ELP311
Communication Engineering Laboratory

Experiment 1
Amplitude Modulation

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Objective

In this experiment, we generate amplitude modulated signals with different values of modulation indices and analyze them. Also, we demodulate the signals using envelope detection.

Theory

Assuming message signal (modulating signal) to be a cosine wave, given by:

$$a(t) = mA_c \cos(2\pi f_a t)$$

where, m is the modulating index.

The carrier signal is given by:

$$\mathrm{c}(t) = A_c \cos(2\pi f_c t)$$

where, $f_c >> f_a$.

The modulated signal using AM modulation is given by:

$$M(t) = A_c(1 + \mathrm{m}\cos(2\pi f_a t))\cos(2\pi f_c t)$$

The envelope of the AM modulated signal is by the amplitude of the term $cos(2\pi f_c t)$ in $M(t)$, i.e.,

$$|A_c(1 + \mathrm{m}\cos(2\pi f_a t))|$$

If $0 < m < 1$, then envelope of the AM modulated signal is same as the message signal but with a DC offset. In this case, we can recover the message signal by envelope detection of the modulated signal.

MATLAB code and Simulink model

Following parameters are used for the experiment:

i. $mA_c = 5\,V$
ii. $f_a = 3000\ \mathrm{Hz}$
iii. $f_c = 100000\ Hz$

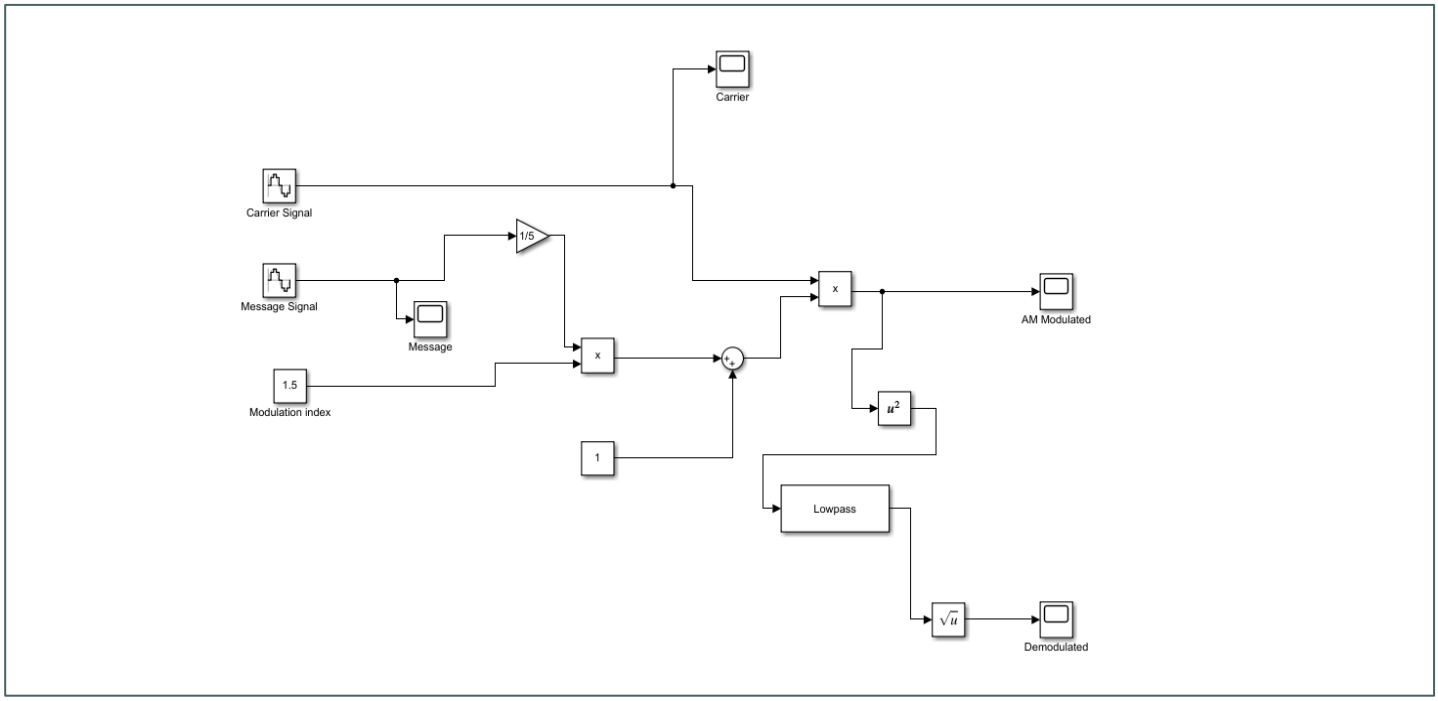
The experiment is performed for $m = 0.5, 1$ and 1.5. The message signal, carrier signal, modulated signal and demodulated signal is plotted in each case, in addition to the trapezoid plot.

