Experiment 3

Getting Start with Simulink

Objectives :

By the end of this experiment, the student should be able to:

1. Build and simulate simple system model using Simulink
2. Use Simulink test and measurement tools.

1. Introduction

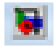
Simulink is a program for simulating signals and dynamic systems. Simulink has two phases of use: model definition and model analysis. It provides an interactive graphical environment and a customizable set of block libraries that let you design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing, video processing, and image processing.

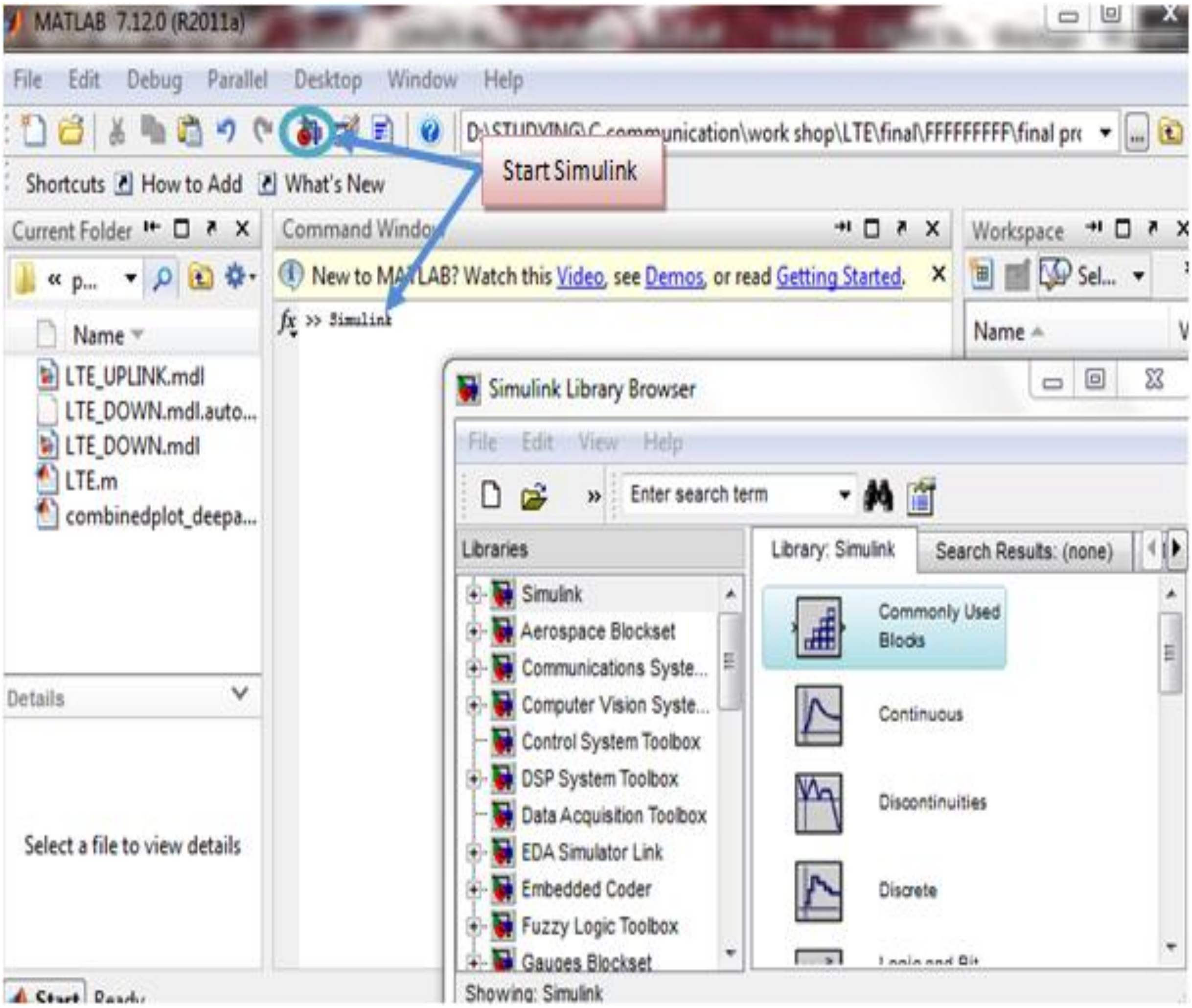
Simulink provides toolboxes for designing, simulating, and analyzing communications systems. The Simulink enables source coding, channel coding, interleaving, analog and digital modulation, equalization, synchronization, and channel modeling.

A typical session starts by either defining a new model or by recalling a previously defined model, and then proceeds to analyze that model. In order to facilitate the model definition, Simulink has a large library of blocks. Models are created by combining proper blocks from the library and edited in the model window principally using mouse-driven operation (**Drag and Drop**) . An important part of mastering Simulink is to become familiar with manipulations of various model components in these windows.

After you create (or define) a model, you can analyze it either by choosing options from the Simulink menus in the model window or by entering commands in the Matlab command window. The progress of an ongoing simulation can be viewed while it is running, and the final results can be made available in the Matlab workspace when the simulation is complete.

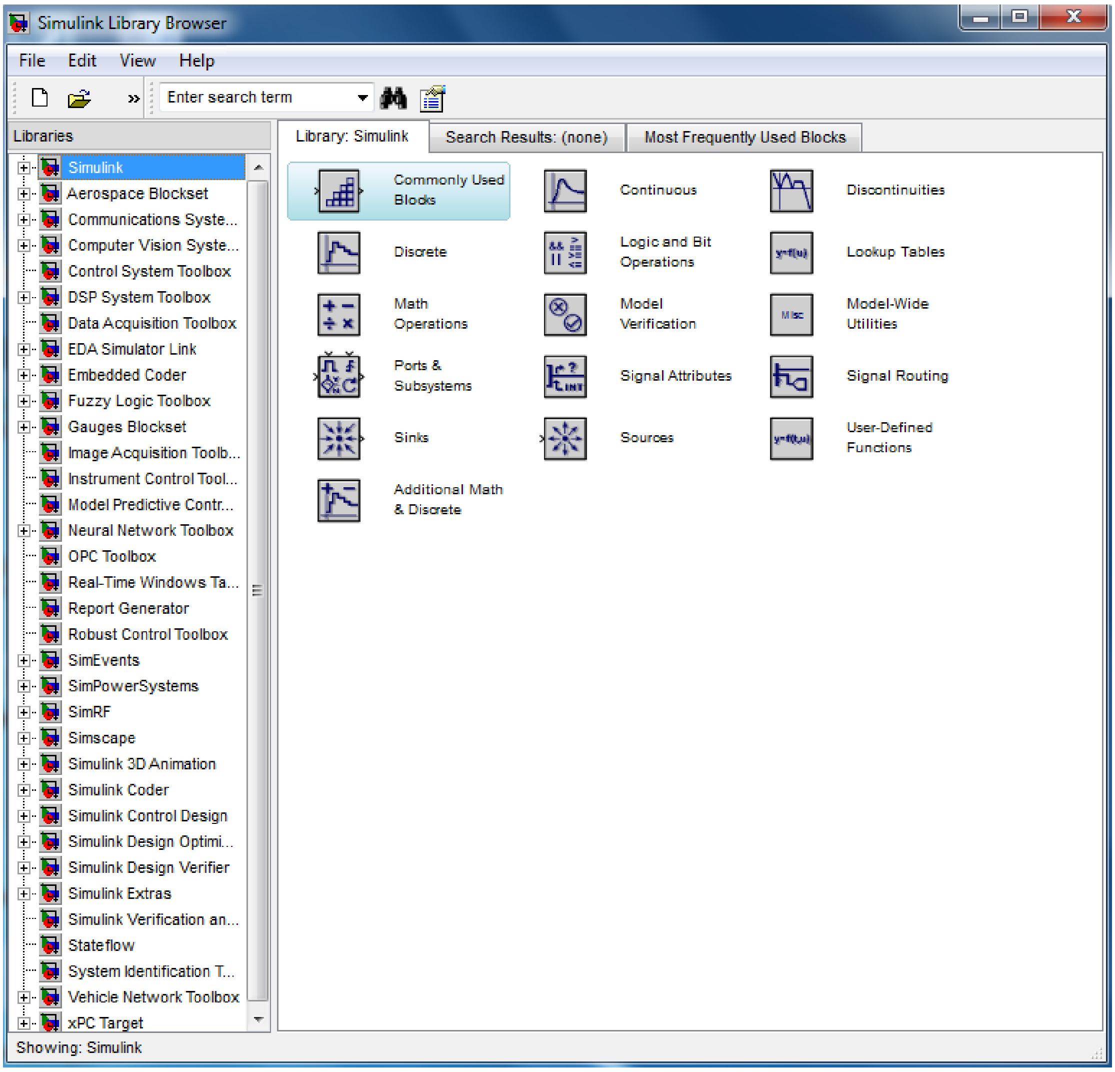
1.1 Starting Simulink:

1. Start up Matlab.
2. Start up Simulink by clicking the Simulink icon  or by typing **>>Simulink** at the Matlab command window.
3. You should see the Simulink Block Library window as shown in figure 1.



1.3 The Simulink Library

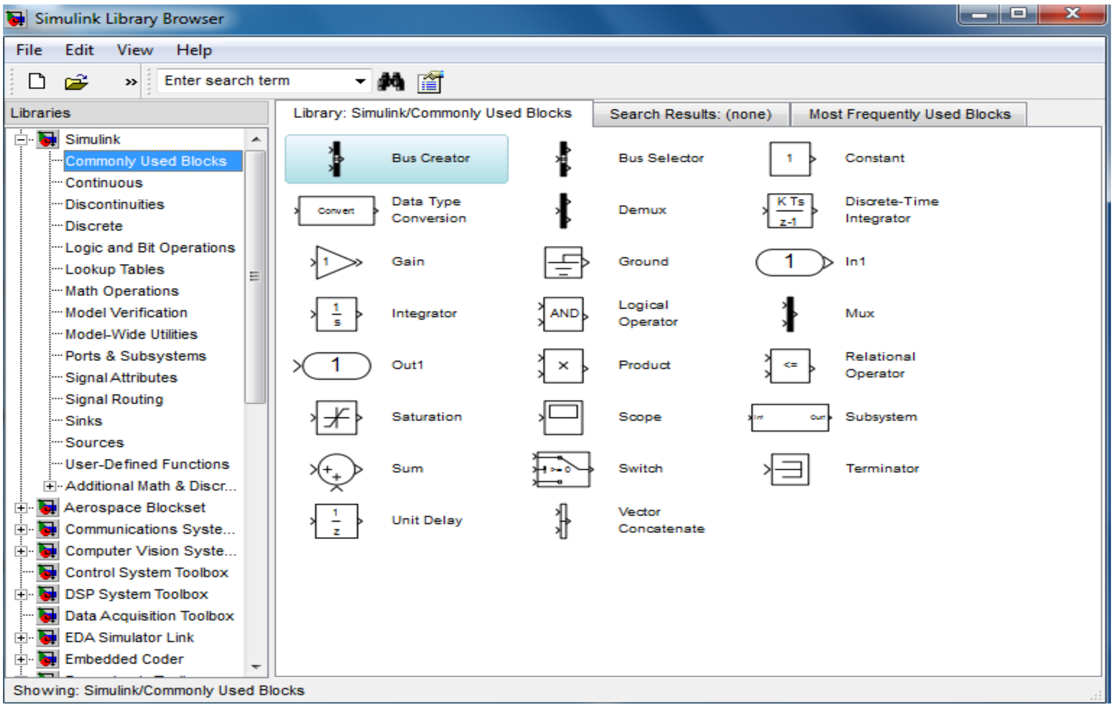
The Simulink Library Browser is the library where you find all the blocks you may use in Simulink. Simulink software includes an extensive library of functions commonly used in modeling a system. These include:



