Amplitude Modulation Demodulation using MATLAB SIMULINK model

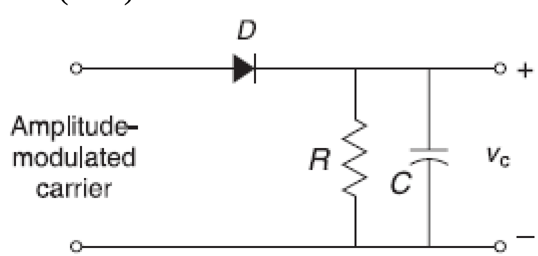
*The following gives implementation of Amplitude Modulation Demodulation (Double Side Band with Carrier or DSB-C) on MATLAB SIMULINK model. For the theoretical background of DSB-C please refer to Section 3.3 of the text book titled **'Principles of Communication Systems', Third Edition by Herbert Taub, Donald L Schilling and Goutam Saha**. To get introductory ideas of MATLAB SIMULINK model development please refer to Chapter 10, MATLAB Experiments 42 and 43 of the above referenced book. We implement non-coherent DSB-C demodulator here which does not require a synchronized local oscillator for demodulation. The coherent detection, useful for DSB-C with modulation index greater than one or suppressed carrier is implemented later.*

The DSB-C modulator output follows eqn. (3.8) as given next.

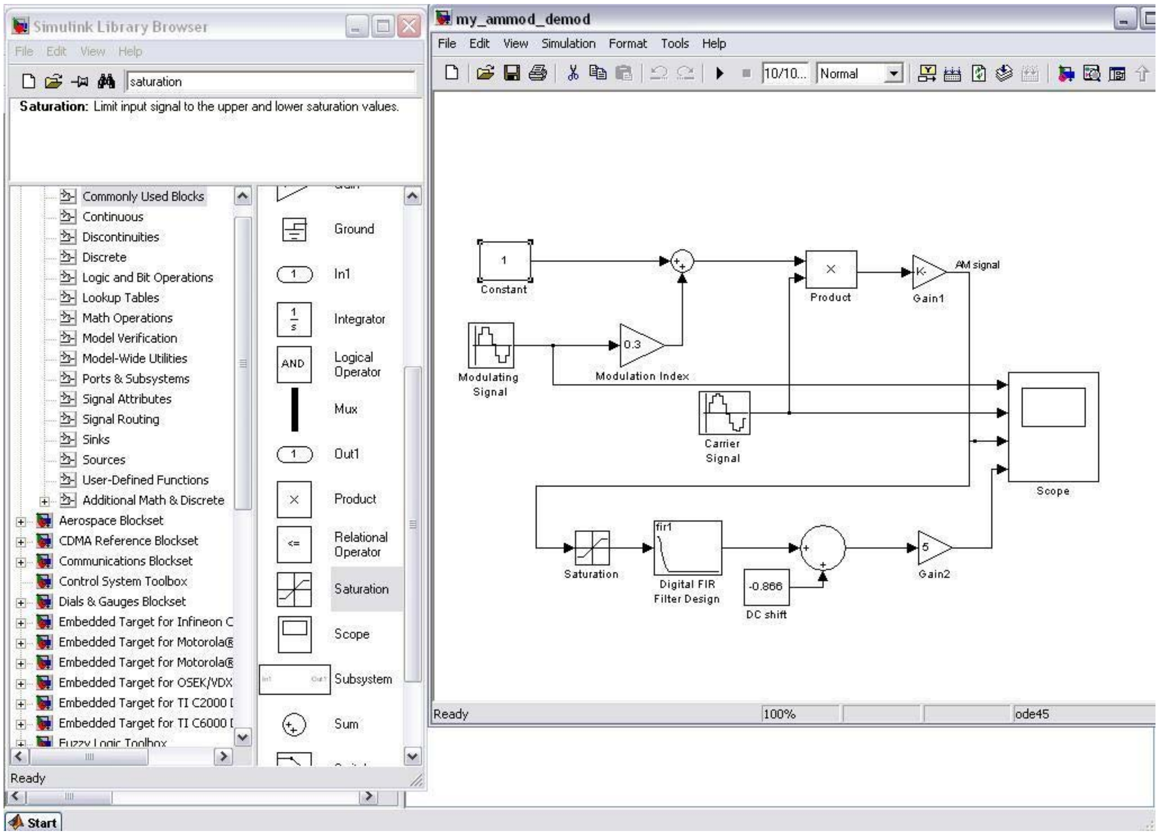
$$v(t) = A_c[1 + m(t)] \cos \omega_c t$$

