Eastern Mediterranean University
Faculty of Engineering
Department of Electrical and Electronic Engineering
EENG 360 Communication System I Laboratory

LAB 7

AMPLITUDE MODULATION & DEMODULATION

Objectives:

- Understanding the principle of amplitude modulation (AM) and demodulation
- Understanding the waveforms of modulated and demodulated signals
- Observing the effects of the percent of modulation
- Designing amplitude modulator and demodulator using Simulink

Theory

Modulation is the process of impressing a low-frequency intelligence signal onto a high frequency carrier signal. Amplitude Modulation (AM) is the process that a high-frequency carrier signal is modulated by a low-frequency modulating signal (usually an audio). In amplitude modulation the carrier amplitude varies with the modulating amplitude, as shown in Fig. 1. If the audio signal (message signal) is $A_m \cos(2\pi f_m t)$ and the carrier signal is $A_c \cos(2\pi f_c t)$, the amplitude-modulated signal can be expressed by

$$x_{AM}(t) = [1 + A_m \cos(2\pi f_m t)] A_c \cos(2\pi f_c t) \qquad (1)$$

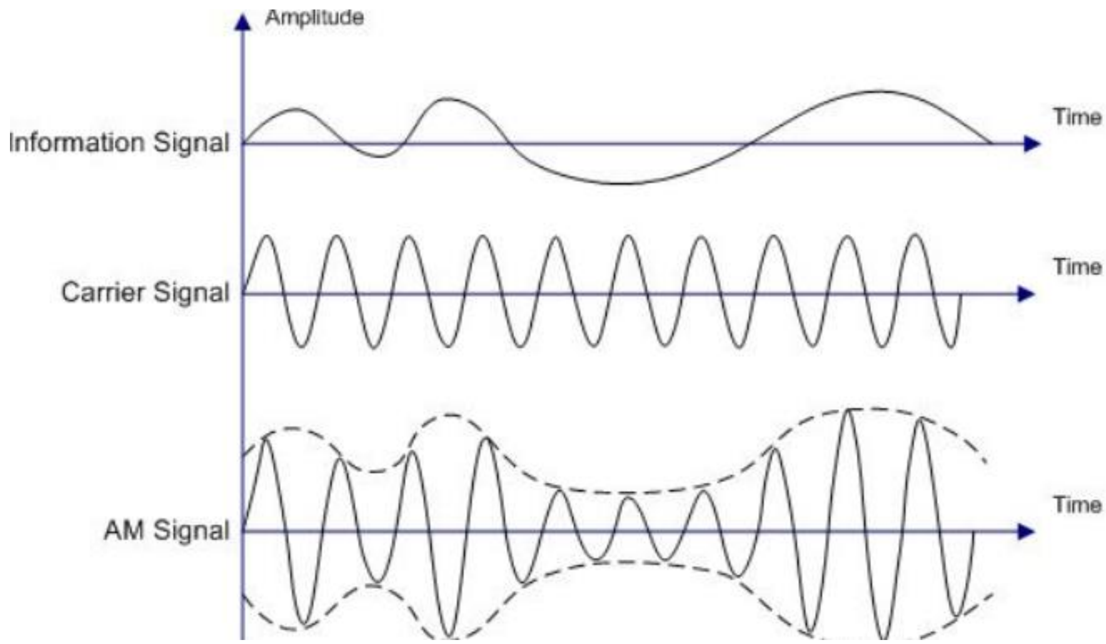


Fig.1: Amplitude modulation waveforms

The process of extracting the information bearing signal from the modulated bandpass signal is known as demodulation or detection. To recover the low frequency baseband signal, the received signal is first rectified and then filtered as depicted in Figure 2.