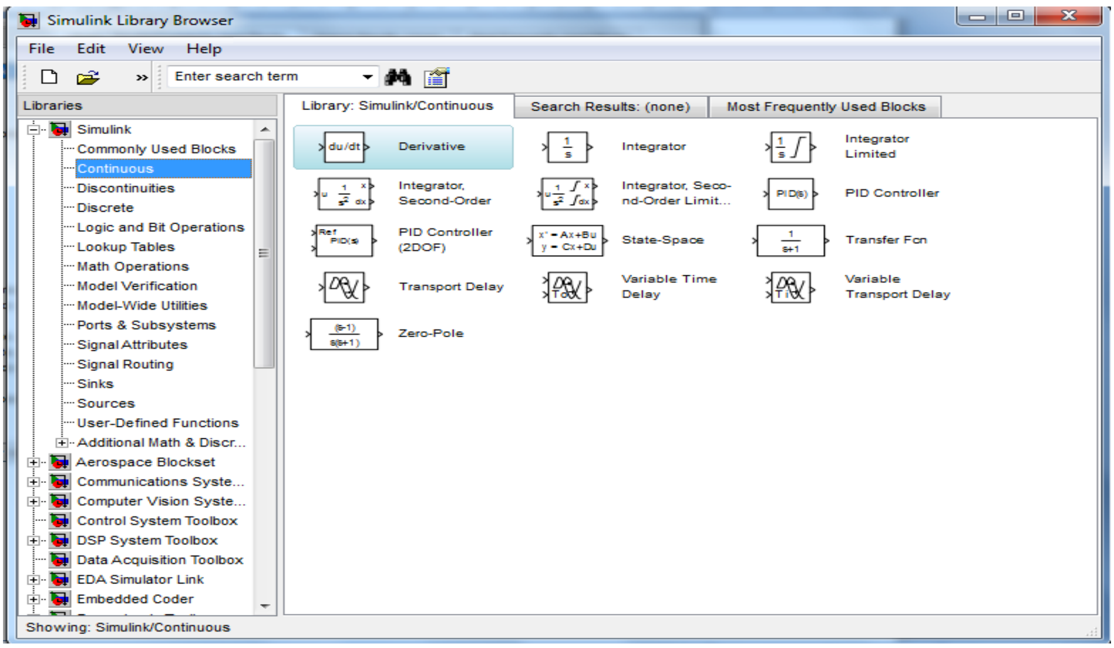
1.3.1 Common Block Libraries:

In this section we will see the most common used block libraries in communication system models.

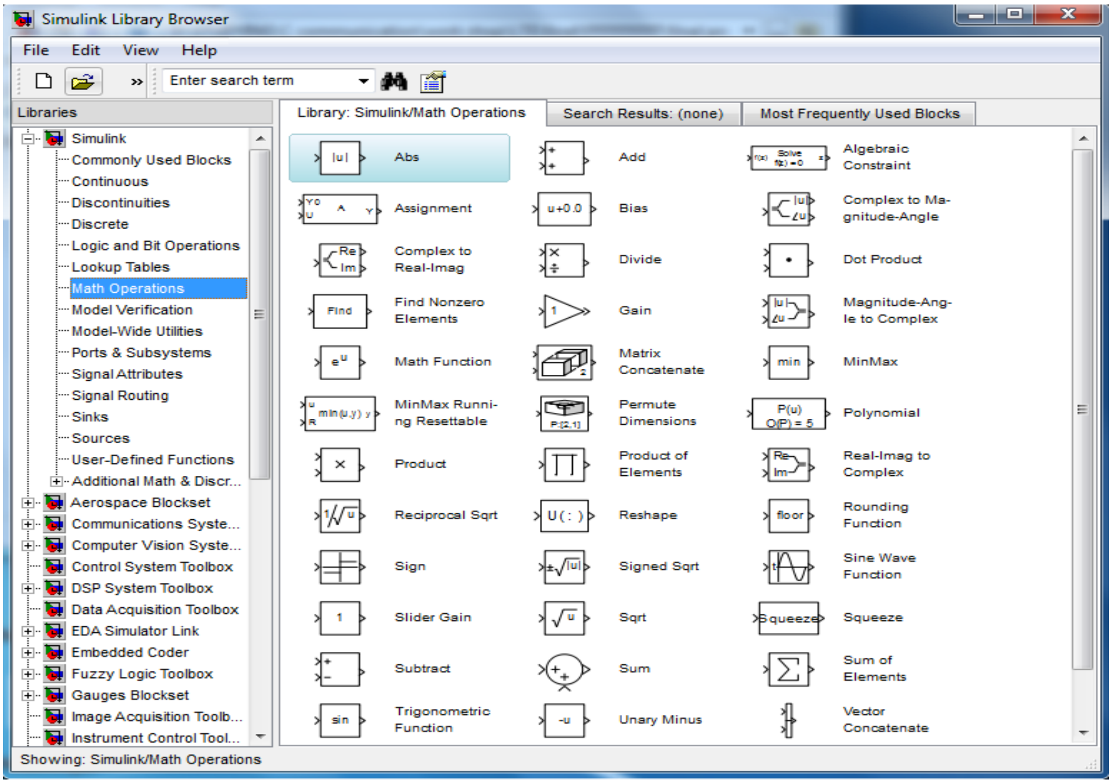
1. **Commonly Used Block**



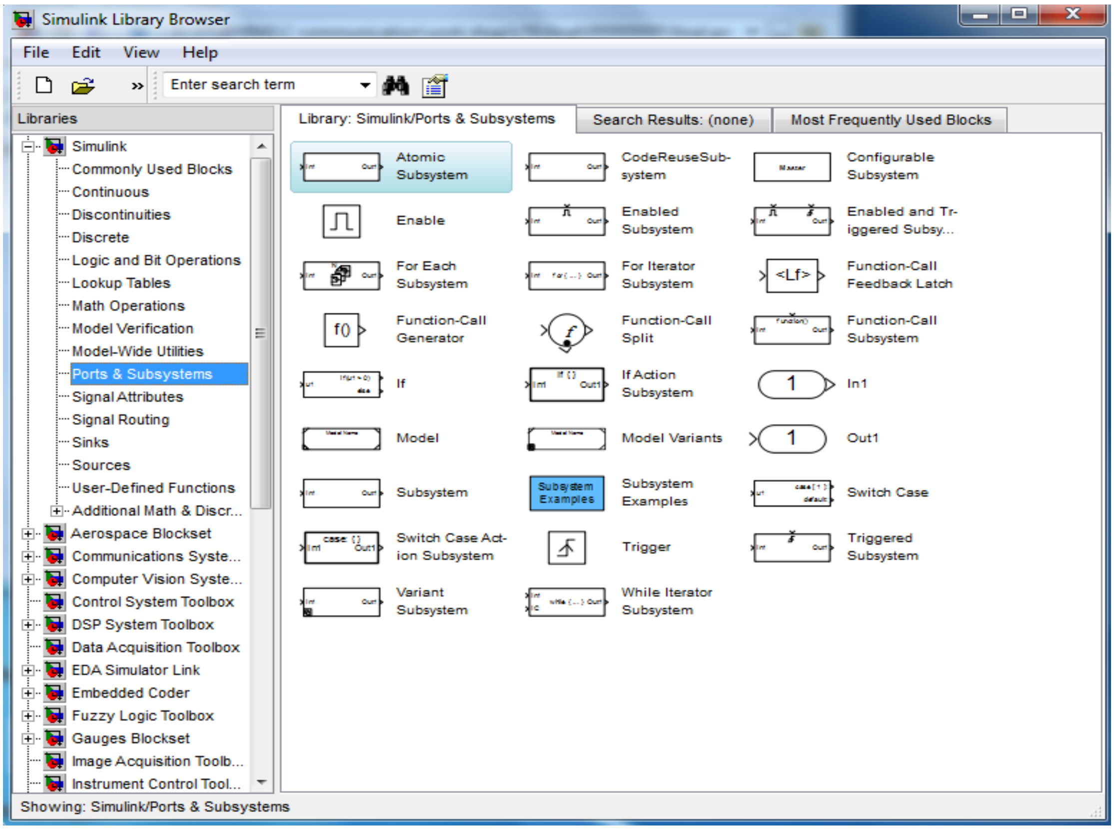
2. **Continuous :**



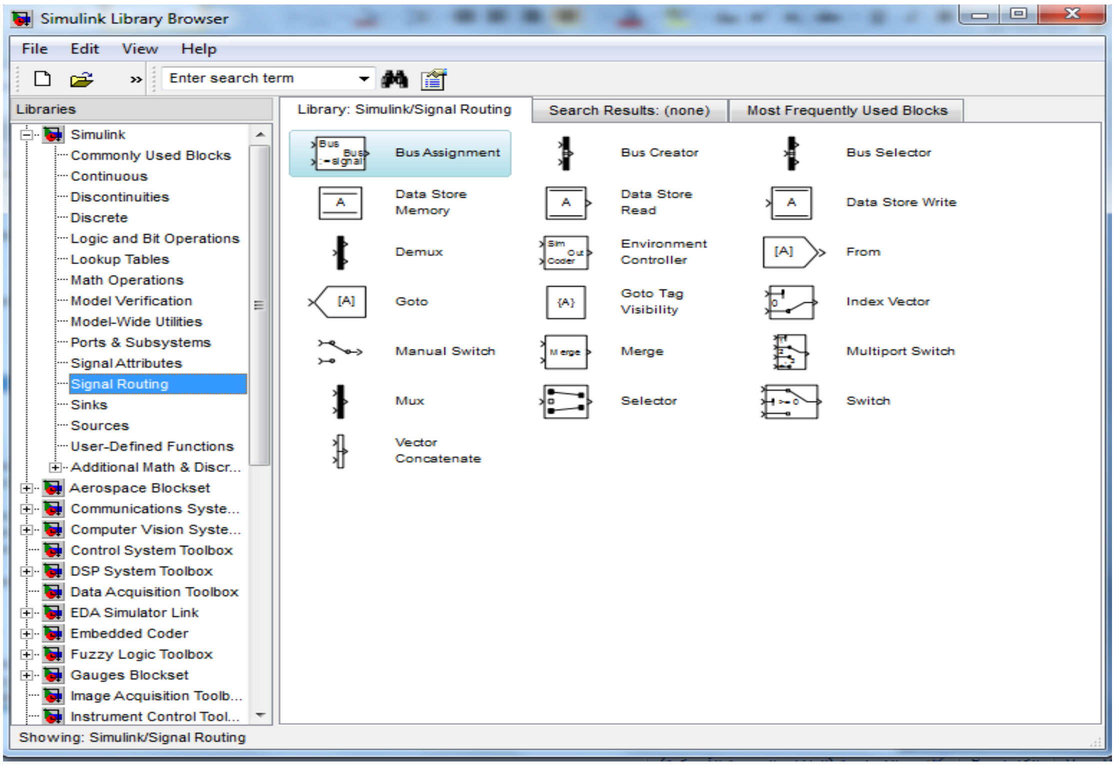
3. Math Operation:



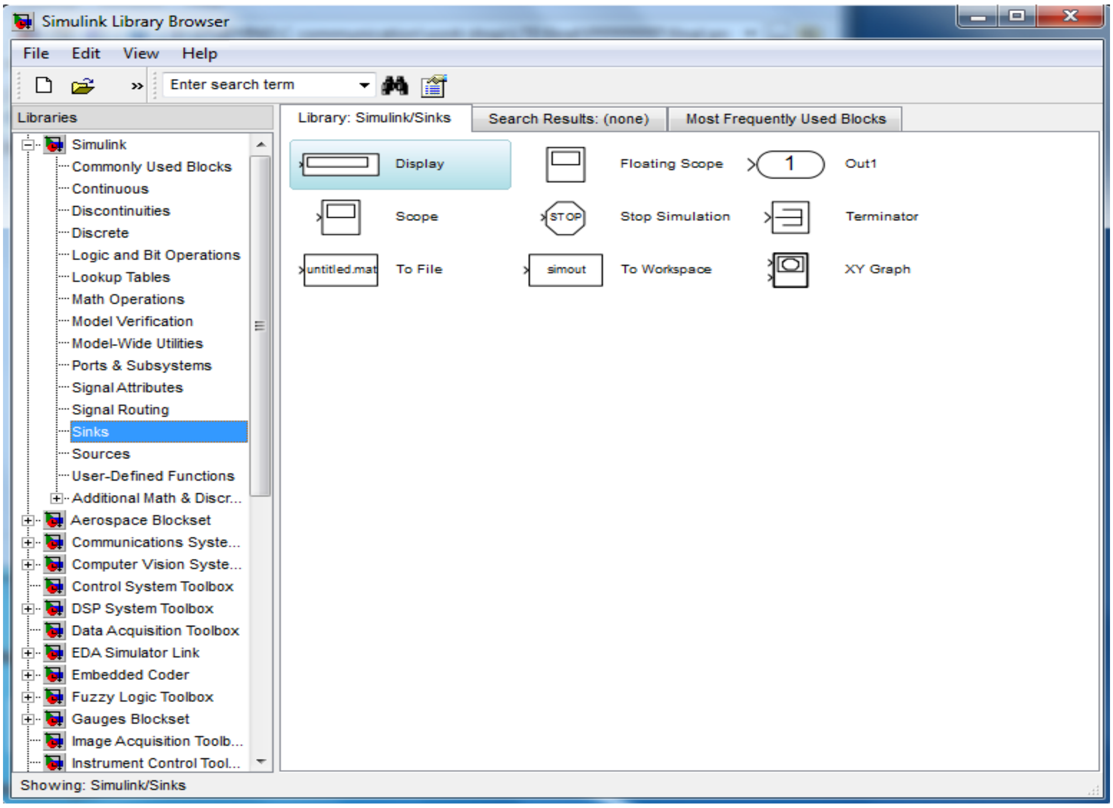
4. Ports and Subsystem



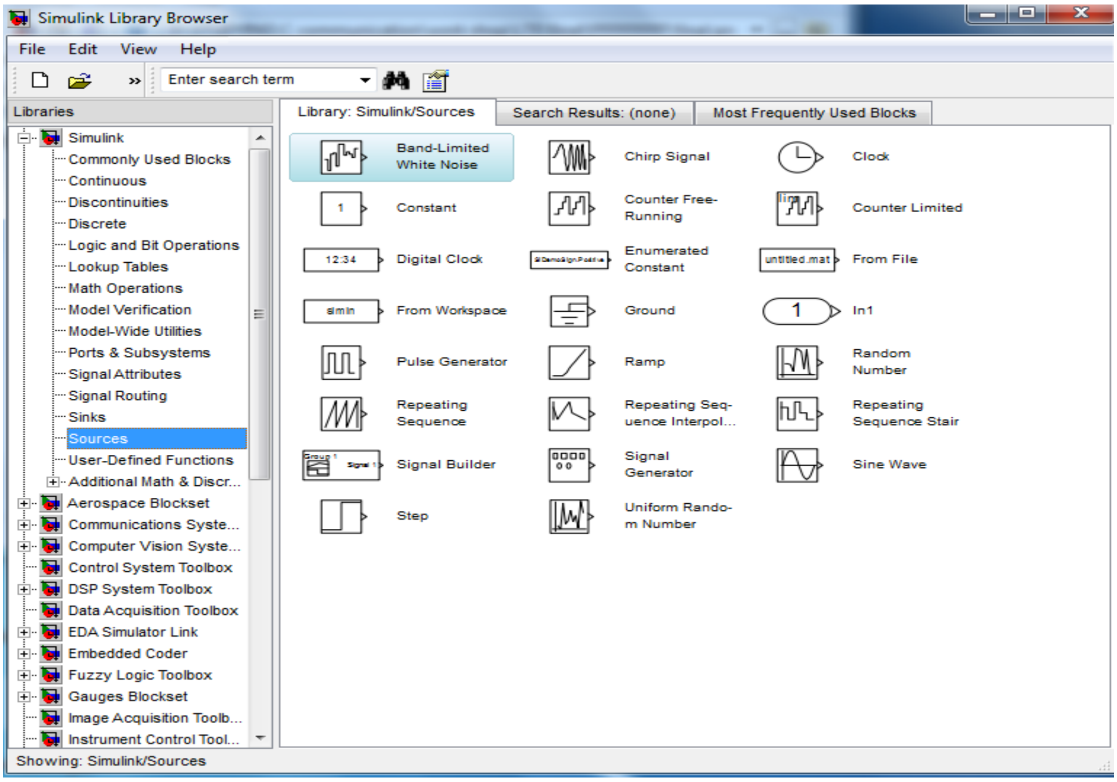
5. Signal Routing



6. Sinks

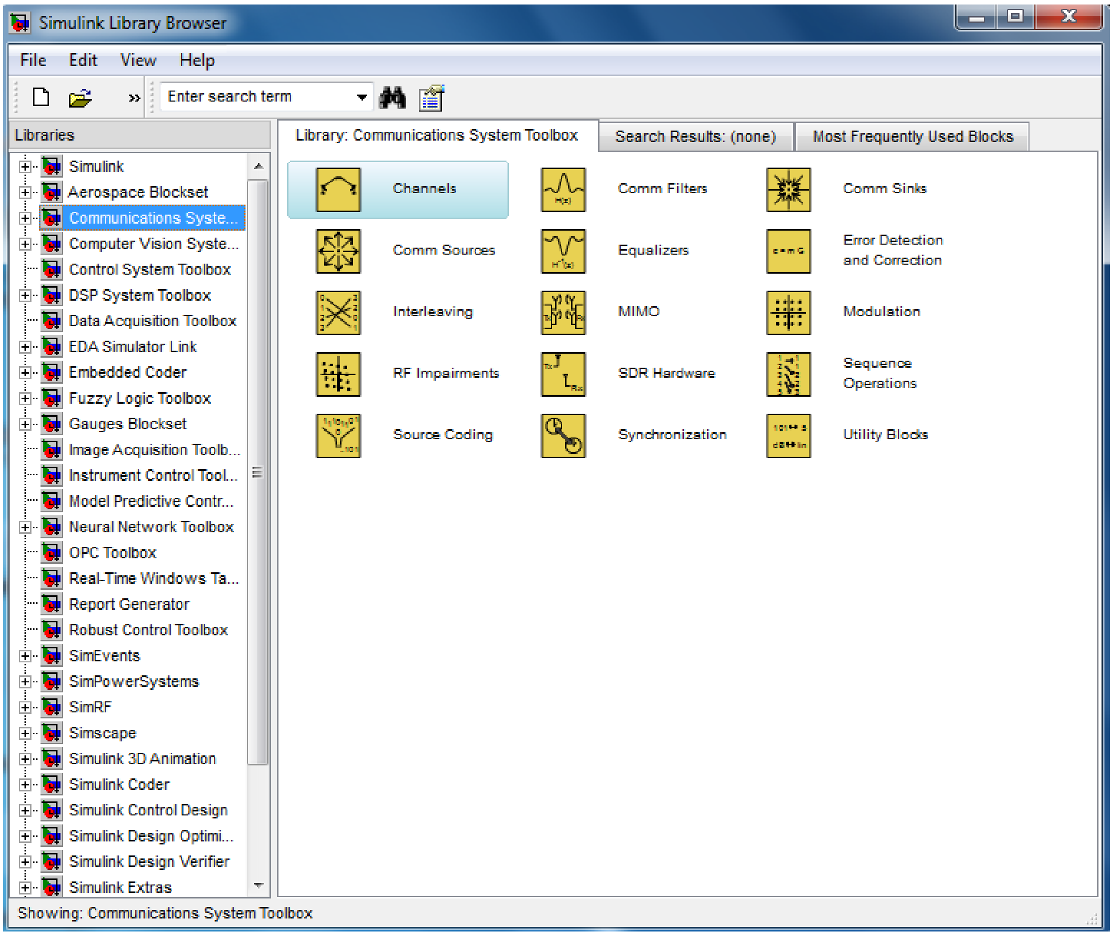


7. Sources


Simulink Library Browser
File Edit View Help
Enter search term
Libraries
Library: Simulink/Sources
Search Results: (none)
Most Frequently Used Blocks
Simulink
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 & Discr...
Aerospace Blockset
Communications Syste...
Computer Vision Syste...
Control System Toolbox
DSP System Toolbox
Data Acquisition Toolbox
EDA Simulator Link
Embedded Coder
Fuzzy Logic Toolbox
Gauges Blockset
Image Acquisition Toolb...
Instrument Control Tool...
Band-Limited White Noise
Chirp Signal
Clock
Constant
Counter Free-Running
Counter Limited
Digital Clock
Enumerated Constant
From File
From Workspace
Ground
In1
Pulse Generator
Ramp
Random Number
Repeating Sequence
Repeating Seq-uence Interpol...
Repeating Sequence Stair
Signal Builder
Signal Generator
Sine Wave
Step
Uniform Rando-m Number
Showing: Simulink/Sources

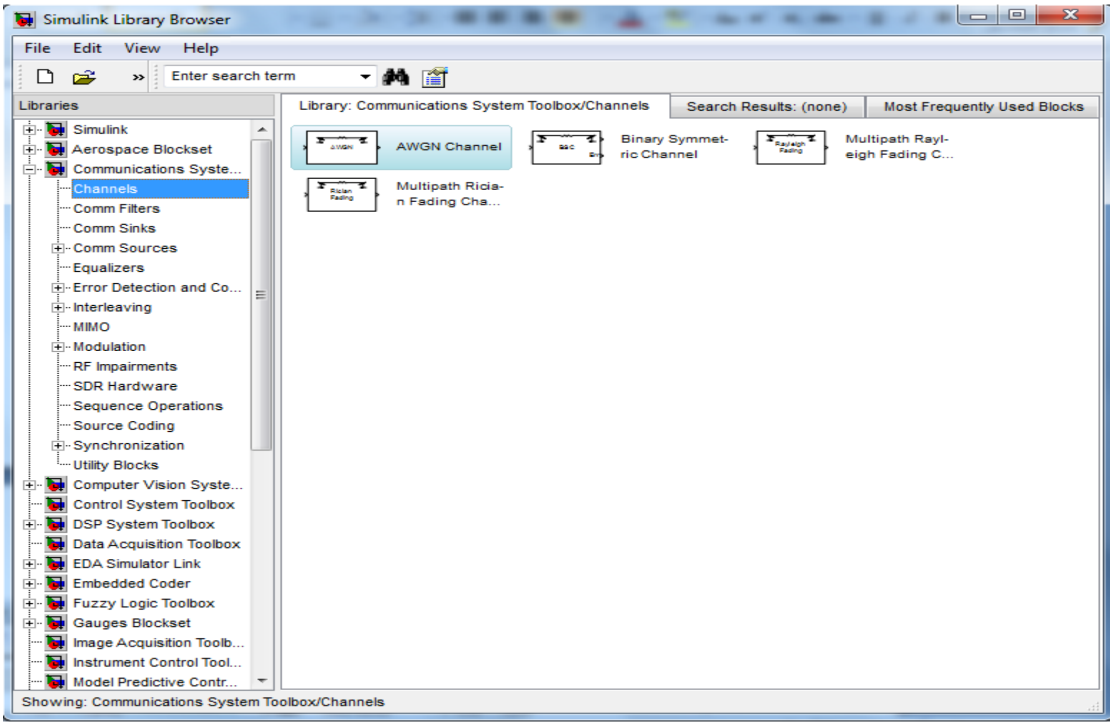
1.4 Communications System Toolbox

Communications System Toolbox provides algorithms for designing, simulating, and analyzing communications systems. The system toolbox enables source coding, channel coding, interleaving, modulation, equalization, synchronization, and channel modeling. You can also analyze bit error rates, generate eye and constellation diagrams, and visualize channel characteristics. Using adaptive algorithms, you can model dynamic communications systems that use OFDM, OFDMA, and MIMO techniques. Algorithms support fixed-point data arithmetic and C or HDL code generation.