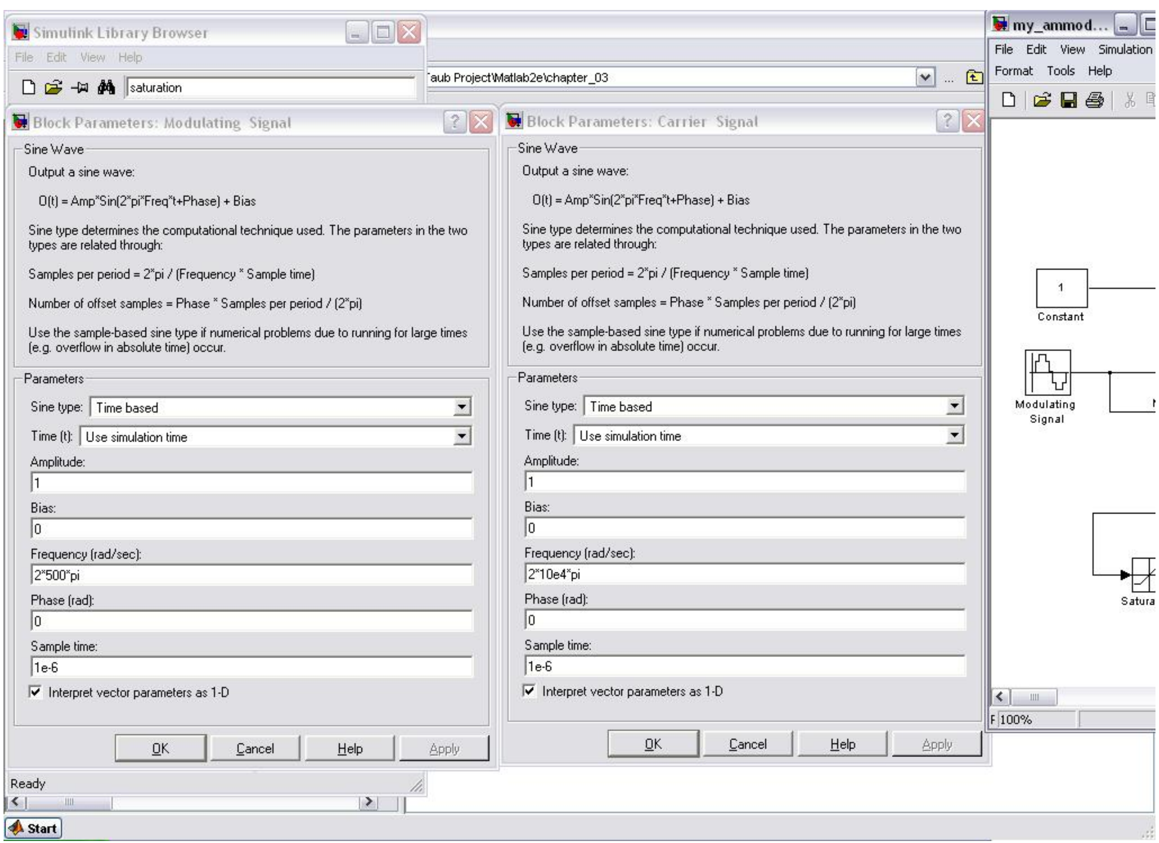
The SIMULINK model considers a sinusoidal (500 Hz) message signal as shown in following figure. To consider a different type of modulating signal this block needs to be changed. At the end we show the performance of the system for a message signal which is a composite of two sinusoidal signals. The carrier frequency is much higher (10000 Hz) while modulating index is made to vary to show the performance for different modulating index.

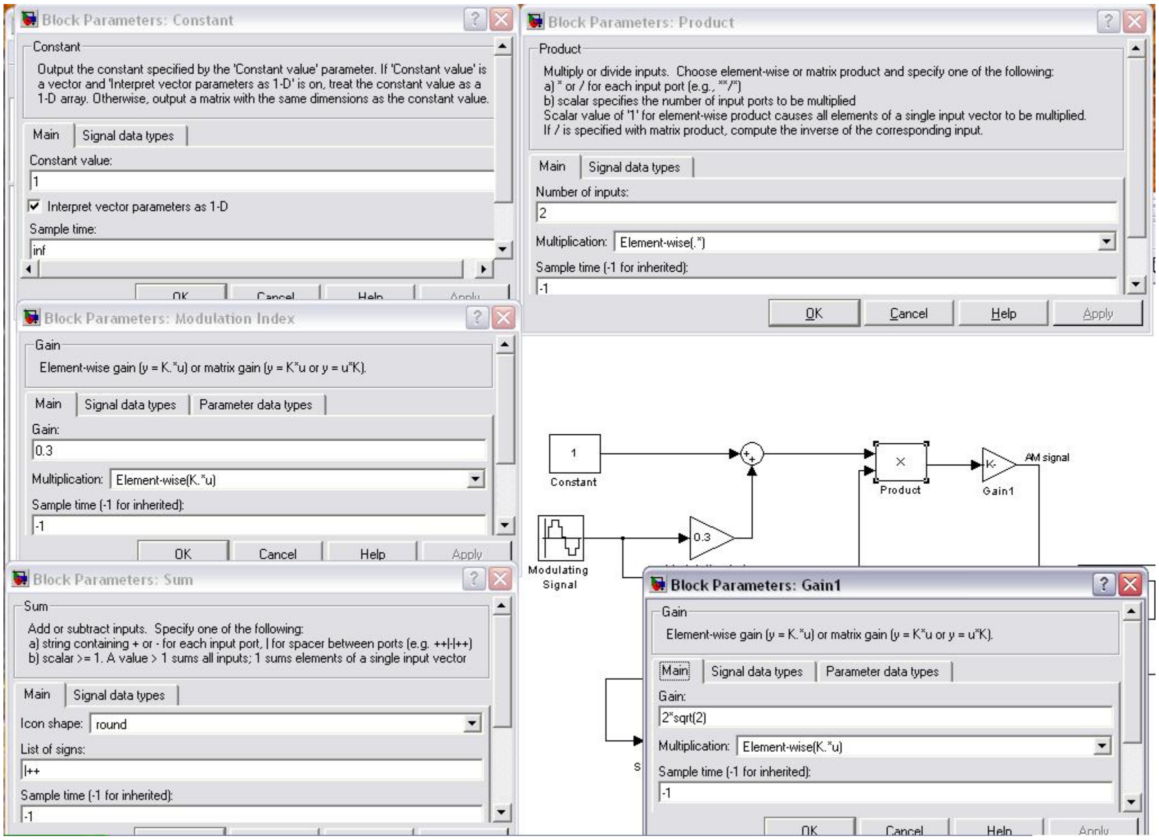
The DSB-C demodulator is non-coherent type which is simple to design and consists of a diode and a Low Pass Filter (LPF) as shown below.

