NATIONAL UNIVERSITY OF SINGAPORE

Department of Electrical and Computer Engineering
EE4302 Advanced Control Systems
Experiment II
Nonlinear System

1.0 OBJECTIVES

(a) Introduction to Simulink a software package for modeling and simulating dyamical linear and nonlinear systems.

(b) Use of root-locus to analyse and Simulink to simulate and the effect of signal saturation.

(c) Design of a Sliding Mode Control system and the use of Simulink to simulate the system.

2.0 INTRODUCTION

Simulink is a software package for modeling, simulating, and analyzing dynamical 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.

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.

3.0 EQUIPMENT

(a) Personal Computer

(b) Simulink software package

4.0 EXPERIMENT

4.1 ROOT-LOCUS ANALYSIS

This example shows you how to build the model in Figure 1.

(a) First type simulink in the MATLAB command window. The Simulink Library Browser appears as shown in Figure 2. Next select the New Model button (top left hand corner) on the Library Browser's toolbar.

To create the model, you will need to drag blocks into the model from the following Simulink block libraries:

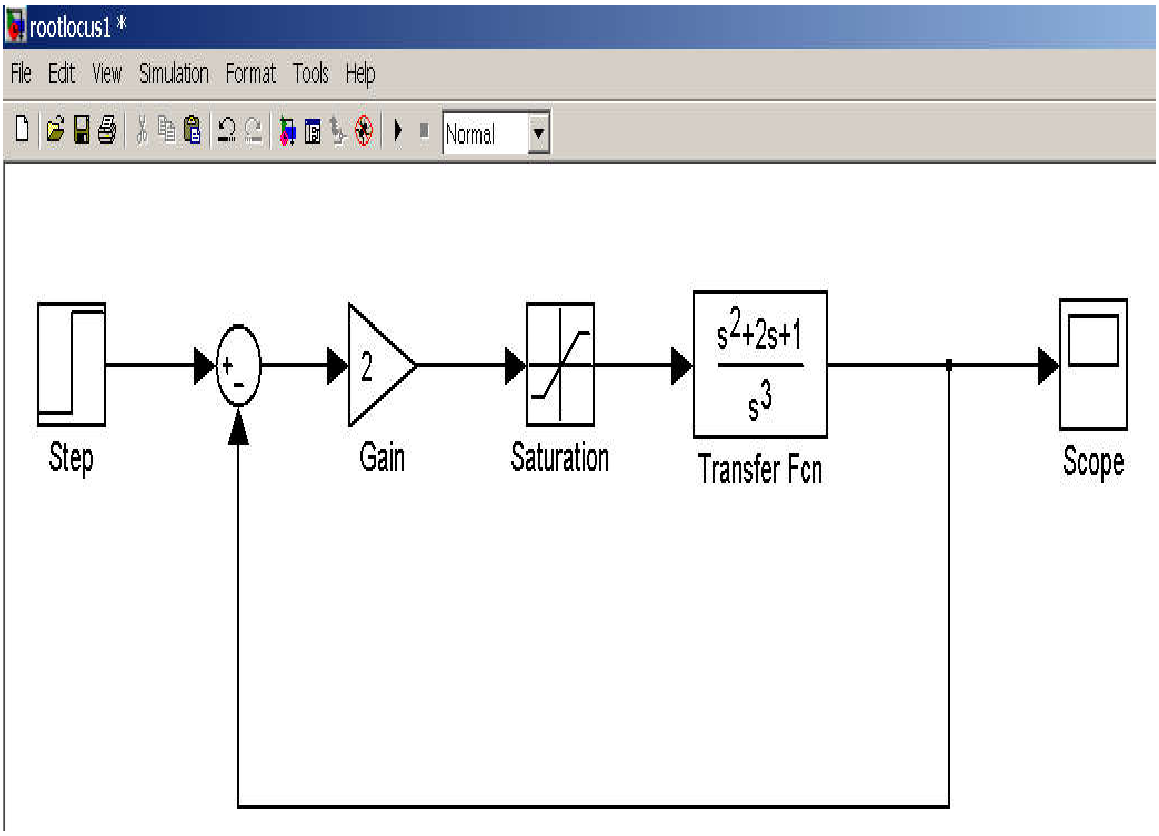

Figure 1: Simulink model for root-locus analysis

- Sources library (the Step block)
- Sinks library (the Scope block)
- Nonlinear library (the Saturation block)
- Continuous library (the Transfer Fcn block)
- Math (the Gain block and the Sum block)

For example drag the Transfer Fcn block from the browser and drop it in the model window. Simulink creates a copy of the Transfer Fcn block at the point where you dropped the node icon. Copy the rest of the blocks in a similar manner from their respective libraries into the model window. You can move a block from one place in the model window to another by dragging the block. The $>$ symbol pointing out of a block is an output port; if the symbol points to a block, it is an input port. A signal travels out of an output port and into an input port of another block through a connecting line. To connect, hold down the mouse button and move the cursor from a output port to an input port. Double-click on each of the block to open a dialog box for you to fill in the parameters for the block. The parameters for the Gain and Transfer Fcn blocks are shown in Figure 1. For the Saturation block, key in $+1$ and -1 for the Upper Limit and Lower Limit respectively. For the Step block, key in 1 for the Final Value.