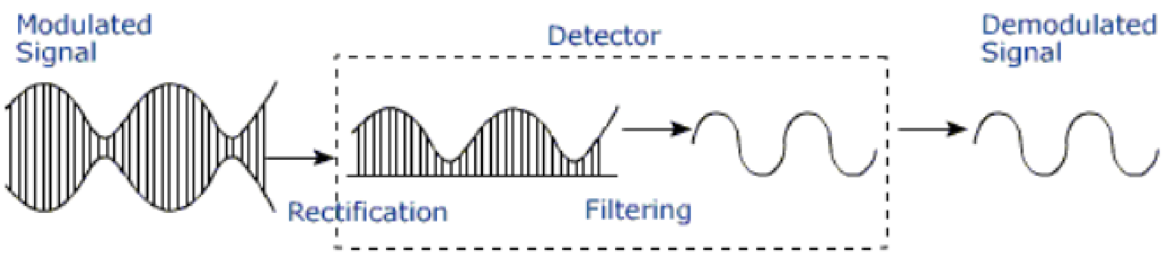
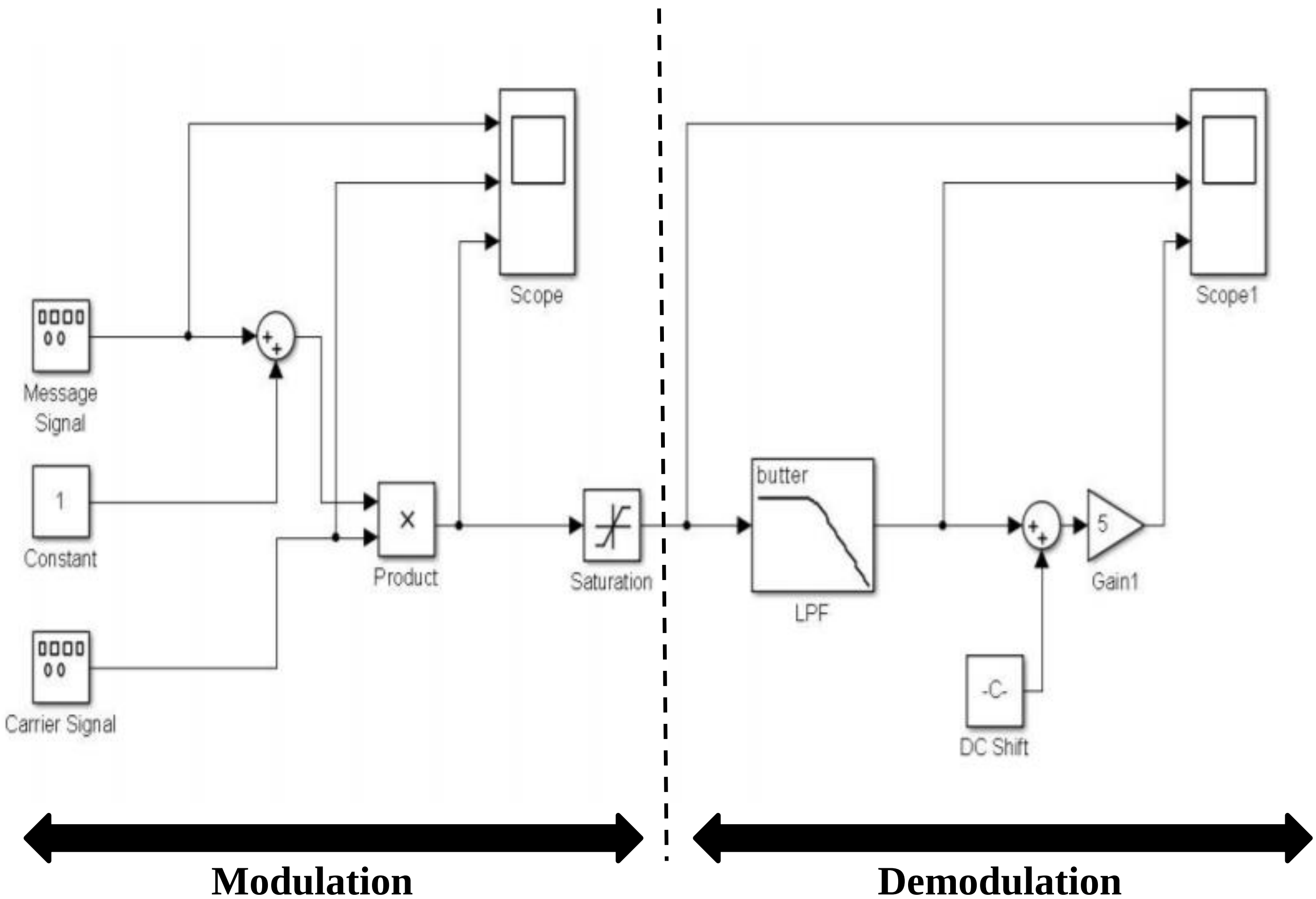