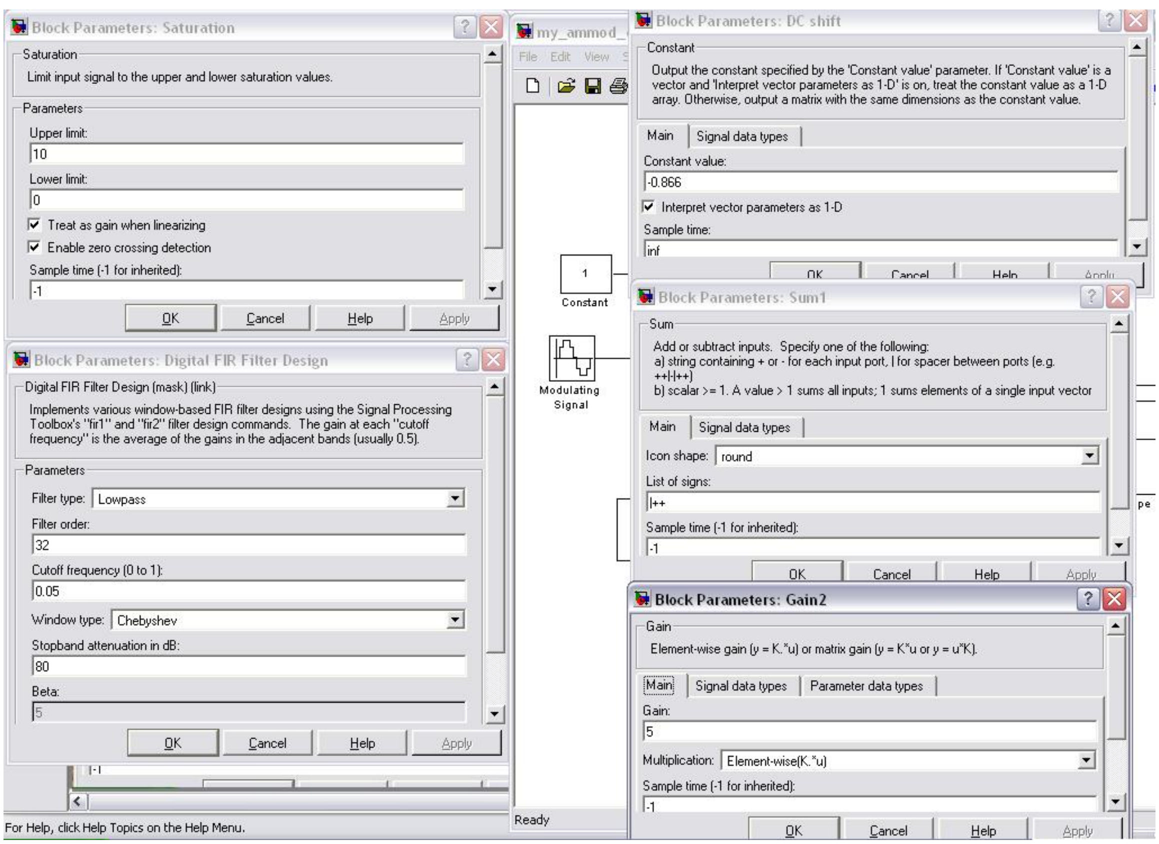


In SIMULINK the diode is implemented by a saturation block which is clipped in the lower side to 0 instead of default -1. LPF filter is implemented by a FIR1 block which is a 32 order Chebyshev Filter, however other filter type will also do. The time scope shows modulating signal, carrier signal, modulated signal, demodulated signal from top to bottom of the plot. In following four figures we show the SIMULINK model and how parameterization is done for each block for first simulation. Note that, modulation index used = 0.3.