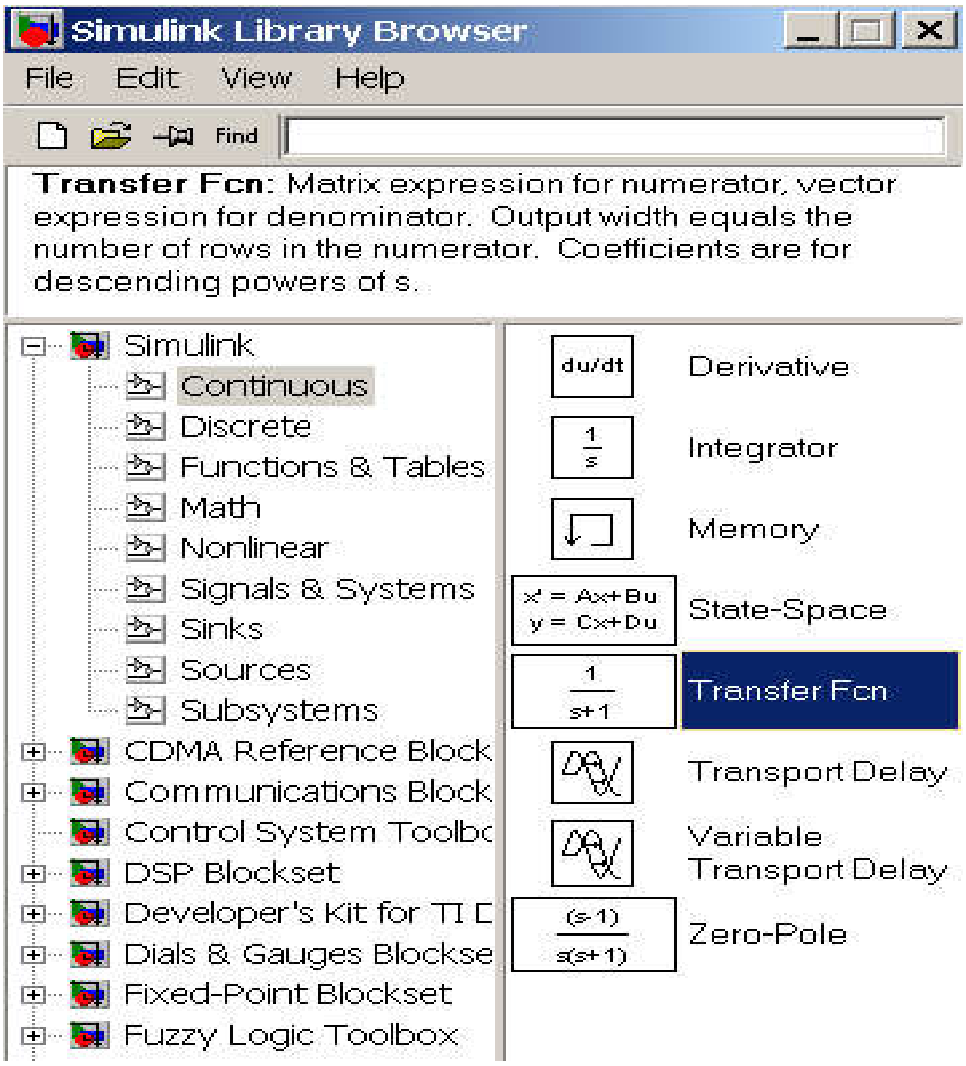

Figure 2: Simulink library browser

Now, double-click on the Scope block to view the simulation output. Keep the Scope window open. First, set the simulation parameters by choosing Simulation Parameters from the Simulation menu. On the dialog box that appears, notice that the Stop time is set to 10.0 (its default value). Change it to 20.0. Close the Simulation Parameters dialog box by clicking on the OK button. Simulink applies the parameters and closes the dialog box.

(b) Choose Start from the Simulation menu and watch the trace on the Scope block.

(c) Repeat Step (b) with Final Value in the Step block = 2, 3 and 4. By trial and error determine the Final Value that gives sustained oscillation. Note down the period of the sustained oscillation.

(d) The behaviour of the system can be qualitatively described by considering the Saturation block as a varying signal-dependent gain. Hence, do a root-locus analysis of the behaviour observed in Part (c) and predict the period of the sustained oscillation.

(e) When you have finished running the simulation, close the model by choosing Close from the File menu.

(f) Analyze your results.

4.2 SLIDING MODE CONTROL DESIGN

Consider the unstable system

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

which has the transfer function

$$\frac{Y(s)}{U(s)} = \frac{1}{s(s-1)}$$

(a) Design a variable-structure controller. Choose the switching line as

$$\sigma = x_1 + x_2$$

and the amplitude of the "sign" function as 0.5.

(b) Simulate the system using simulink. Plot the states, control signal and phase plane trajectory.

(c) Modify the variable-structure controller such that chattering is eliminated and simulate the system using simulink. Plot the states and control signal.

(d) Analyze your results.

— End —