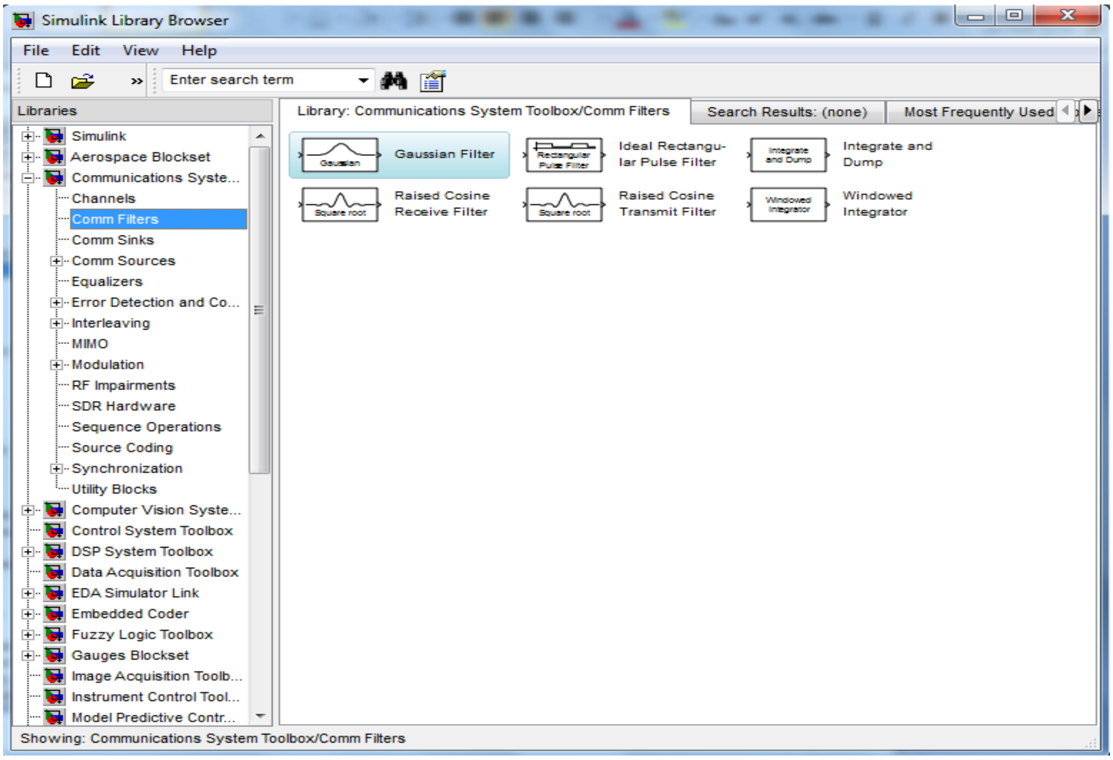


1.4.1 Common Block Libraries:

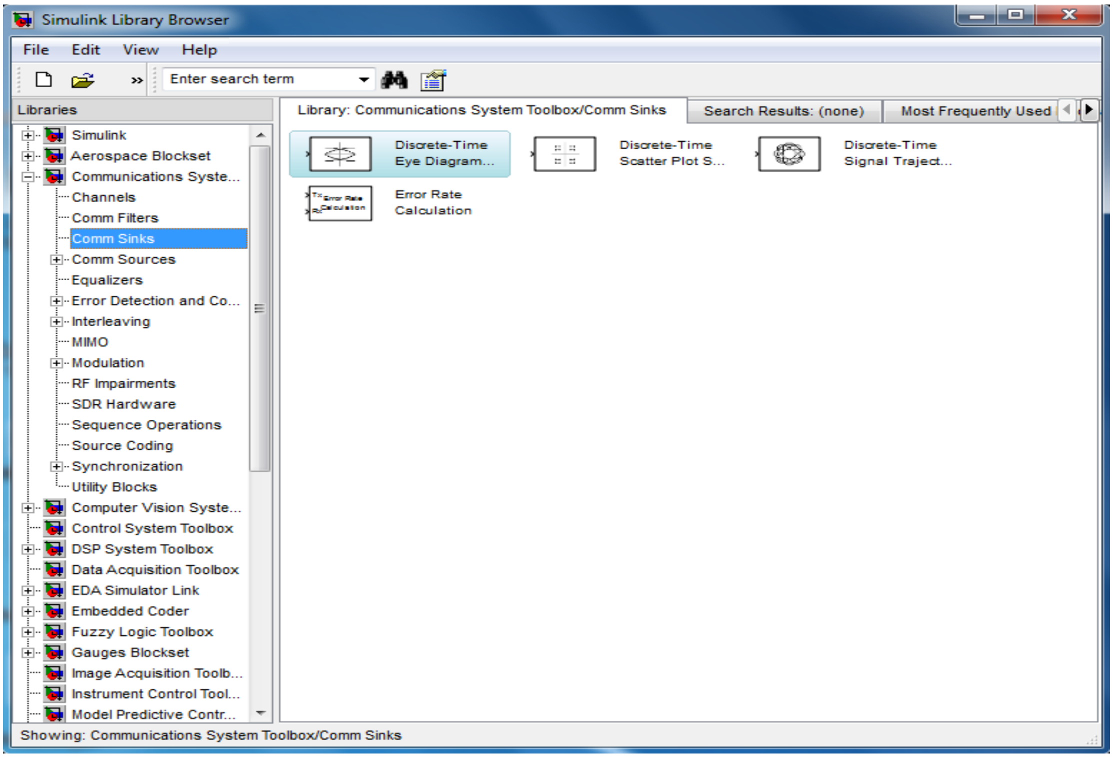
1. Channel :



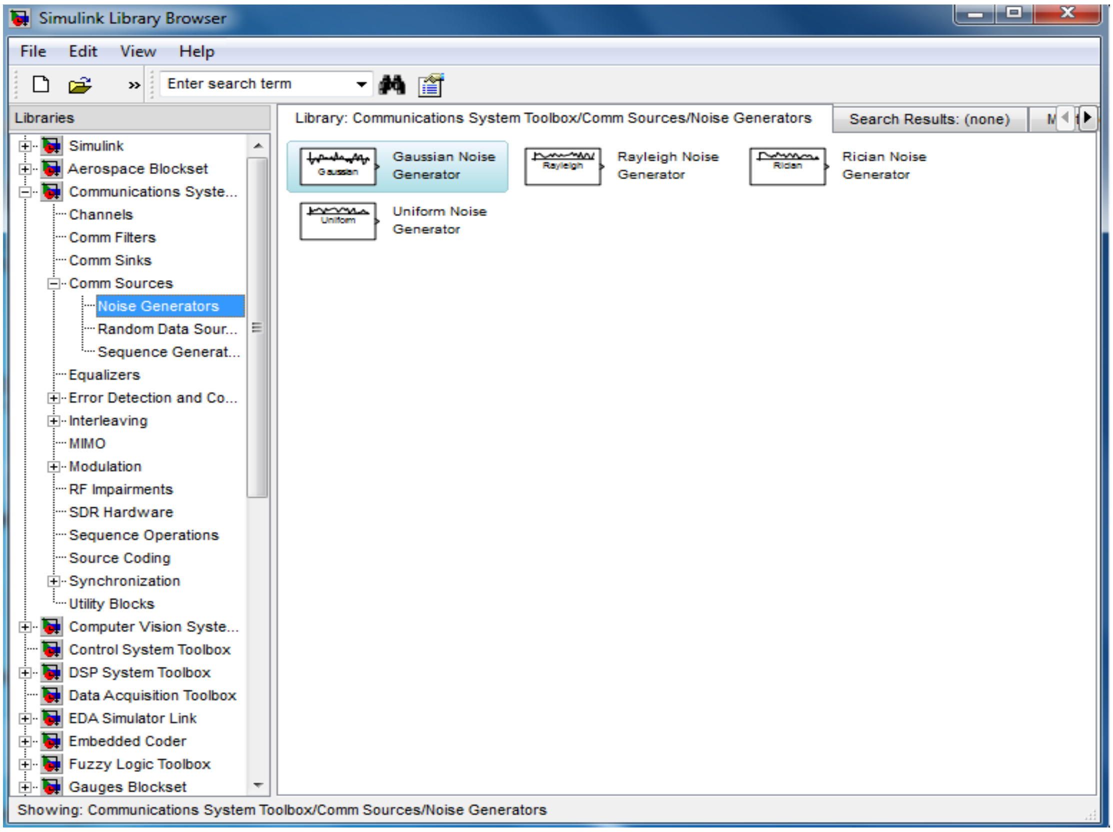
1. Common filters:



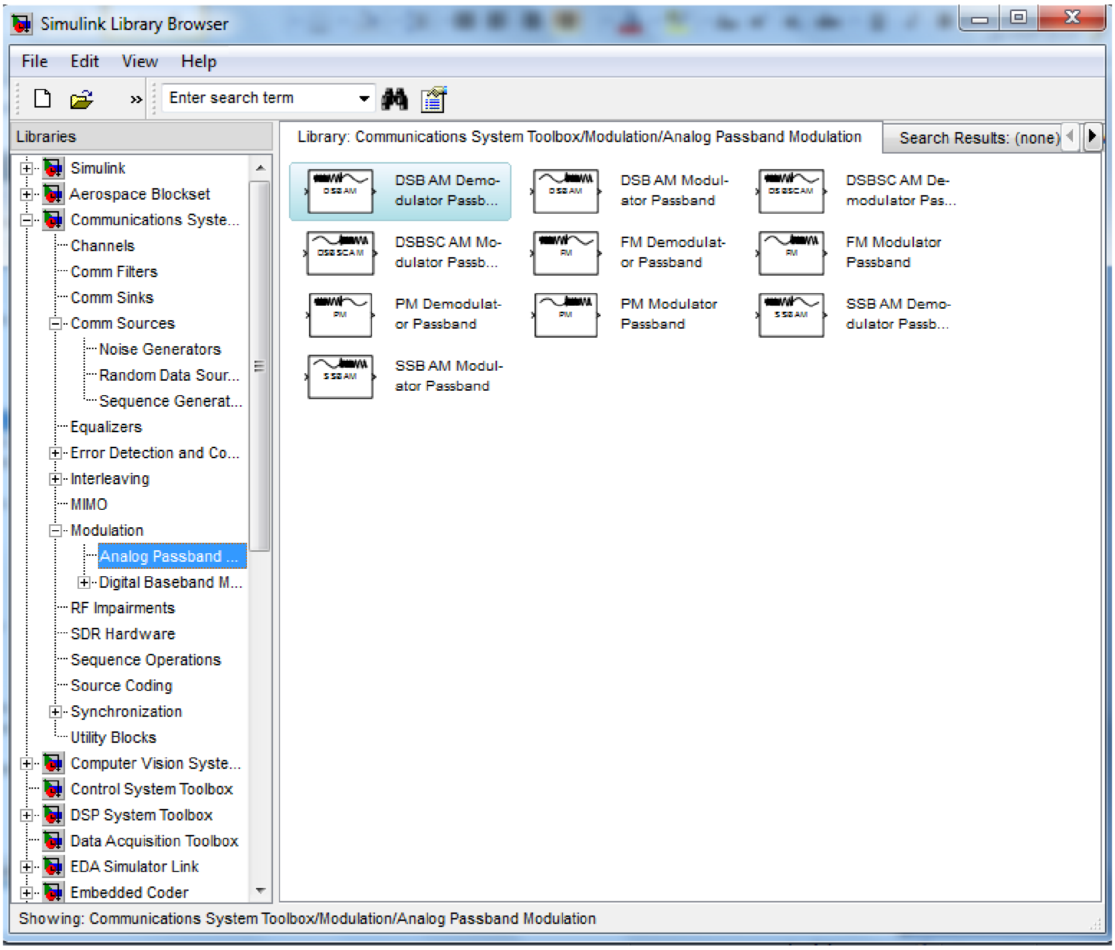
2. Common Sink:



3. Common Source:

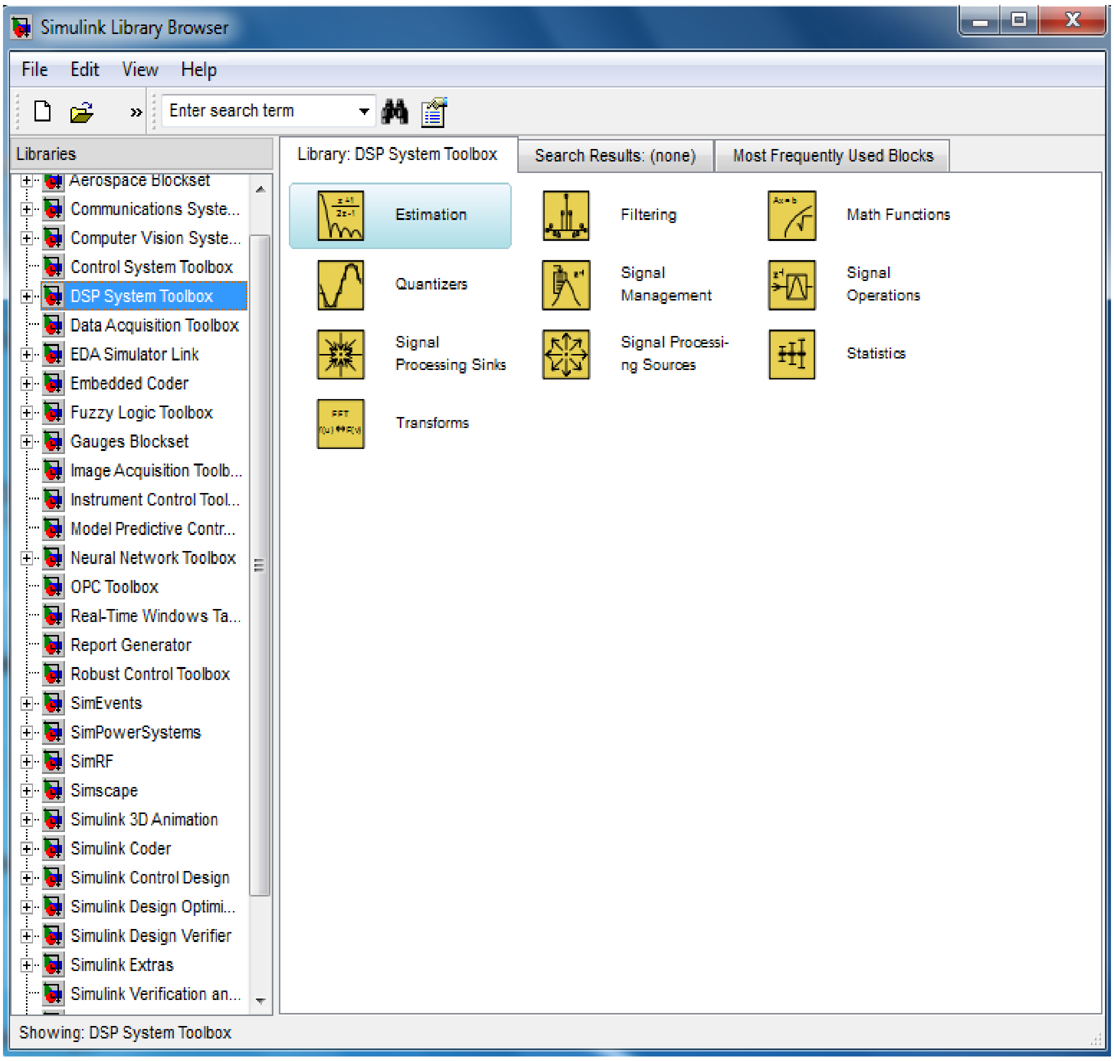


4. Modulation:



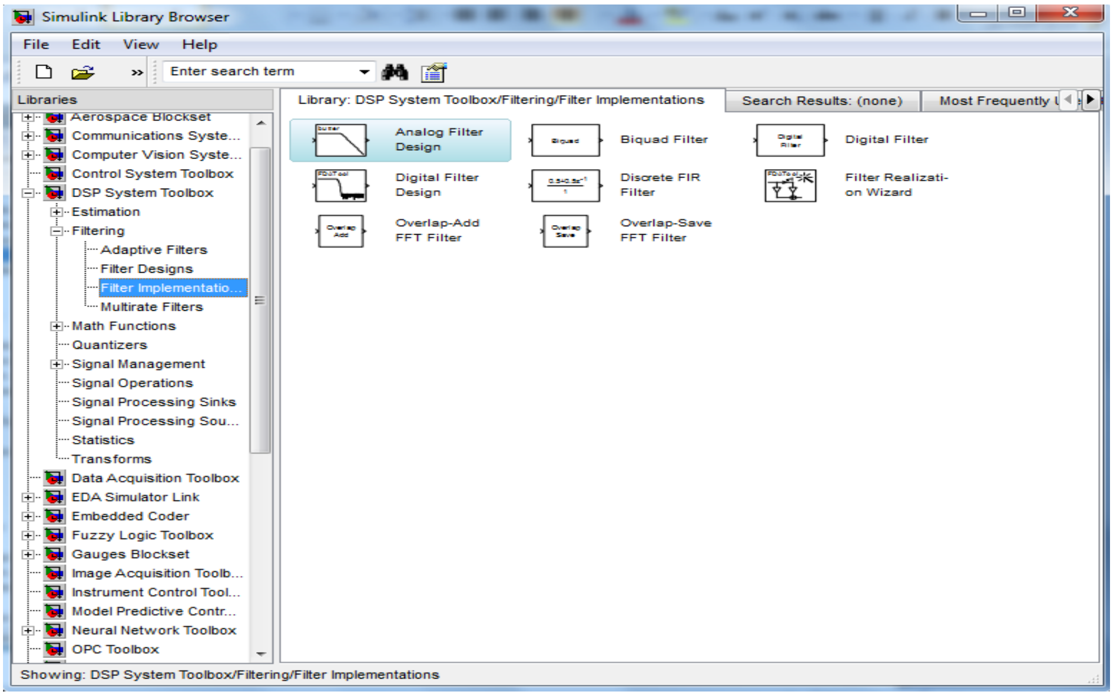
1.5 DSP System Toolbox

DSP System Toolbox provides algorithms for designing and simulating signal processing systems. he system toolbox includes design methods for filters, FFTs, multirate processing, and DSP techniques for processing streaming data and creating real-time prototypes. You can design adaptive and multirate filters, implement filters using computationally efficient architectures, and simulate floating-point digital filters. Tools for signal I/O from files and devices, signal generation, spectral analysis, and interactive visualization enable you to analyze system behavior and performance. For rapid prototyping and embedded system design, the system toolbox supports fixed-point arithmetic and C or HDL code generation.

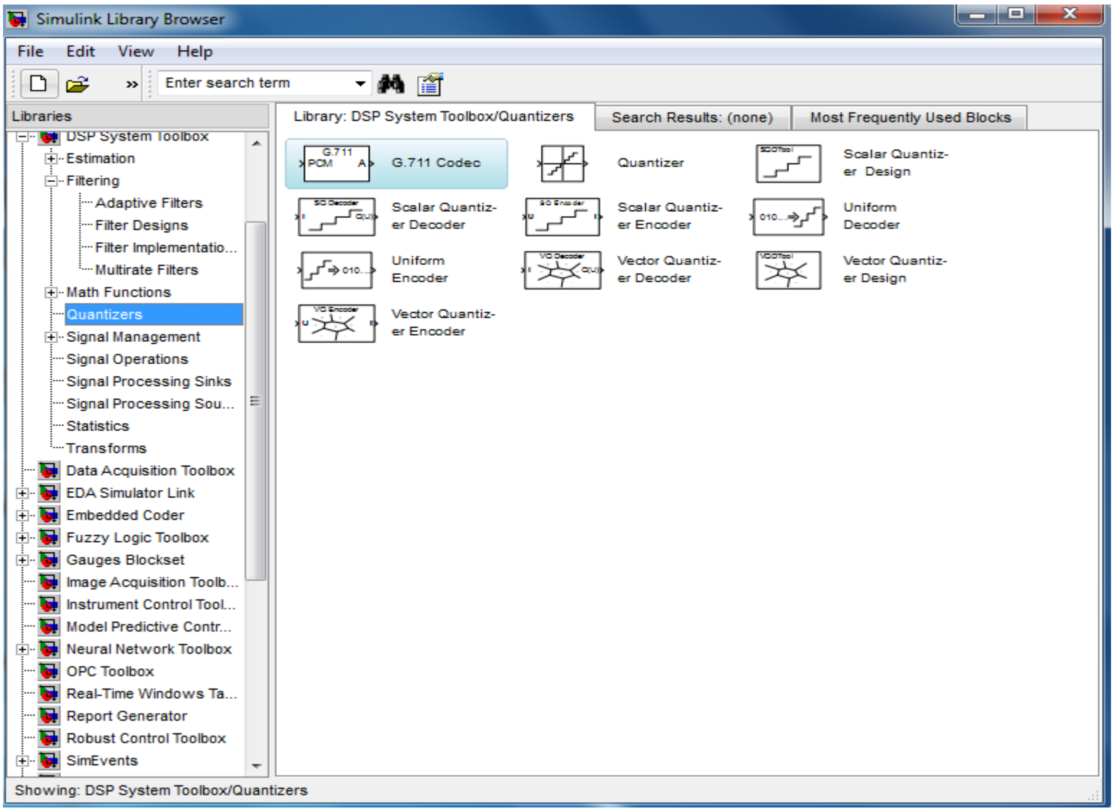


Common Block Libraries:

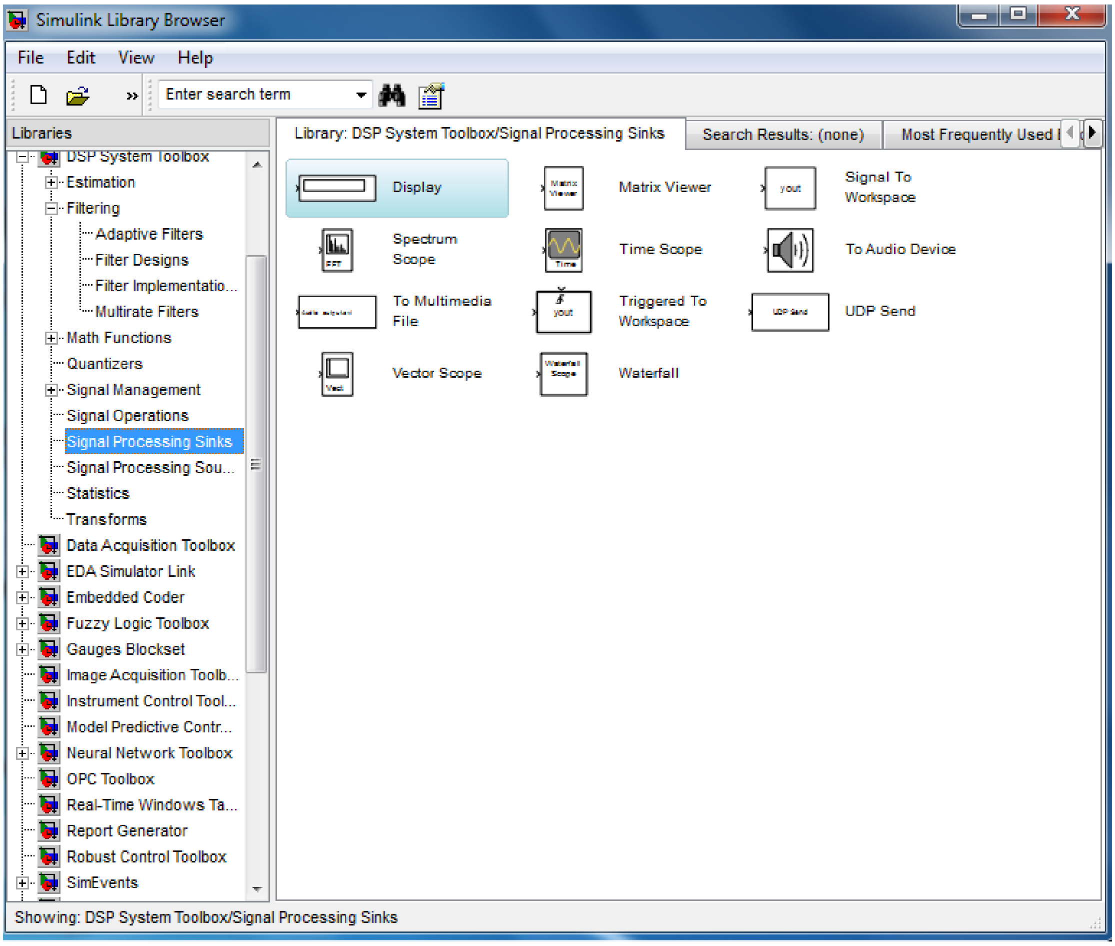
1. Filter Implementation



2. Quantizers



3. Signal Processing Sinks



1.6 Building a Simple Model

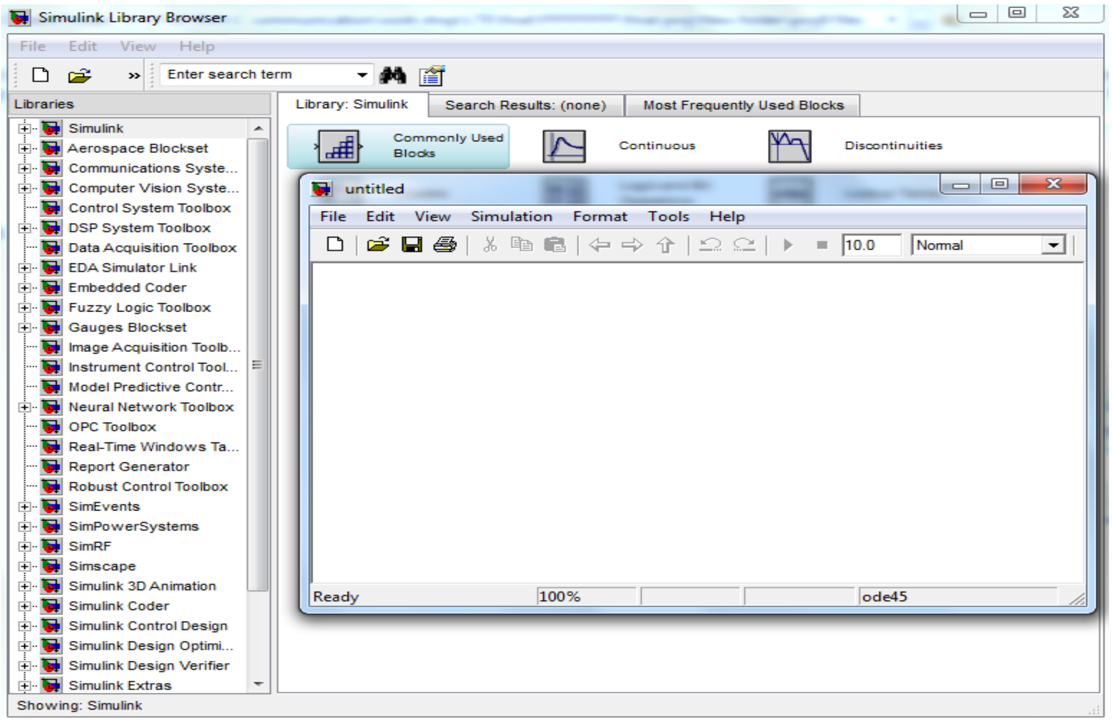
The Basic Steps

This section describes the basic steps in building a model. It explains how to:

- Open a new model window
- Open block libraries
- Move blocks into a model window
- Connect the blocks
- Set block parameters
- Set simulation parameters
- Run the model

1. Opening a New Model Window

The first step in building a model is to open a new model window. To do so, by clicking the new form icon  or select New from the **File** menu, and then select **Model**. This opens an empty model window, as shown in the following figure.



2. Opening Block Libraries

The next step is to select the blocks for the model. These blocks are contained in libraries. To view the libraries for the products you have installed, type Simulink at the MATLAB prompt (or, on Microsoft Windows, click the Simulink button on the MATLAB toolbar).

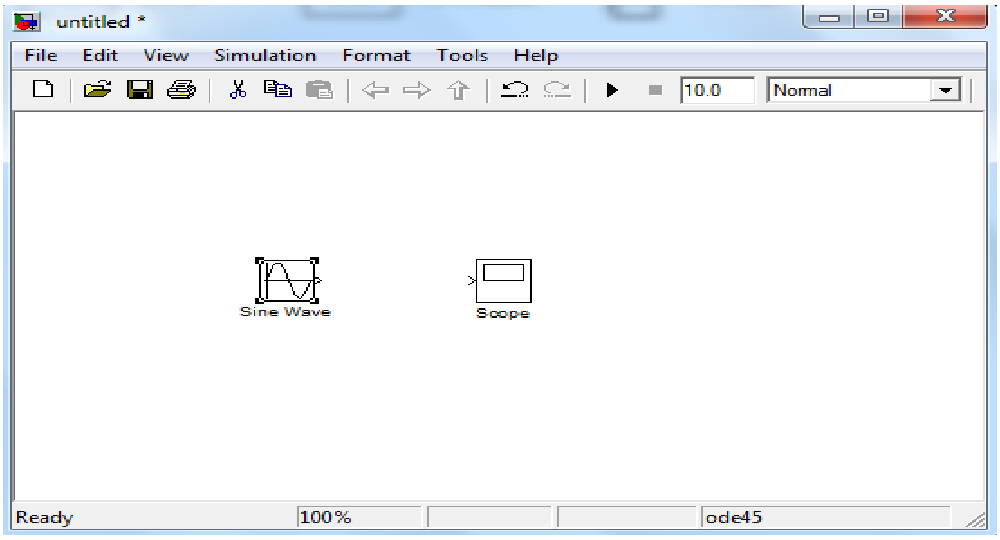
3. Simulink Library Browser

The left pane displays the installed products, each of which has its own library of blocks. To open a library, click the plus sign **(+)** next to the name of the blockset in the left pane. This displays the contents of the library in the right-hand pane. You can find the blocks you need to build models of communication systems in the libraries of the Communications System Toolbox, the DSP Toolbox Blockset, and Simulink.

4. Moving Blocks into the Model Window

The next step in building the model is to move blocks from the Simulink Library Browser into the model window. To do so,

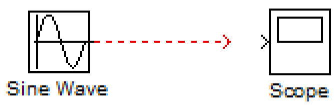
1. Click the + sign next to **Simulink** in the left pane of the Library Browser. This displays a list of the Signal Processing Blockset libraries.
2. Click **Sources** in the left pane. This displays a list of the Sources library blocks in the right pane.
3. Click the Sine Wave block and **Drag** and **Drop** it into the model window.
4. Click **Sinks** in the left pane of the Library Browser. This displays a list of the Sinks library blocks in the right pane.
5. Click the Scope Block and **drag** and **Drop** it into the model window.



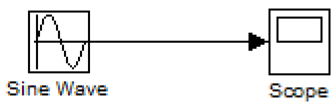
5. Connecting Blocks

The small arrowhead pointing outward from the right side of the Sine Wave block is an output port for the data the block generates. The arrowhead pointing inward on the Scope block is an input port.

To connect the two blocks, click the output port of the SineWave block and drag the mouse toward the input port of the Vector Scope block, as shown in the following figure.

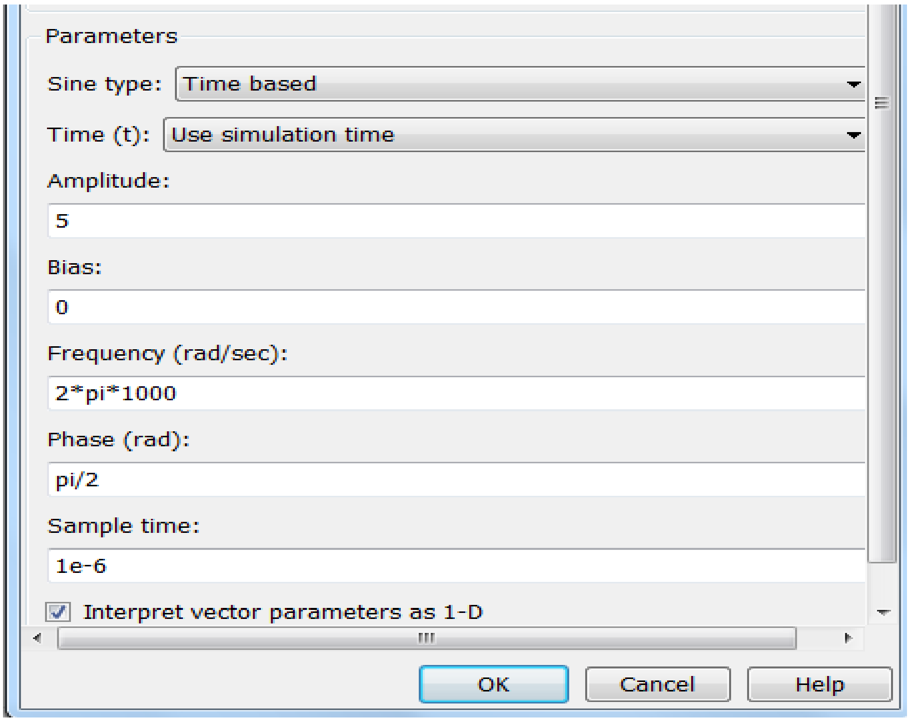


When the pointer is on the input port of the Vector Scope block, release the mouse button. You should see a solid arrow appear, as in the following figure.



6. Setting Block Parameters

To set parameters for the Sine Wave block, double-click the block to open its dialog, as shown in the following figure. Change the following parameters by clicking in the field next to the parameter, deleting the default setting, and entering the new setting in its place:

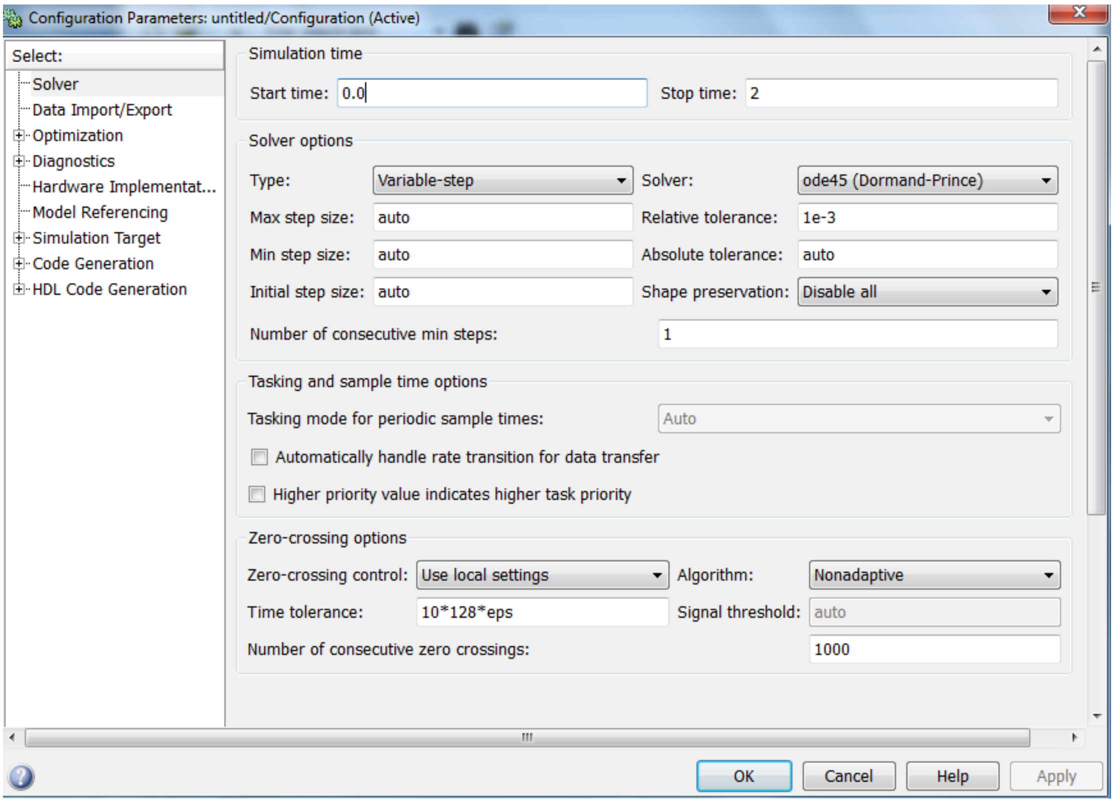


7. Setting Simulation Parameters

Besides individual block parameters, the model also has overall simulation parameters. To view the current settings,

1. Select the **Simulation** menu at the top of the model window.

2. Select **Configuration parameters** to open the **Configuration Parameters** dialog box, as shown in the following figure.