Fig. 2: Illustration of an amplitude demodulation

Procedure

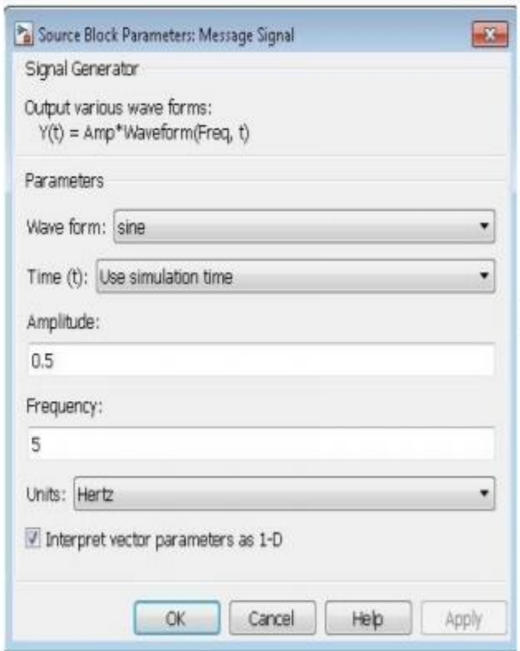
1. Arrange the functional blocks as shown in Simulink model.
2. Assign required parameters to each functional block.
3. Observe the outputs on scope.