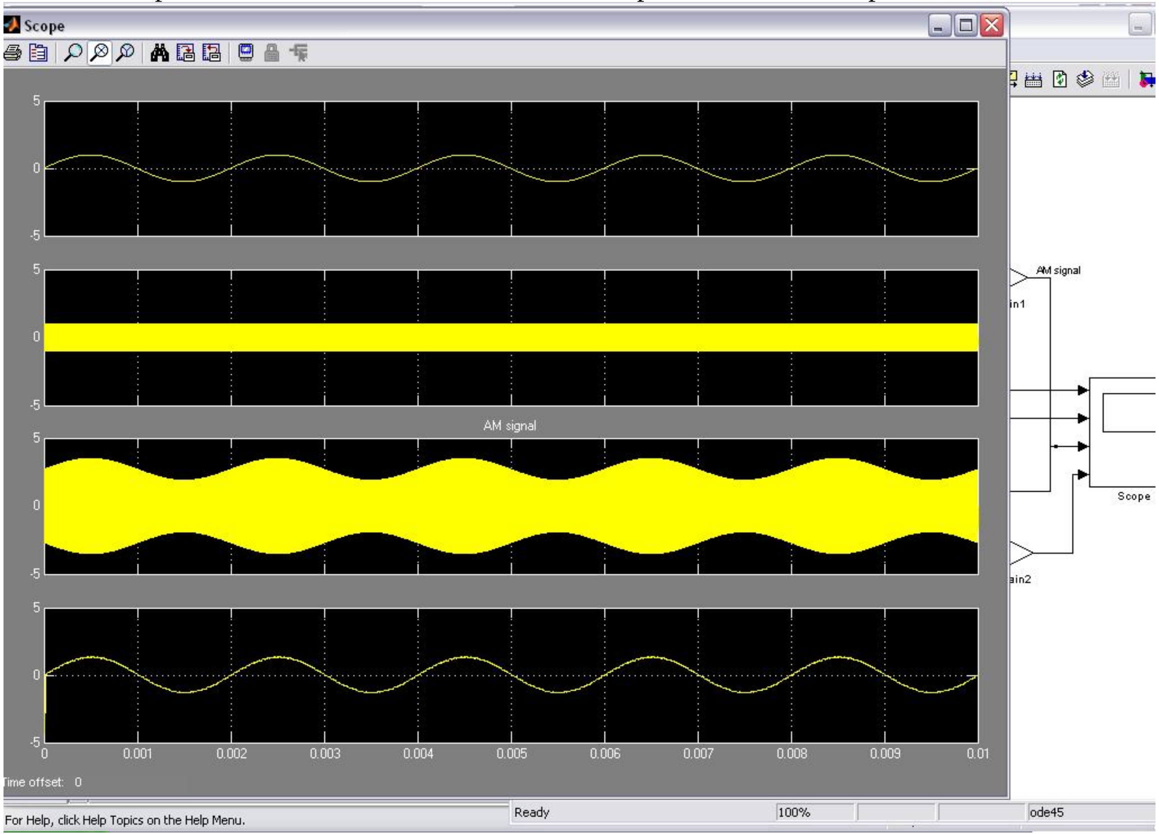

Simulink Library Browser
File Edit View Help
saturation
Saturation: Limit input signal to the upper and lower saturation values.
Commonly Used Blocks
Continuous
Discontinuities
Discrete
Logic and Bit Operations
Lookup Tables
Math Operations
Model Verification
Model-Wide Utilities
Ports & Subsystems
Signal Attributes
Signal Routing
Sinks
Sources
User-Defined Functions
Additional Math & Discrete
Aerospace Blockset
CDMA Reference Blockset
Communications Blockset
Control System Toolbox
Dials & Gauges Blockset
Ground
In1
Integrator
Logical Operator
Mux
Out1
Product
Relational Operator
Saturation
Scope
Subsystem
Sum
Ready
my_ammod_demod
File Edit View Simulation Format Tools Help
Normal
Constant
Product
Gain1
AM signal
Modulating Signal
Modulation Index
Carrier Signal
Scope
Saturation
Digital FIR Filter Design
DC shift
-0.866
Gain2
Ready
100%
ode45
Start