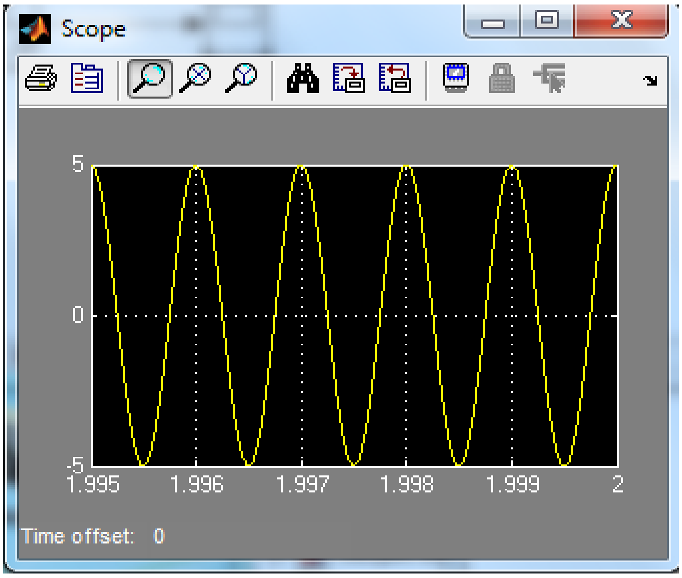


The **Stop time** determines the time at which the simulation ends. Setting **Stop time** to inf causes the simulation to run indefinitely, until you stop it by selecting **Stop** from the **Simulation** menu.

The **Stop time** is not the actual time it takes to run a simulation. The actual run-time for a simulation depends on factors such as the model's complexity and your computer's clock speed. The settings in the **Configuration Parameters** dialog box affect only the parameters of the current model.

8. Running the Model

Run the model by clicking start simulation icon  or selecting **Start** from the **Simulation** menu. When you do so, a scope window appears, displaying a sine wave as shown in the following figure.



1.7 Continuous Signals

The Simulink libraries also contain blocks that generate continuous signals. This means that they update the signal at variable time intervals, whose length is determined by the numerical solver the simulation uses. For example, the Sine Wave block in the Simulink Sources library can generate a continuous sine wave.

1.8 Discrete Signals and Sample Times

The Sine Wave block in the Signal Processing Blockset generates a discrete signal. This means that it updates the signal at integer multiples of a fixed time interval, called the sample time. You can set the length of this time interval in the **Sample time** parameter in the block's dialog.

The sample time T_s can be calculated based on Nyquist theorem that me be stated simply as follow: sampling frequency f_s should be at least twice of the highest frequency contained in the message signal f_m or in mathematical terms

$$f_s \geq 2f_m$$

$$T_s = \frac{1}{f_s}$$

Note

Many blocks in the Communications Blockset accept only discrete signals. To find out whether a block accepts continuous signals, consult the reference page for the block.

1.9 Frames and Frame-Based Processing

A *frame* is a sequence of samples combined into a single vector. By setting **Samples per frame** to 100 in the Sine Wave block, you set the frame size to 100, so that each frame contains 100 samples. This enables the Vector Scope block to display enough data for a good picture of the sine wave.

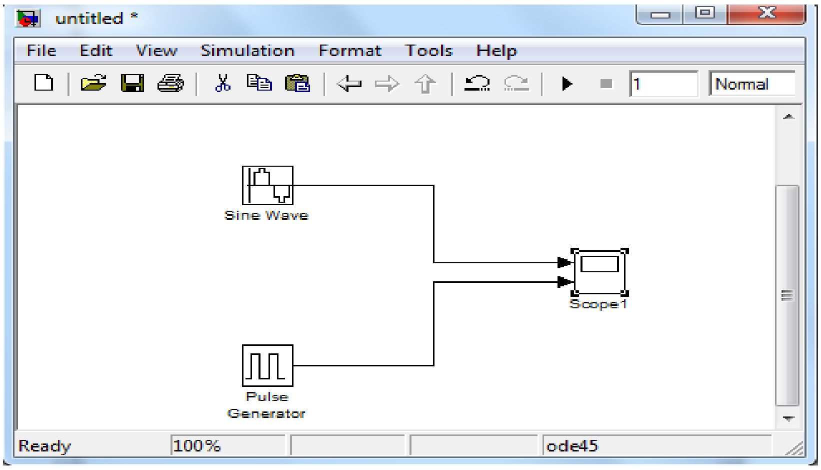
Another important reason to set the frame size is that many Communications Blockset blocks require their inputs to be vectors of specific sizes. If you connect a source block, such as the Sine Wave block, to one of these blocks, you can set the input size correctly by setting **Samples per frame** to the required value. The model described in "Reducing the Error Rate Using a Hamming Code" shows how to do this.

In frame-based processing all the samples in a frame are processed simultaneously. In sample-based processing, on the other hand, samples are processed one at a time. The advantage of frame-based processing is that it can greatly increase the speed of a simulation. If you see double lines between blocks, the model uses frame-based processing.

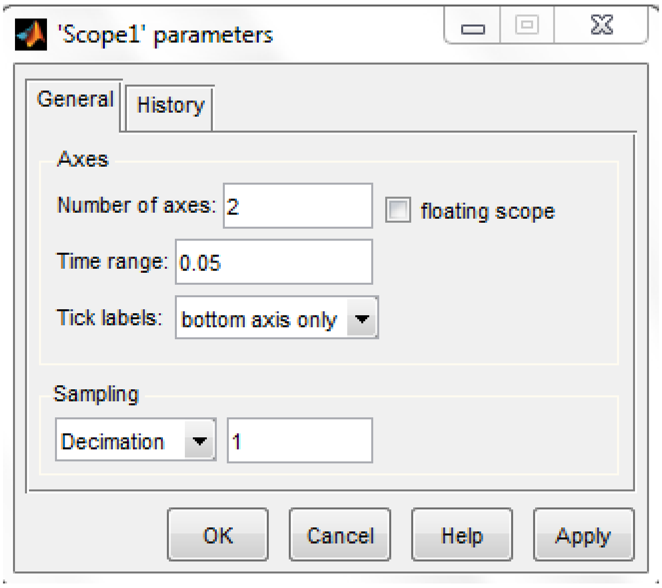
Time and Spectral Analysis

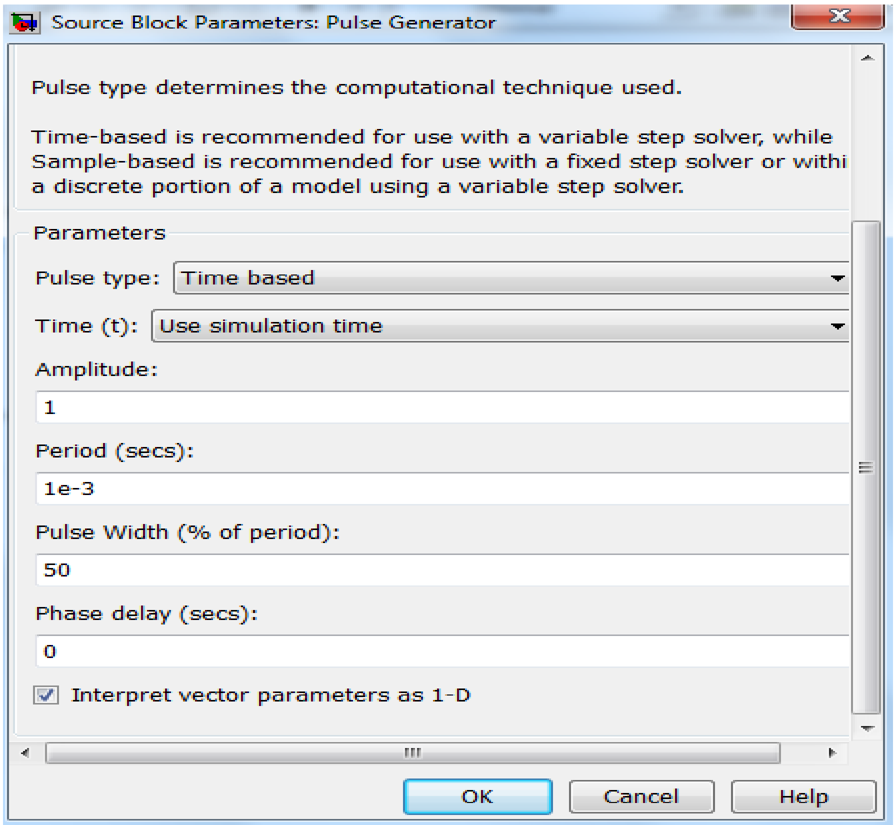
This section deals with looking at the waveforms of simple sine wave and pulse wave.

Figure 2.1 shows the design for viewing the waveforms of toe signals.

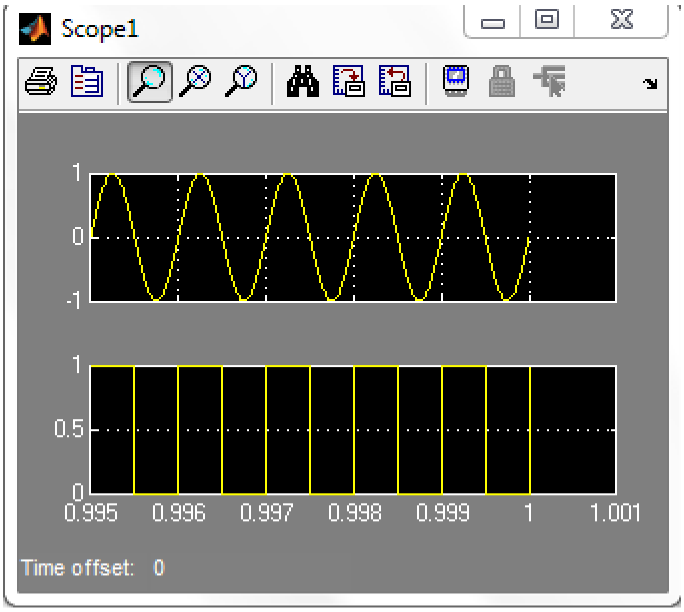


The blocks parameters:




Source Block Parameters: Pulse Generator
Pulse type determines the computational technique used.
Time-based is recommended for use with a variable step solver, while Sample-based is recommended for use with a fixed step solver or withi a discrete portion of a model using a variable step solver.
Parameters
Pulse type: Time based
Time (t): Use simulation time
Amplitude:
1
Period (secs):
1e-3
Pulse Width (% of period):
50
Phase delay (secs):
0
Interpret vector parameters as 1-D
OK
Cancel
Help

The results:

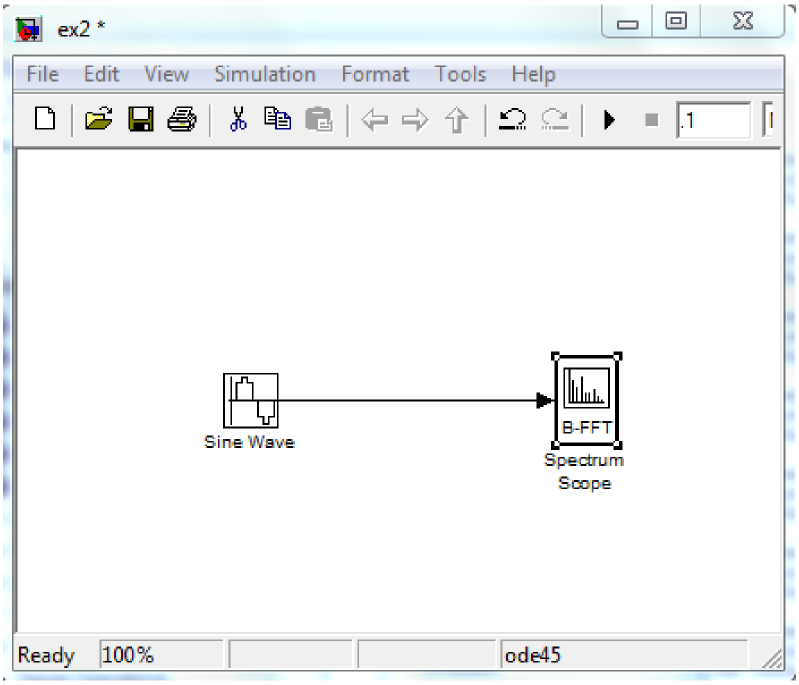

Scope1
1
0
-1
1
0.5
0
0.995
0.996
0.997
0.998
0.999
1
1.001
Time offset: 0

Spectrum Scope

This section deals with looking at the spectrum of simple waves. We first look at the spectrum of a simple sine wave.