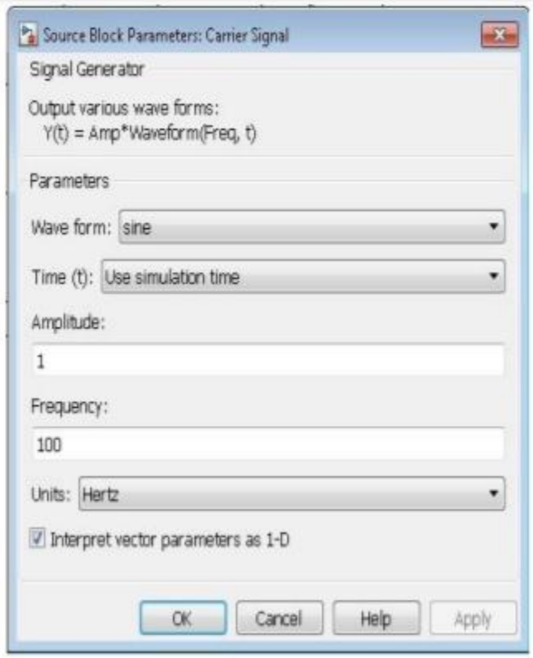
Simulink Model

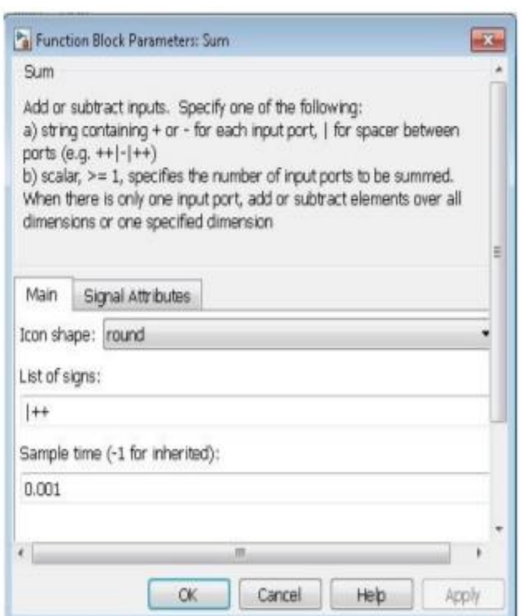


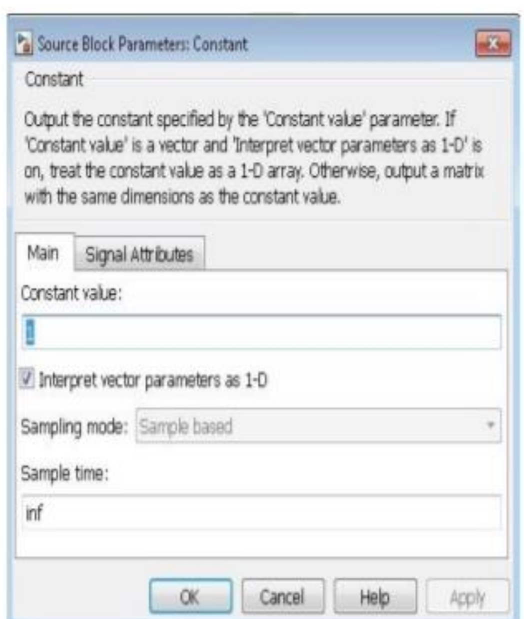
Parameters

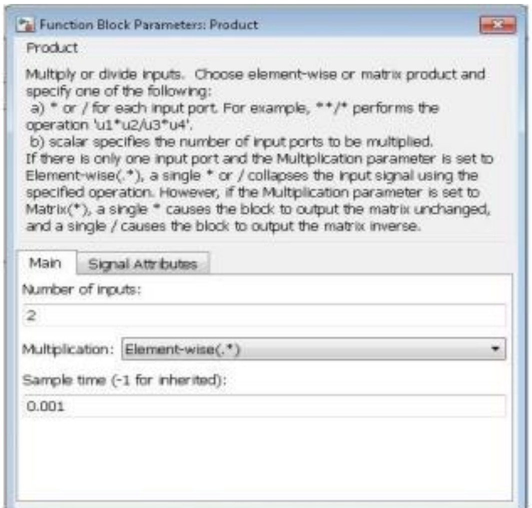
- **Under modulation**

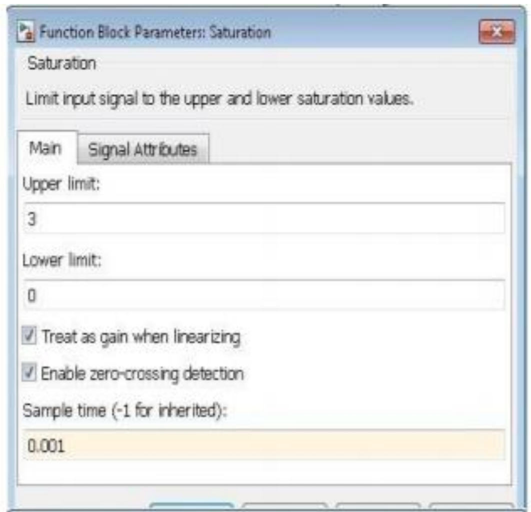


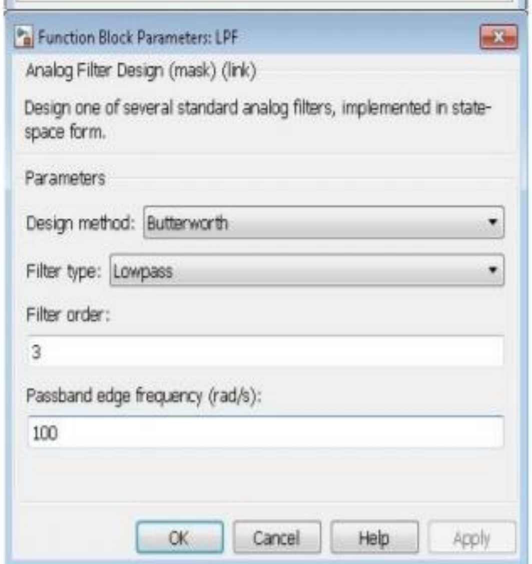


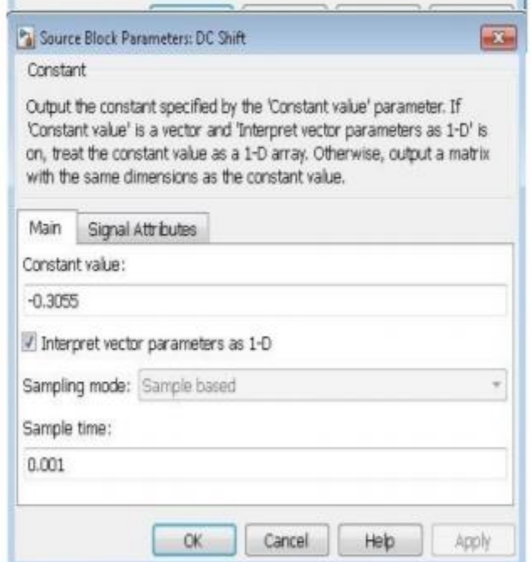


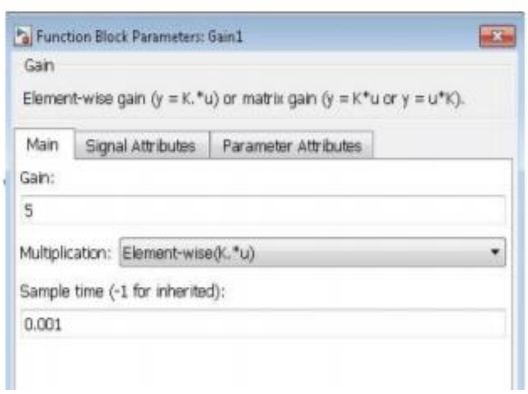



Function Block Parameters: Product
Product
Multiply or divide inputs. Choose element-wise or matrix product and specify one of the following:
a) * or / for each input port. For example, **/* performs the operation 'u1*u2/u3*u4'.
b) scalar specifies the number of input ports to be multiplied.
If there is only one input port and the Multiplication parameter is set to Element-wise(.*), a single * or / collapses the input signal using the specified operation. However, if the Multiplication parameter is set to Matrix(*), a single * causes the block to output the matrix unchanged, and a single / causes the block to output the matrix inverse.
Main
Signal Attributes
Number of inputs:
2
Multiplication:
Element-wise(.*)
Sample time (-1 for inherited):
0.001