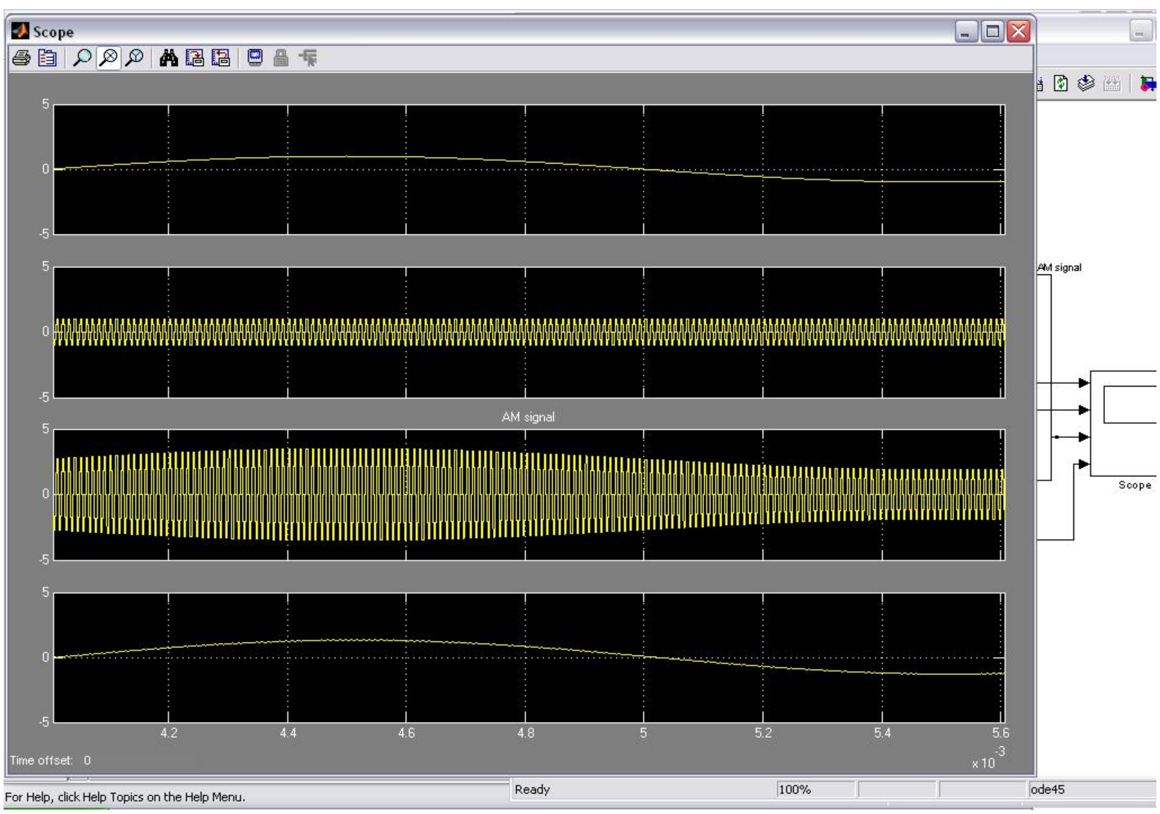

Simulink Library Browser
Block Parameters: Modulating Signal
Sine Wave
Output a sine wave:
O(t) = Amp*Sin(2*pi*Freq*t+Phase) + Bias
Sine type determines the computational technique used. The parameters in the two types are related through:
Samples per period = 2*pi / (Frequency * Sample time)
Number of offset samples = Phase * Samples per period / (2*pi)
Use the sample-based sine type if numerical problems due to running for large times (e.g. overflow in absolute time) occur.
Parameters
Sine type: Time based
Time (t): Use simulation time
Amplitude:
1
Bias:
0
Frequency (rad/sec):
2*500*pi
Phase (rad):
0
Sample time:
1e-6
Interpret vector parameters as 1-D
OK Cancel Help Apply
Block Parameters: Carrier Signal
Frequency (rad/sec):
2*10e4*pi
my_ammod...
Constant
Modulating Signal
Ready
Start


Block Parameters: Constant
Constant
Output the constant specified by the 'Constant value' parameter. If 'Constant value' is a vector and 'Interpret vector parameters as 1-D' is on, treat the constant value as a 1-D array. Otherwise, output a matrix with the same dimensions as the constant value.
Main
Signal data types
Constant value:
1
Interpret vector parameters as 1-D
Sample time:
inf
Block Parameters: Product
Product
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.
If / is specified with matrix product, compute the inverse of the corresponding input.
Main
Signal data types
Number of inputs:
2
Multiplication:
Element-wise(.*)
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply
Block Parameters: Modulation Index
Gain
Element-wise gain (y = K.*u) or matrix gain (y = K*u or y = u*K).
Main
Signal data types
Parameter data types
Gain:
0.3
Multiplication:
Element-wise(K.*u)
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply
1
Constant
Product
Gain1
AM signal
0.3
Modulating Signal
Block Parameters: Sum
Sum
Add or subtract inputs. Specify one of the following:
a) string containing + or - for each input port, | for spacer between ports (e.g. ++|-|++)
b) scalar >= 1. A value > 1 sums all inputs; 1 sums elements of a single input vector
Main
Signal data types
Icon shape:
round
List of signs:
|++
Sample time (-1 for inherited):
-1
Block Parameters: Gain1
Gain
Element-wise gain (y = K.*u) or matrix gain (y = K*u or y = u*K).
Main
Signal data types
Parameter data types
Gain:
2*sqrt(2)
Multiplication:
Element-wise(K.*u)
Sample time (-1 for inherited):
-1

