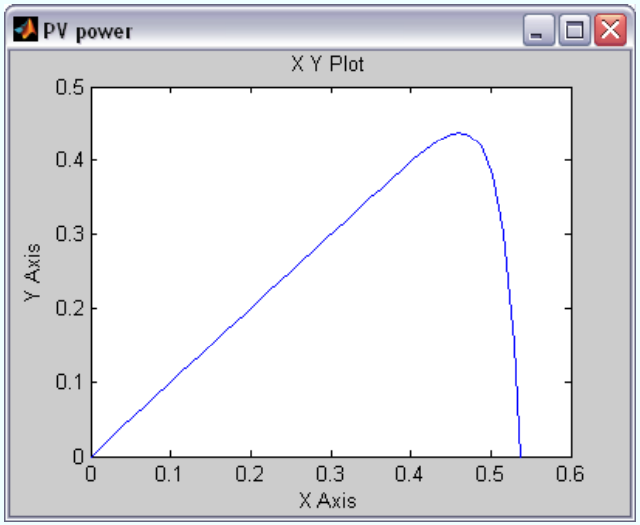


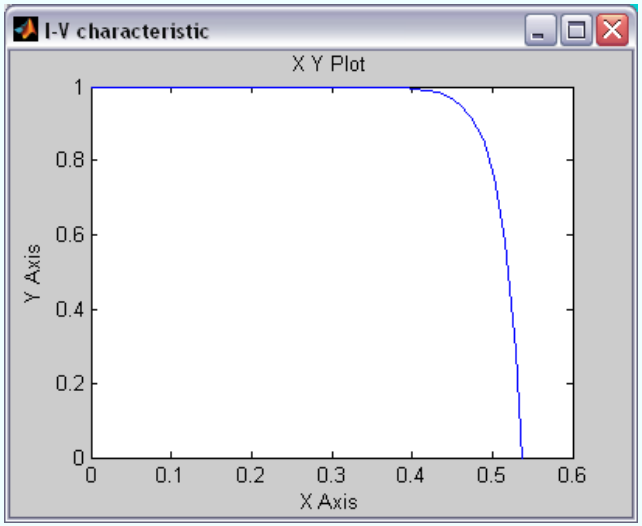
pv1.mdl Simulink model

Run pv1 simulation

Output power P_{pv} (i.e the product of i_{PV} and v_{PV}) as a function of v_{PV} is immediately displayed in a X-Y Plot window

Output current i_{PV} as a function of v_{PV} is immediately displayed in another X-Y Plot window

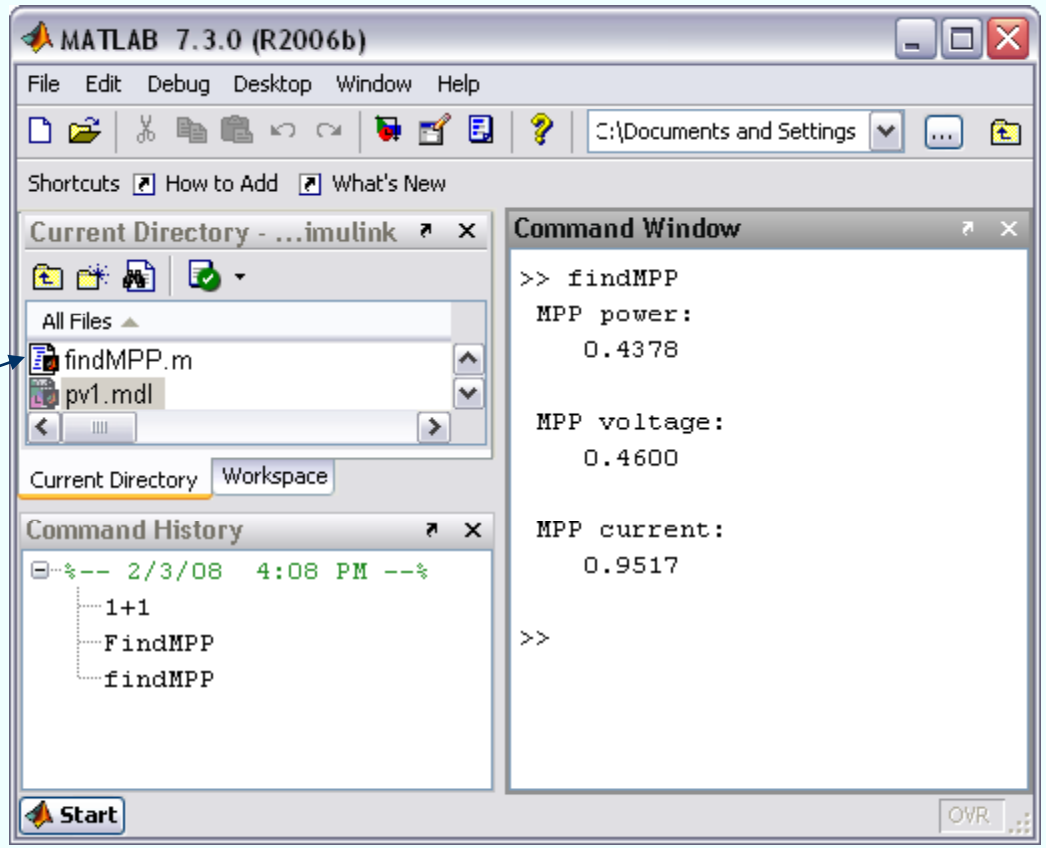




Output power P_{pv}, current i_{PV}, voltage v_{PV}, and simulation time are stored in a “structure” variable PV, which is made available (using the “To Workspace” block) for further processing in the MATLAB Command Window

Example of MATLAB processing of simulation results

Type “findMPP” and Enter in the MATLAB Command Window. This runs the MATLAB script **findMPP.m**, which takes the simulation results and finds the maximum power point (power, voltage and current) and again plots power P_{pv} and I_{pv} as functions of V_{pv}.



Double-click on the findMPP.m file to open the script and examine the MATLAB code

More notes

- Simulink model and MATLAB Figure windows include a “Copy” function in the “Edit” menu. This is useful for reporting results: you can simply copy and paste your models or graphical results into a Word or PowerPoint document
- You may want to explore other options in the MATLAB Figure window. For example, find out how add a grid, change the line type, thickness or color, change the x-axis or y-axis scales, etc.
- This tutorial is very limited in scope, just to get you started with the tools we will be using to model and test various electrical or electro-mechanical energy systems in ECEN2060. You may want to browse through Simulink/MATLAB HELP documentation to further explore the tool capabilities