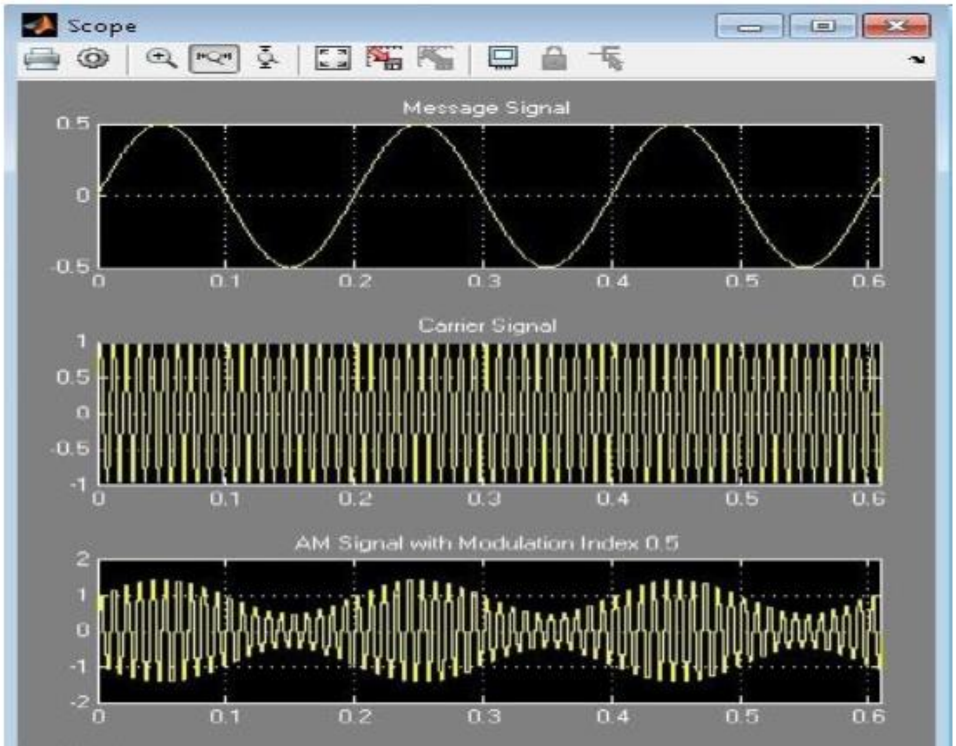

Function Block Parameters: Saturation
Saturation
Limit input signal to the upper and lower saturation values.
Main
Signal Attributes
Upper limit:
3
Lower limit:
0
Treat as gain when linearizing
Enable zero-crossing detection
Sample time (-1 for inherited):
0.001

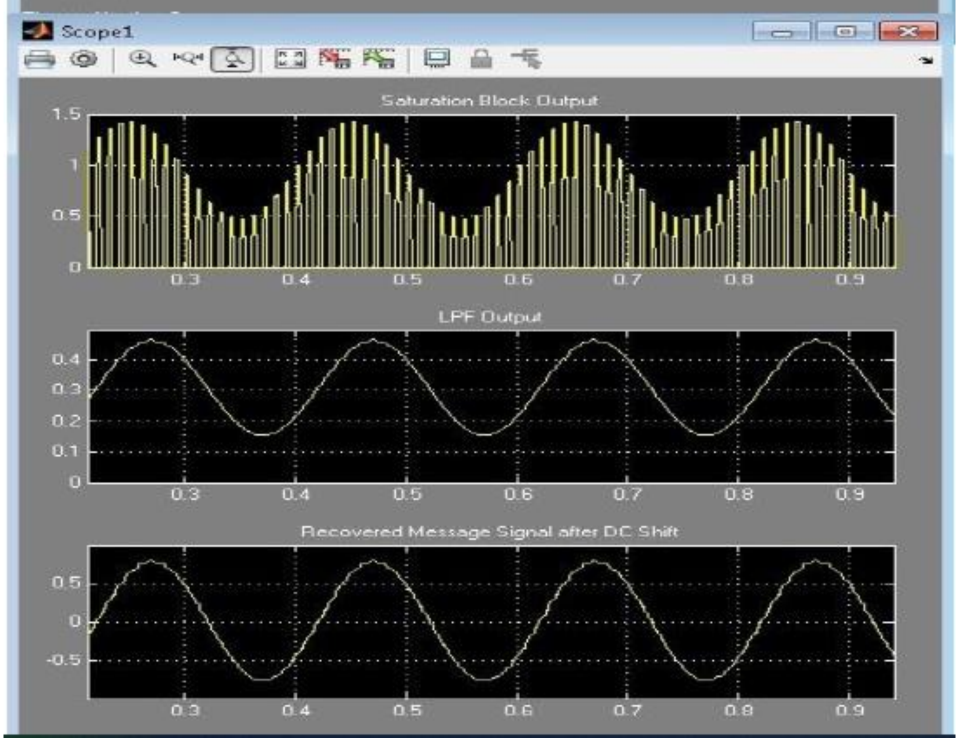

Function Block Parameters: LPF
Analog Filter Design (mask) (link)
Design one of several standard analog filters, implemented in state-space form.
Parameters
Design method:
Butterworth
Filter type:
Lowpass
Filter order:
3
Passband edge frequency (rad/s):
100
OK
Cancel
Help
Apply


Source 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 Attributes
Constant value:
-0.3055
Interpret vector parameters as 1-D
Sampling mode:
Sample based
Sample time:
0.001
OK
Cancel
Help
Apply


Function Block Parameters: Gain1
Gain
Element-wise gain (y = K.*u) or matrix gain (y = K*u or y = u*K).
Main
Signal Attributes
Parameter Attributes
Gain:
5
Multiplication:
Element-wise(K.*u)
Sample time (-1 for inherited):
0.001

