**The lecture 3**

**Simulink tool**

Simulink® is a software package for modeling, simulating, and analyzing dynamic systems. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two. Systems can also be multirate, i.e., have different parts that are sampled or updated at different rates.

**Tool for Interactive Simulation**

Simulink encourages you to try things out. You can easily build models from scratch, or take an existing model and add to it. Simulations are interactive, so you can change parameters on the fly and immediately see what happens. You have instant access to all the analysis tools in MATLAB®, so you can take the results and analyze and visualize them. A goal of Simulink is to give you a sense of the *fun* of modeling and simulation, through an environment that encourages you to pose a question, model it, and see what happens.

Simulink is also practical. With thousands of engineers around the world using it to model and solve real problems, knowledge of this tool will serve you well throughout your professional career.

**Tool for Model-Based Design**

With Simulink, you can move beyond idealized linear models to explore more realistic nonlinear models, factoring in friction, air resistance, gear slippage, hard stops, and the other things that describe real-world phenomena. Simulink turns your computer into a lab for modeling and analyzing systems that simply wouldn’t be possible or practical otherwise, whether the behavior of an automotive clutch system, the flutter of an airplane wing, the dynamics of a predator-prey model, or the effect of the monetary supply on the economy. For modeling, Simulink provides a graphical user interface (GUI) for building models as block diagrams, using click-and-drag mouse operations. With this interface, you can draw the models just as you would with pencil and paper (or as most textbooks depict them). This is a far cry from previous simulation packages that require you to formulate differential equations and difference equations in a language or program. Simulink includes a comprehensive block library of sinks, sources, linear and nonlinear components, and connectors. You can also customize and create your own blocks. For information on creating your own blocks, see the separate *Writing S-Functions* guide.

Models are hierarchical, so you can build models using both top-down and bottom-up approaches. You can view the system at a high level, and then double-click blocks to go down through the levels to see increasing levels of model detail. This approach provides insight into how a model is organized and how its parts interact.

After you define a model, you can simulate it, using a choice of integration methods, either from the Simulink menus or by entering commands in the MATLAB Command Window. The menus are particularly convenient for interactive work, while the command-line approach is very useful for running a batch of simulations (for example, if you are doing Monte Carlo simulations or want to sweep a parameter across a range of values). Using scopes and other display blocks, you can see the simulation results while the simulation is running. In addition, you can change parameters and immediately see what happens, for “what if” exploration. The simulation results can be put in the MATLAB workspace for post processing and visualization.

Model analysis tools include linearization and trimming tools, which can be accessed from the MATLAB command line, plus the many tools in MATLAB and its application toolboxes. In addition, MATLAB and Simulink are integrated, and you can simulate, analyze, and revise your models in either environment at any point.

**Running a demo model**

An interesting demo program provided with Simulink models the thermodynamics of a house. To run this demo, follow these steps:

1Start MATLAB. See your MATLAB documentation if you are not sure how to do this.

2Run the demo model by typing thermo in the MATLAB Command Window.

This command starts up Simulink and creates a model window that contains this model.



3. Double-click the Scope block labeled Thermo Plots. The Scope block displays two plots labeled Indoor vs. Outdoor Temp and Heat Cost ($), respectively.

**4** To start the simulation, pull down the **Simulation** menu and choose the **Start** command (or, on Microsoft Windows, click the **Start** button on the Simulink toolbar). As the simulation runs, the indoor and outdoor temperatures appear in the Indoor vs. Outdoor Temp plot and the cumulative heating cost appears in the Heat Cost ($) plot.

**5** To stop the simulation, choose the **Stop** command from the **Simulation** menu (or click the **Pause** button on the toolbar).

**6** When you are finished running the simulation, close the model by choosing **Close** from the **File** menu.

**Description of the Demo**

The demo models the thermodynamics of a house. The thermostat is set to 70 degrees Fahrenheit and is affected by the outside temperature, which varies by applying a sine wave with amplitude of 15 degrees to a base temperature of 50 degrees. This simulates daily temperature fluctuations.

The model uses subsystems to simplify the model diagram and create reusable systems. A subsystem is a group of blocks that is represented by a Subsystem block. This model contains five subsystems: one named Thermostat, one named House, and three Temp Convert subsystems (two convert Fahrenheit to Celsius, one converts Celsius to Fahrenheit).

The internal and external temperatures are fed into the House subsystem, which updates the internal temperature. Double-click the House block to see the underlying blocks in that subsystem.



The Thermostat subsystem models the operation of a thermostat, determining when the heating system is turned on and off. Double-click the block to see the underlying blocks in that subsystem.



Both the outside and inside temperatures are converted from Fahrenheit to Celsius by identical subsystems.



**Some Things to Try**

Here are several things to try to see how the model responds to different parameters:

**•**Each Scope block contains one or more signal display areas and controls that enable you to select the range of the signal displayed, zoom in on a portion of the signal, and perform other useful tasks. The horizontal axis represents time and the vertical axis represents the signal value.

**•**The Constant block labeled Set Point (at the top left of the model) sets the desired internal temperature. Open this block and reset the value to 80 degrees. See how the indoor temperature and heating costs change. Also, adjust the outside temperature (the Avg Outdoor Temp block) and see how it affects the simulation.

**•**Adjust the daily temperature variation by opening the Sine Wave block labeled Daily Temp Variation and changing the **Amplitude** parameter.