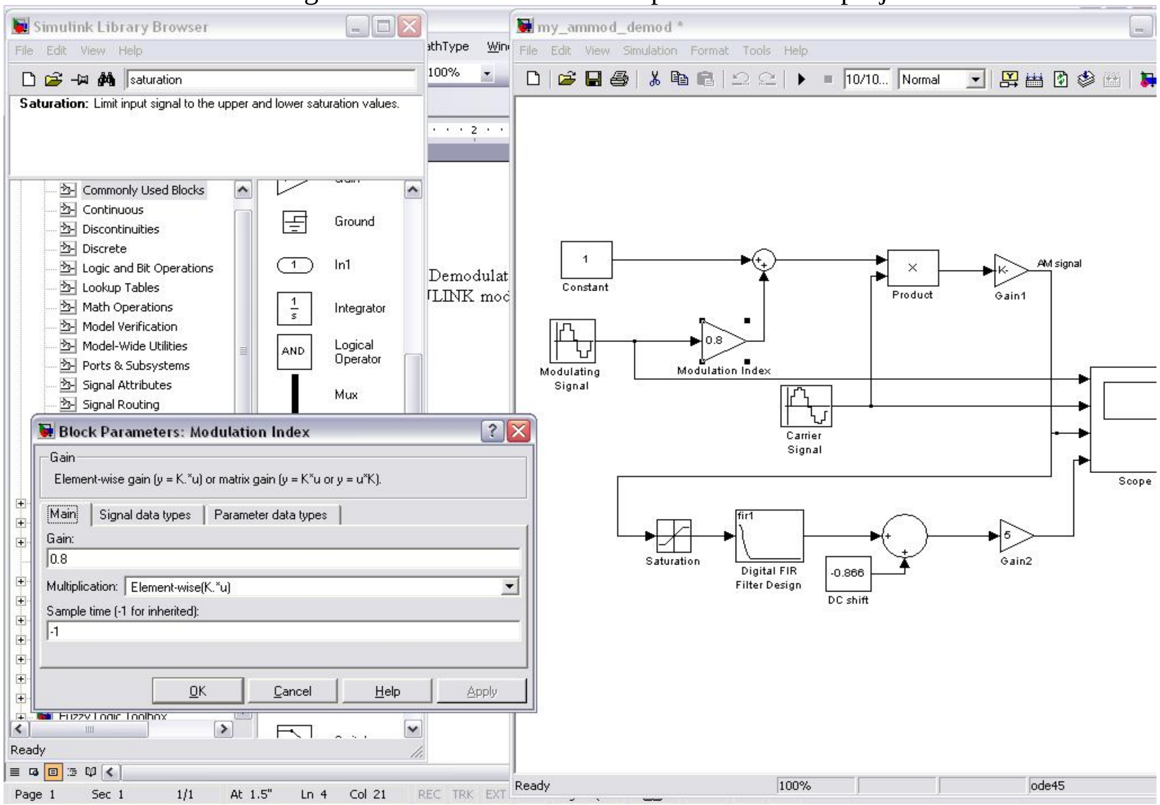

Block Parameters: Saturation
Saturation
Limit input signal to the upper and lower saturation values.
Parameters
Upper limit:
10
Lower limit:
0
Treat as gain when linearizing
Enable zero crossing detection
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply
my_ammod_
File
Edit
View
Block Parameters: DC shift
Constant
Output the constant specified by the 'Constant value' parameter. If 'Constant value' is a vector and 'Interpret vector parameters as 1-D' is on, treat the constant value as a 1-D array. Otherwise, output a matrix with the same dimensions as the constant value.
Main
Signal data types
Constant value:
-0.866
Interpret vector parameters as 1-D
Sample time:
inf
1
Constant
Modulating Signal
Block Parameters: Sum1
Sum
Add or subtract inputs. Specify one of the following:
a) string containing + or - for each input port, | for spacer between ports (e.g. ++|-|++)
b) scalar >= 1. A value > 1 sums all inputs; 1 sums elements of a single input vector
Main
Signal data types
Icon shape:
round
List of signs:
|++
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply
Block Parameters: Digital FIR Filter Design
Digital FIR Filter Design (mask) (link)
Implements various window-based FIR filter designs using the Signal Processing Toolbox's "fir1" and "fir2" filter design commands. The gain at each "cutoff frequency" is the average of the gains in the adjacent bands (usually 0.5).
Parameters
Filter type:
Lowpass
Filter order:
32
Cutoff frequency (0 to 1):
0.05
Window type:
Chebyshev
Stopband attenuation in dB:
80
Beta:
5
OK
Cancel
Help
Apply
Block Parameters: Gain2
Gain
Element-wise gain (y = K.*u) or matrix gain (y = K*u or y = u*K).
Main
Signal data types
Parameter data types
Gain:
5
Multiplication:
Element-wise(K.*u)
Sample time (-1 for inherited):
-1
OK
Cancel
Help
Apply
For Help, click Help Topics on the Help Menu.
Ready