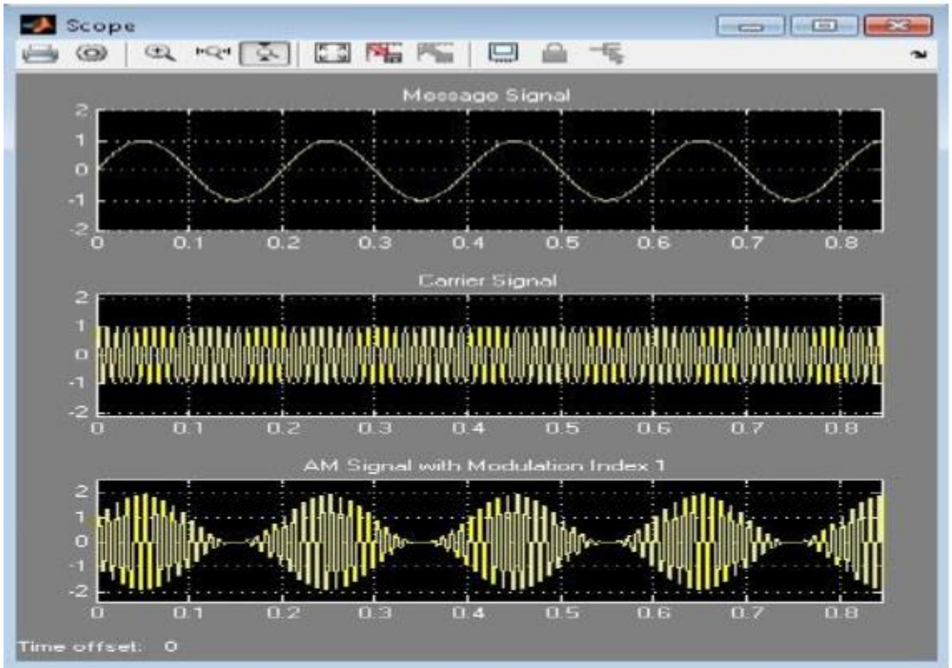
Output

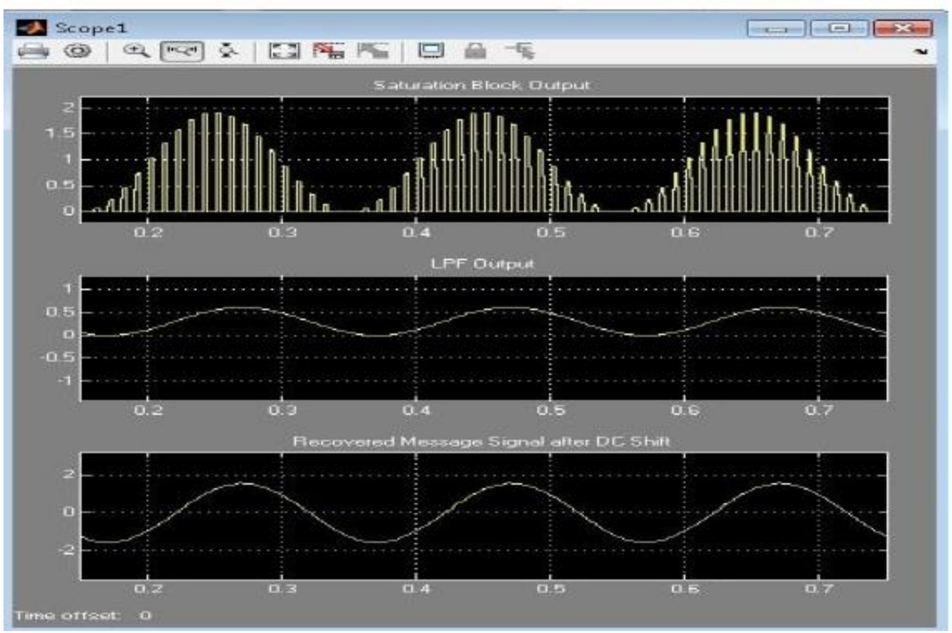

Scope
Message Signal
Carrier Signal
AM Signal with Modulation Index 0.5


Scope1
Saturation Block Output
LPF Output
Recovered Message Signal after DC Shift