MATLAB code

```
clear variables;
%% Parameters
m = input("Enter value of modulation index(m): ");

% message signal parameters

Am = 5;% in Volts
fa = 3000; %Hertz
Ta = 1/fa;
t = 0:Ta/999:6*Ta; %Total simulation time
```

```
% Carrier signal parameters
Ac = Am/m;
fc = 1e5;
Tc = 1/fc;

%% Modulating signal plot
ym = Am*sin(2*pi*fa*t);   %Modulating signal eqn
subplot(5, 1, 1);
plot(t, ym); grid on;
title('  Modulating Signal  ');
xlabel('  time(sec)  ')
ylabel('  Amplitude(Volts)  ')

%% carrier signal plot
yc = Ac*sin(2*pi*fc*t);   %Carrier signal eqn
subplot(5, 1, 2)
plot(t, yc); grid on;
title('  Carrier Signal  ');
xlabel('  time(sec)  ')
ylabel('  Amplitude(Volts)  ')

%% Modulated signal plot
y = Ac*(1+m*sin(2*pi*fa*t)).*sin(2*pi*fc*t);
subplot(5, 1, 3)
plot(t, y); grid on;
title('  Amplitude Modulated Signal  ');
xlabel('  time(sec)  ')
ylabel('  Amplitude(Volts)  ')

%% trapezoid plot
subplot(5,1,4)
plot(ym, y); grid on;
title('  Trapezoid plot  ');
xlabel('  Modulating signal  ');
ylabel('  Modulated signal  ');

%% Demodulation
envelope = abs(hilbert(y)); %This gets the envelope of signal
subplot(5,1,5)
plot(t, envelope, 'r'); grid on;
title('  AM demodulated signal  ');
xlabel('  time(sec)  ');
ylabel('  Amplitude(Volts)  ');
```