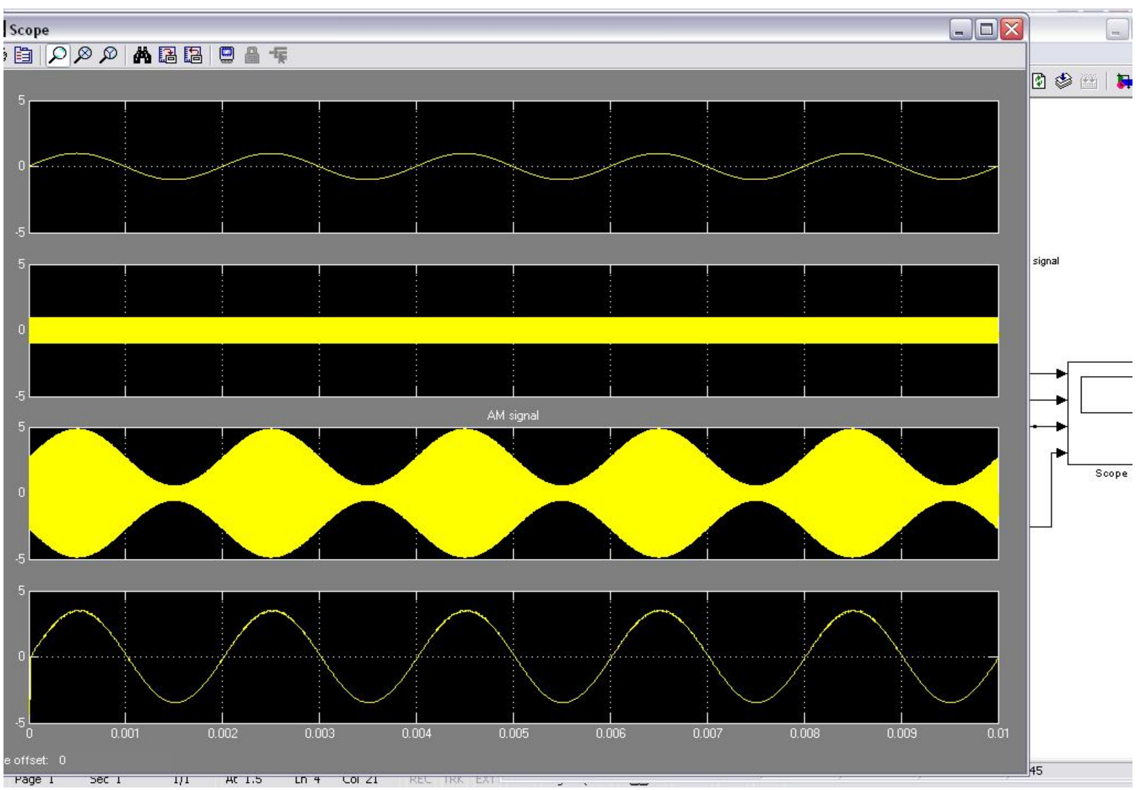
Next are the plots of simulation for 10 ms on time scope in default and expanded X-axis mode.