%100 Modulation

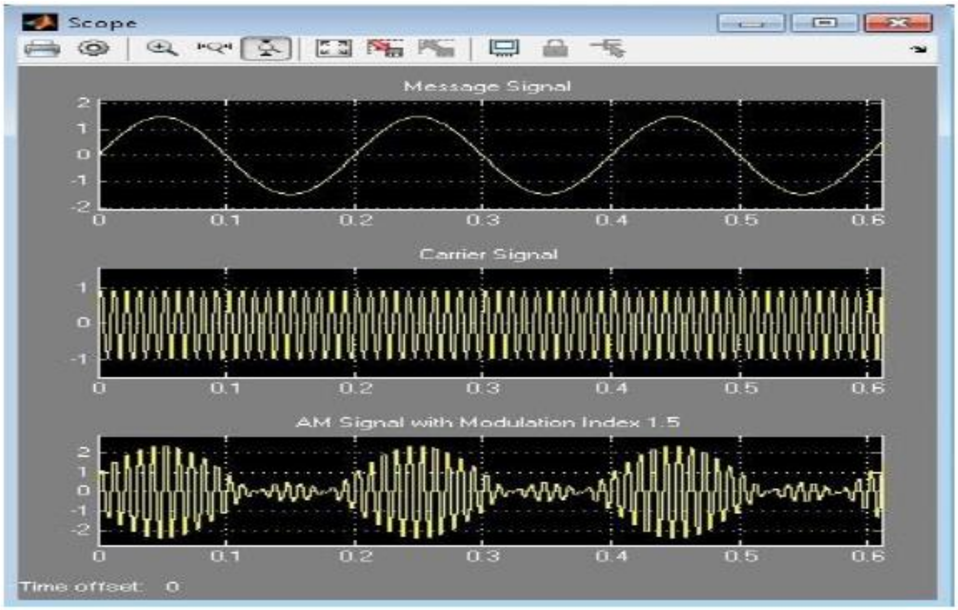
- Change Message signal amplitude to 1 Volt
- Change DC shift to -0.31

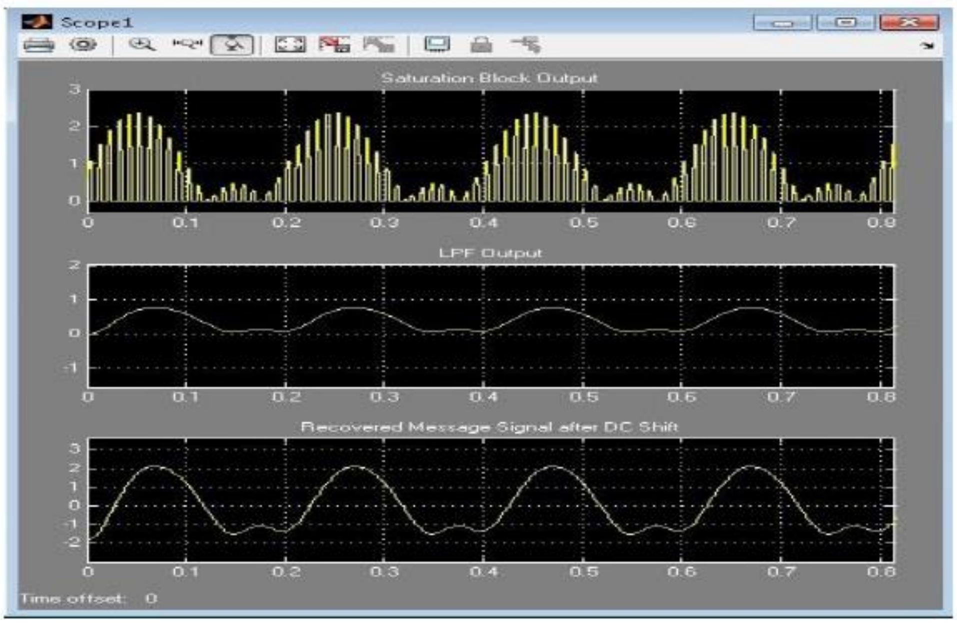




Over Modulation

- Change Message signal to 1.5 volt
- Change DC shift to -0.35





Assignment

1. Define AM and draw its spectrum.

2. Use ***freqspectrum*** function in MATLAB to verify your answer.

3. Show how an amplitude modulated signal can be demodulated using (a) a square law device (b) a product detector

4. What is the condition for overmodulation?