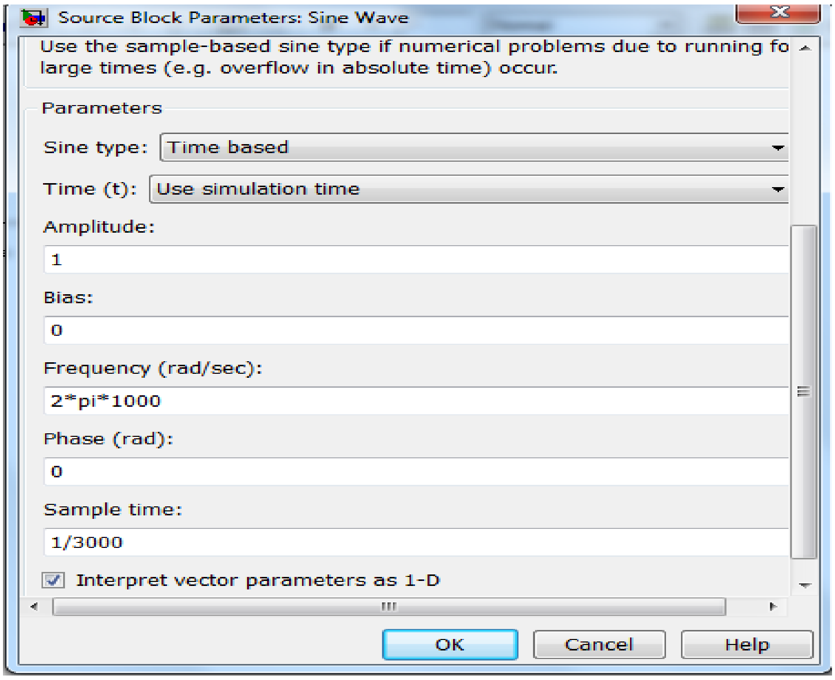
Spectrum of a simple sine wave: - Figure 1.2 shows the design for viewing the

spectrum of a simple sine wave.

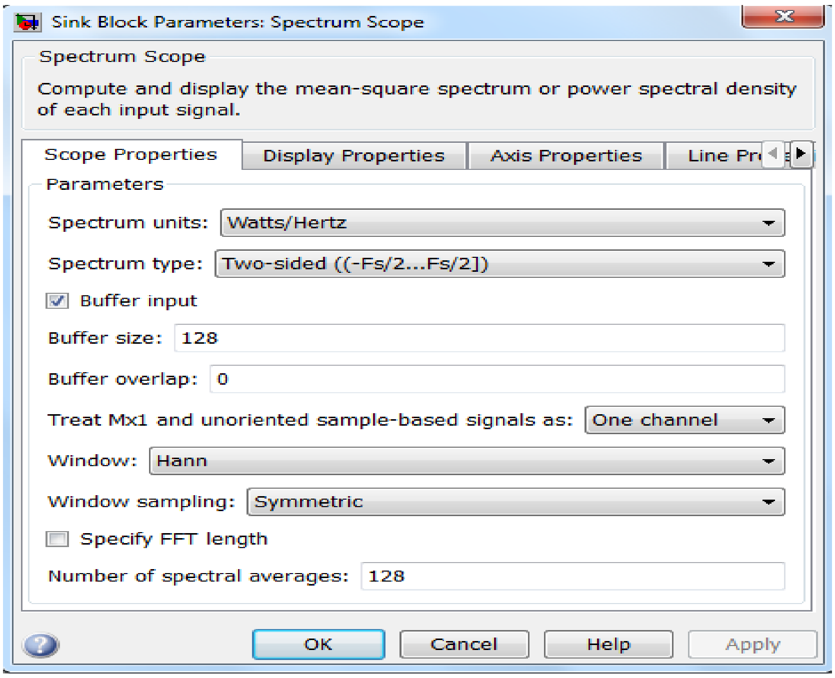


Parameters:

The sine wave block parameters as shown in

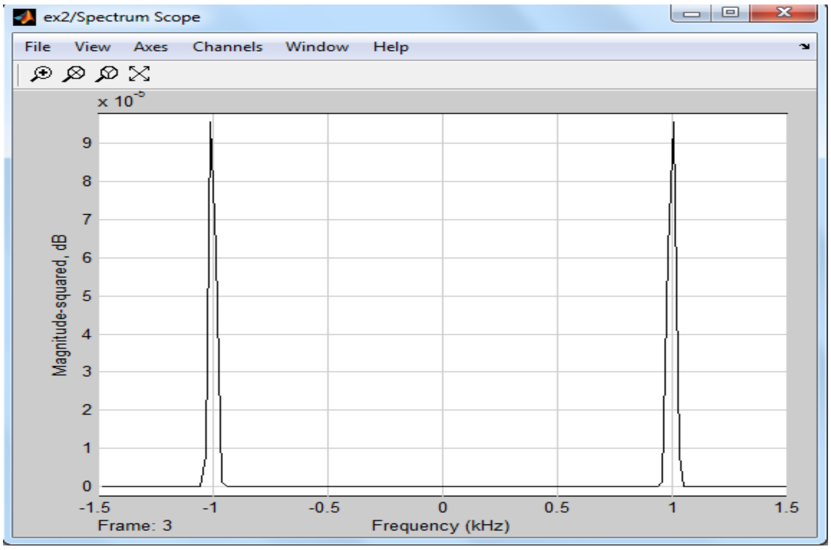


The frequency domain spectrum is obtained through a buffered-FFT scope, which comprises of a Fast Fourier Transform of 128 samples which also has a buffering of 128 of them in one frame. The property block of the B-FFT is also displayed in figure 1.5.



Result:

The below figure shows the frequency domain corresponding of the sine wave

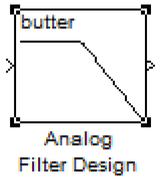


Notes:

- From the property box of the B-FFT scope the axis properties can be changed and the Line properties can be changed. The line properties are not shown in the above. The Frequency range can be changed by using the frequency range pop down menu and so can be the y-axis the amplitude scaling be changed to either real magnitude or the dB (log of magnitude) scale. The upper limit can be specified as shown by the Min and Max Y-limits edit box. The sampling time in this case has been set to 1/3000.
- The sampling frequency of the B-FFT scope should match with the sampling time of the input time signal.
- Also as indicated above the FFT is taken for 128 points and buffered with half of them for an overlap.
- Calculating the Power: The power can be calculated by squaring the value of the voltage of the spectrum analyzer.
- Note: The signal analyzer if chosen with half the scale, the spectrum is the single-sided analyzer, so the power in the spectrum is the total power.
- Similar operations can be done for other waveforms – like the square wave, triangular. These signals can be generated from the signal generator block.

Analog Filter design

This section we will use the analog filters implementation tool that founded at DSP Toolbox.



1. Design low pass filter

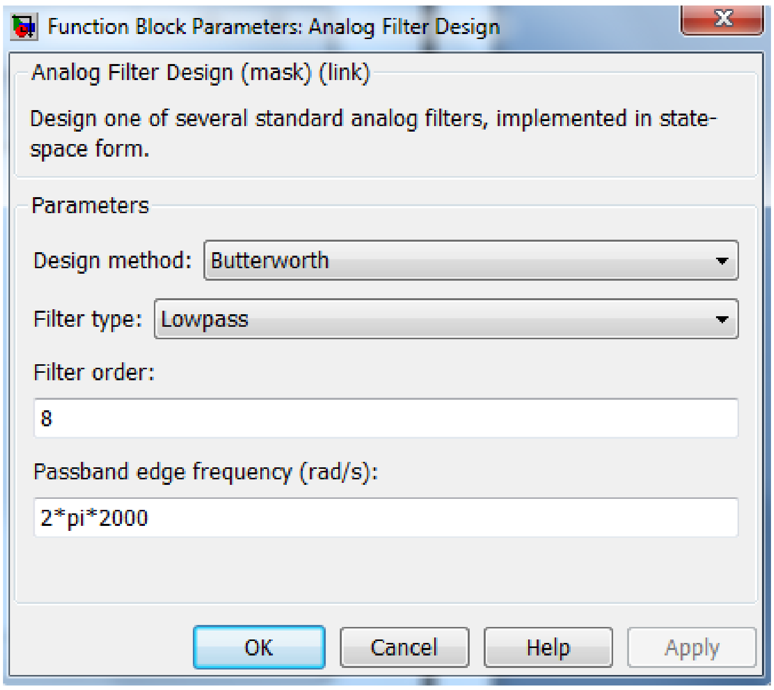
Now we will implement low pass filter with the following criteria

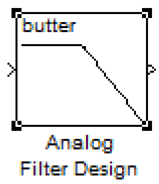
Type: low pass filter

Design Method : Butterworth

Order : 8

Cut off frequency : 2kHz





2. Design High Pass Filter

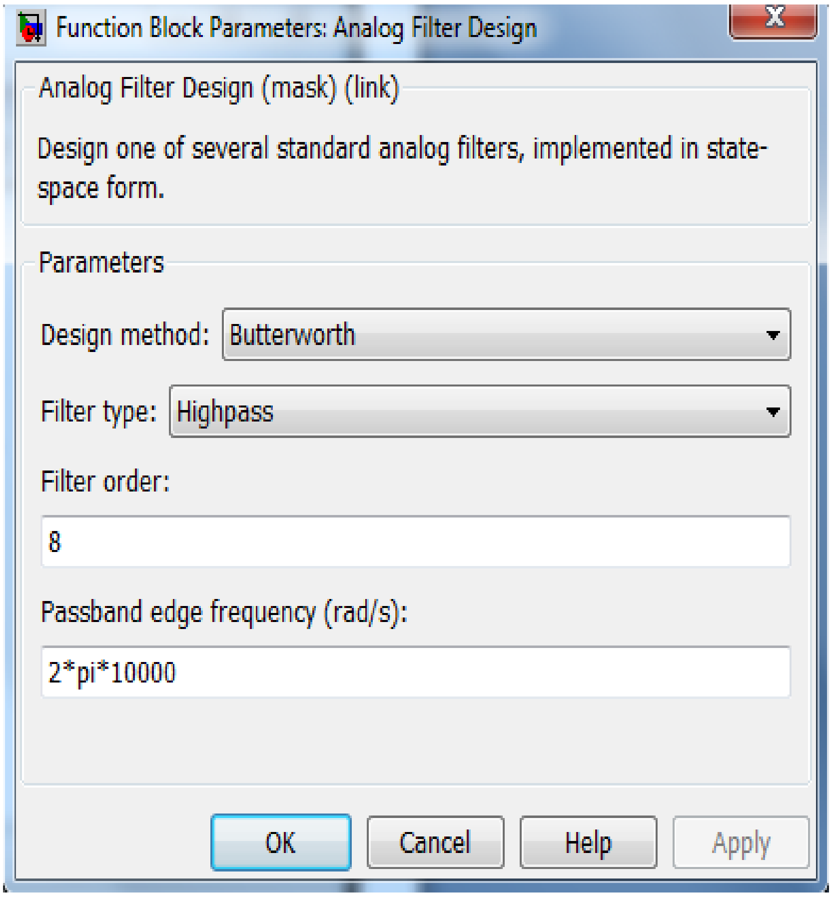
In the same manner we will implement high pass filter with the following criteria :

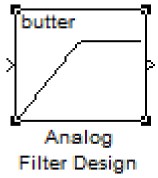
Type: high pass filter

Design Method : Butterworth

Order : 8

Cut off frequency : 10kHz





3. Design Band Pass Filter

Finally we will implement band pass filter with the following criteria :

Type: band pass filter

Design Method : Butterworth

Order : 8

lower Cut off frequency : 2KHz

upper cut off frequency :10kHz