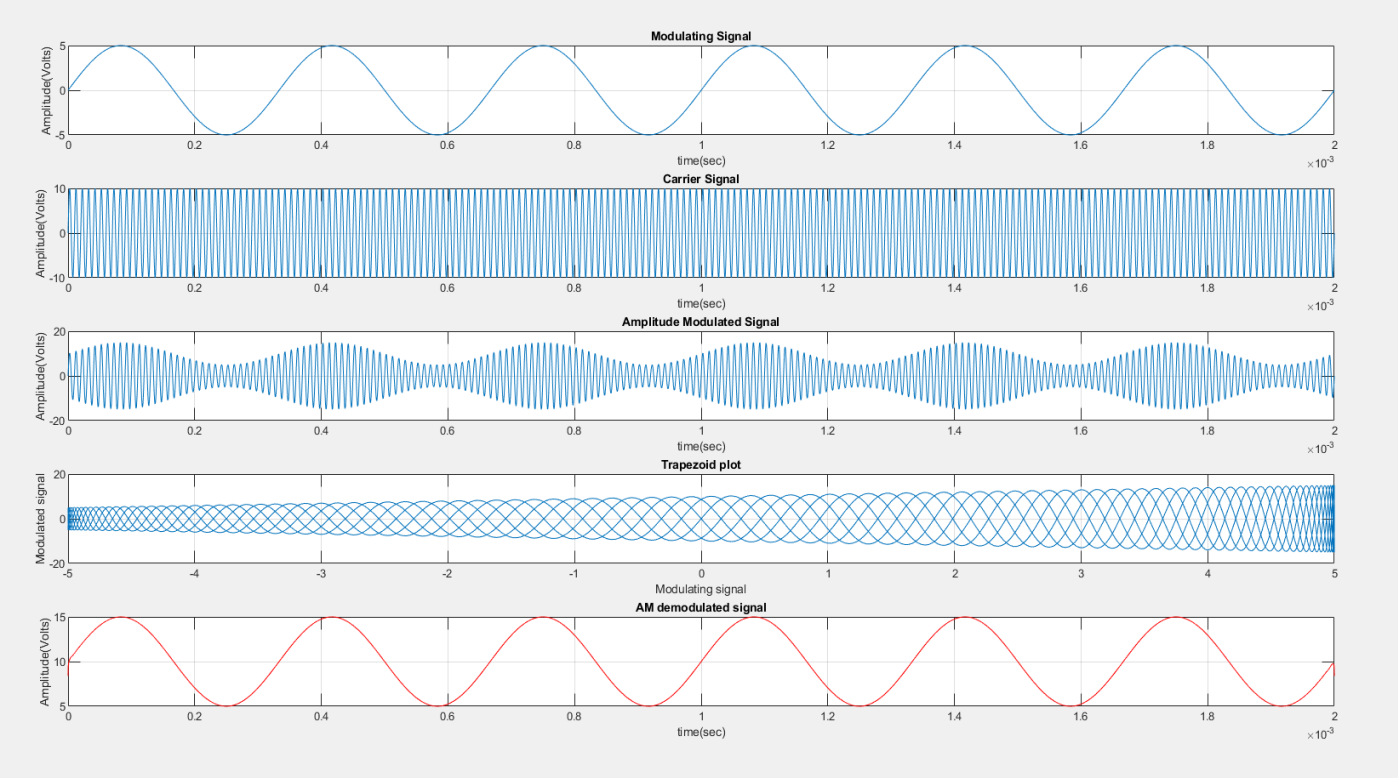
Simulink model



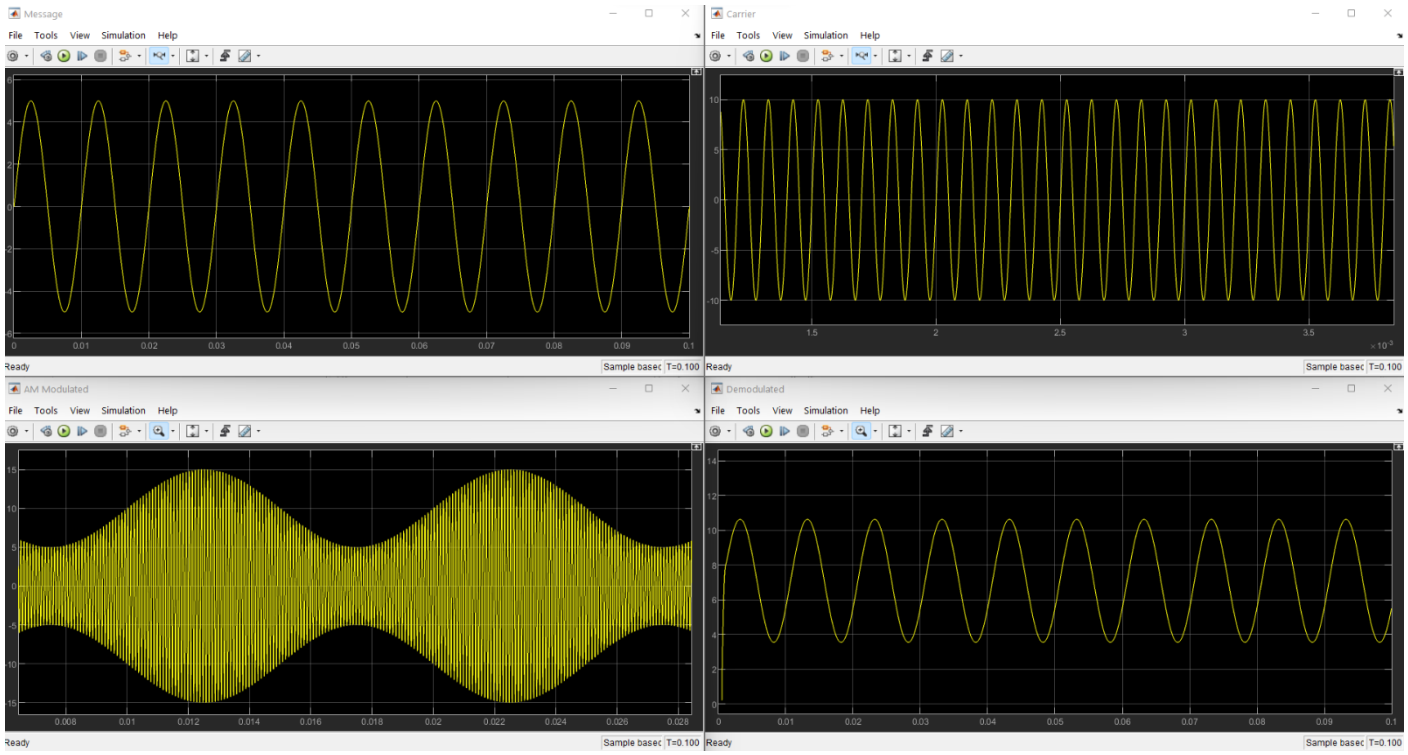
Plots

1. $m = 0.5$

MATLAB plot