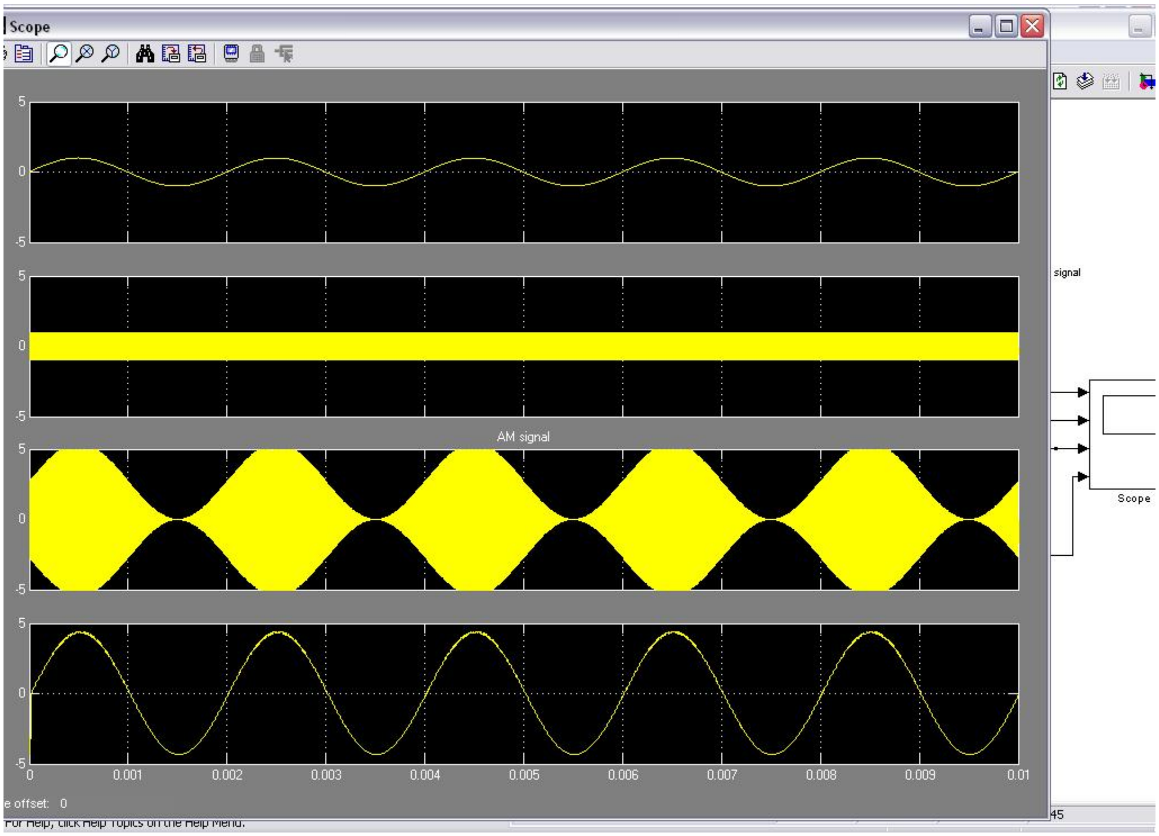


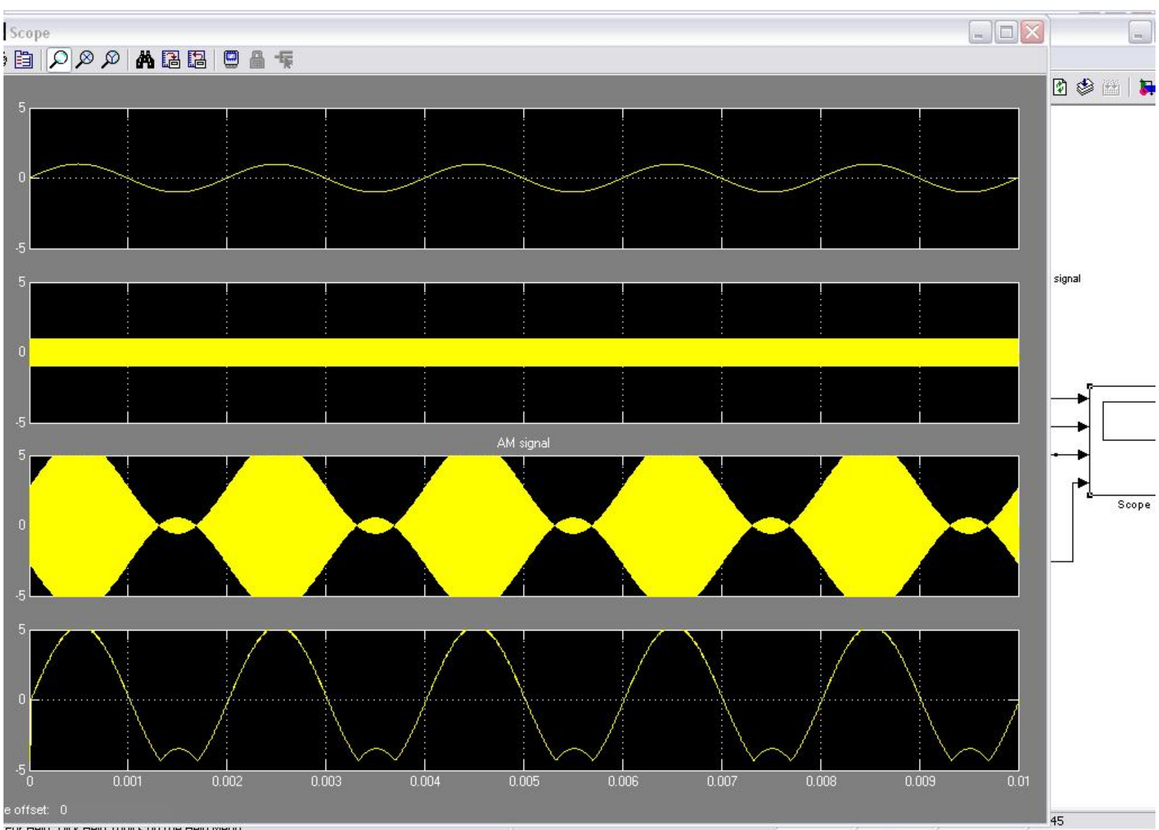


Next are the plots of simulation for 10 ms on time scope for modulation index 0.8. This we follow for modulation indices 1.0, 1,2. Note that for 1.2 demodulated signal is distorted. Coherent detector can extract the signal in this case which we implement in next project.






Scope
AM signal
e offset: 0
For Help, click Help Topics on the Help Menu.


Scope
AM signal
e offset: 0
For Help, click Help Topics on the Help Menu.

Next is the model for a composite modulating signal and its simulation. Note the frequency and amplitudes of two sinusoidal signals that makes the composite. Note that amplitude of composite signal does not exceed 1. The modulation index is kept at 0.8.