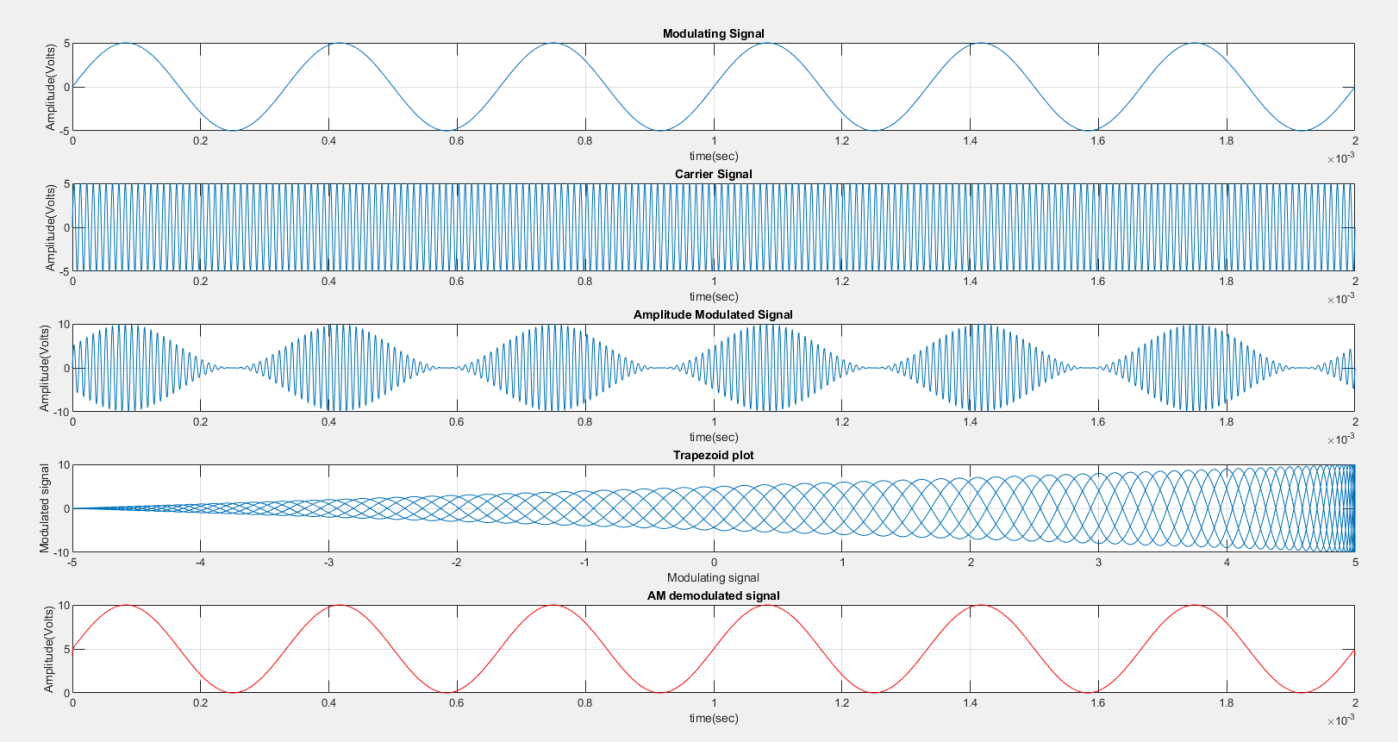


Simulink plot

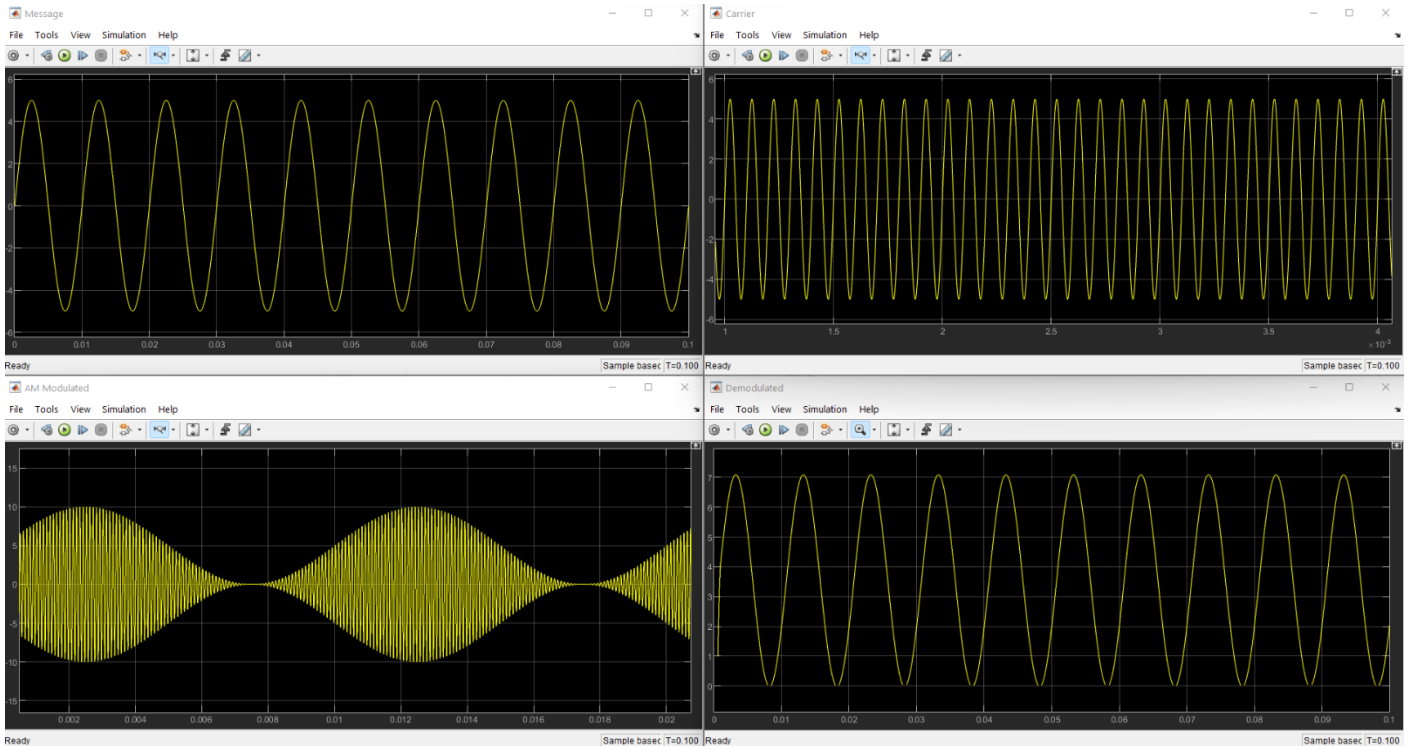


2. $m = 1$

MATLAB plot

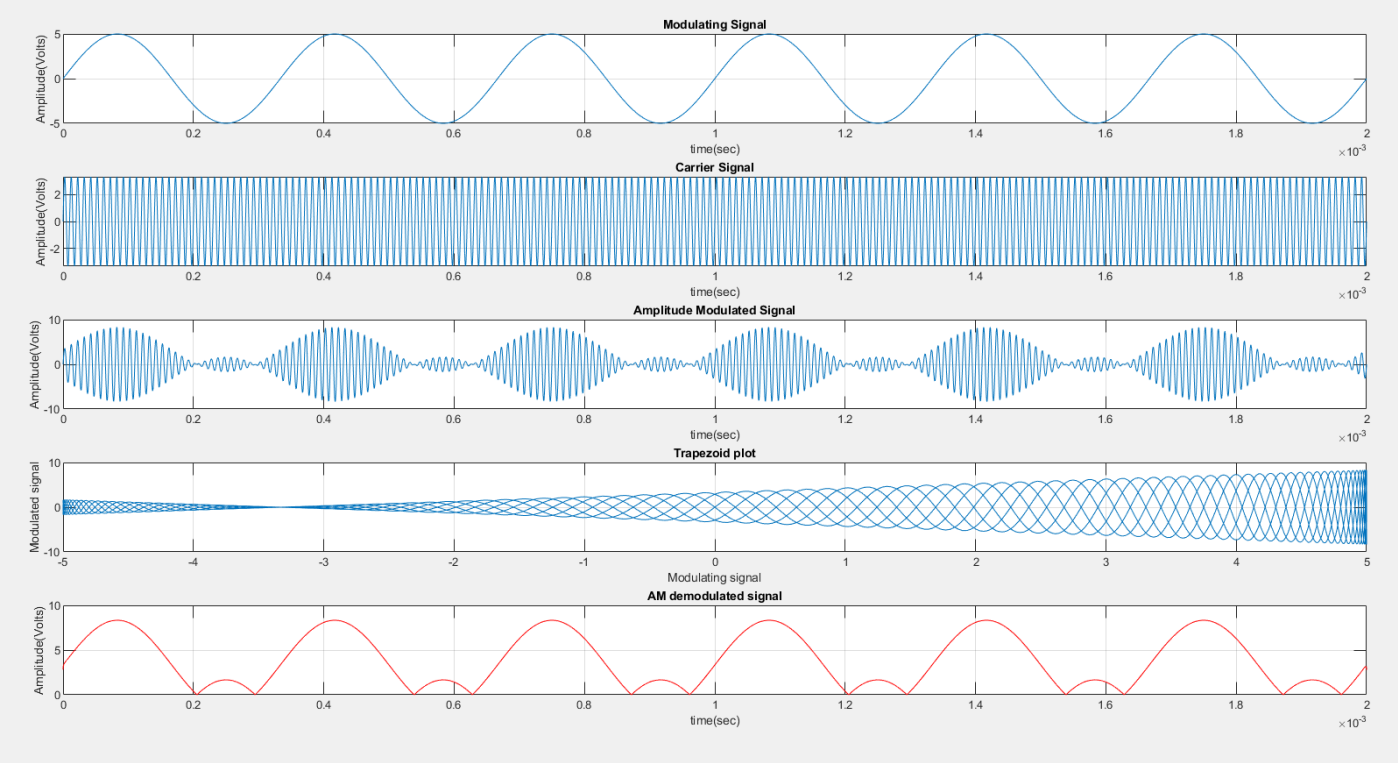


Simulink plot

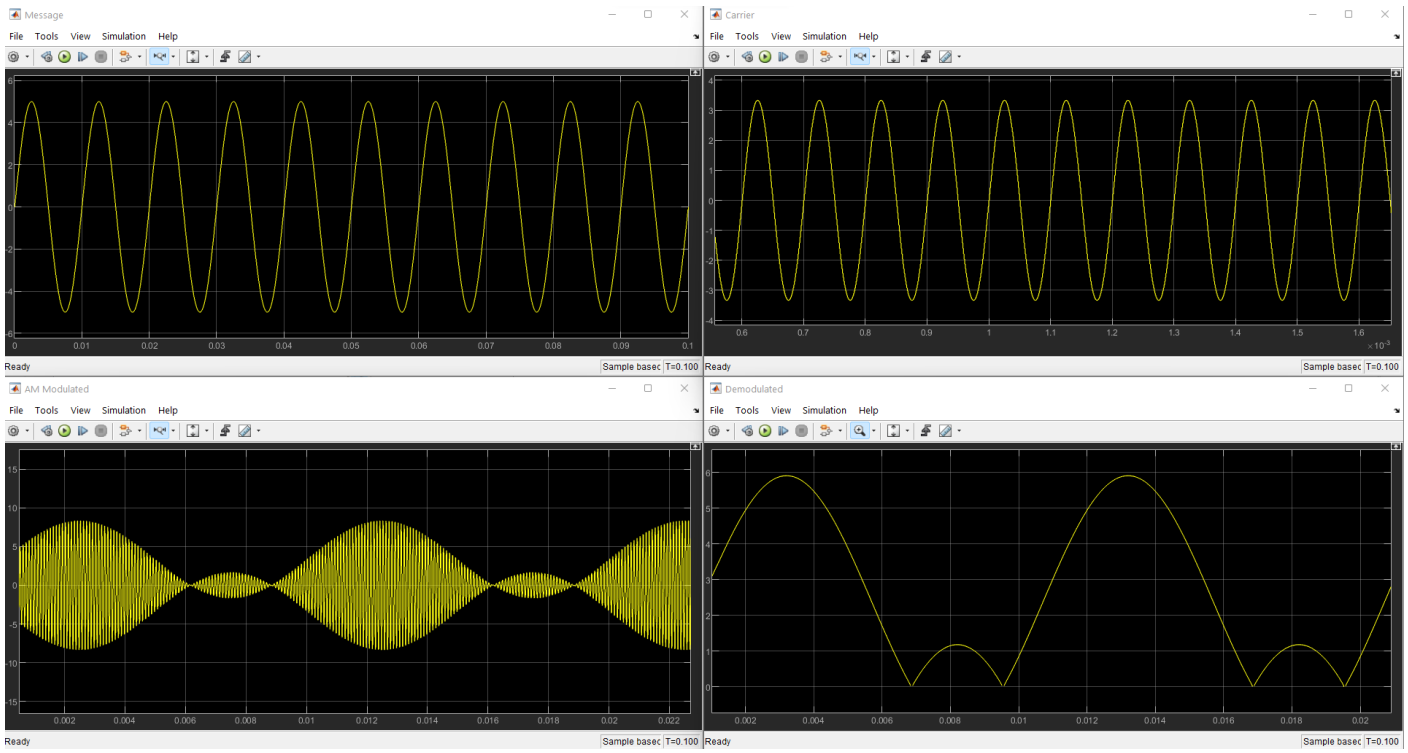


3. $m = 1.5$

MATLAB plot



Simulink plot



Inferences

We can observe that the MATLAB plots (theoretical) and Simulink plots (experimental) are identical. This implies that theory agrees with experimental results.

Further, when $m = 1.5$, message signal cannot be retrieved from AM signal by envelope detection. This expected since demodulation using envelope detection works only for $0 < m \leq 1$.
