ECS301: PRINCIPLES OF COMMUNICATION
PROGRAMMING ASSIGNMENT

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PROJECT TITLE: Generation of AM signals and study the effect of modulation index.

THEORY: Amplitude modulation is a process by which the message wave signal is transmitted by modulating the amplitude of the carrier signal. There are three main types of amplitude modulation. They are;

- Double Sideband Amplitude Modulation
- Double sideband-suppressed carrier modulation (DSB-SC).
- Single Sideband Modulation (SSB).
- Vestigial Sideband Modulation (VSB).

Considering a sinusoidal carrier wave:

$$c(t) = A_c cos(2\pi F_c t)$$

where Fc= Frequency of Carrier Signal, Ac= Amplitude of Carrier Signal. We can assume the phase of the signal carrier wave to be zero.

Considering a message carrier wave:

$$m(t) = A_m cos(2\pi F_m t)$$

where Fm= Frequency of Message Signal, Am= Amplitude of Message Signal. We can assume the phase of the signal carrier wave to be zero.

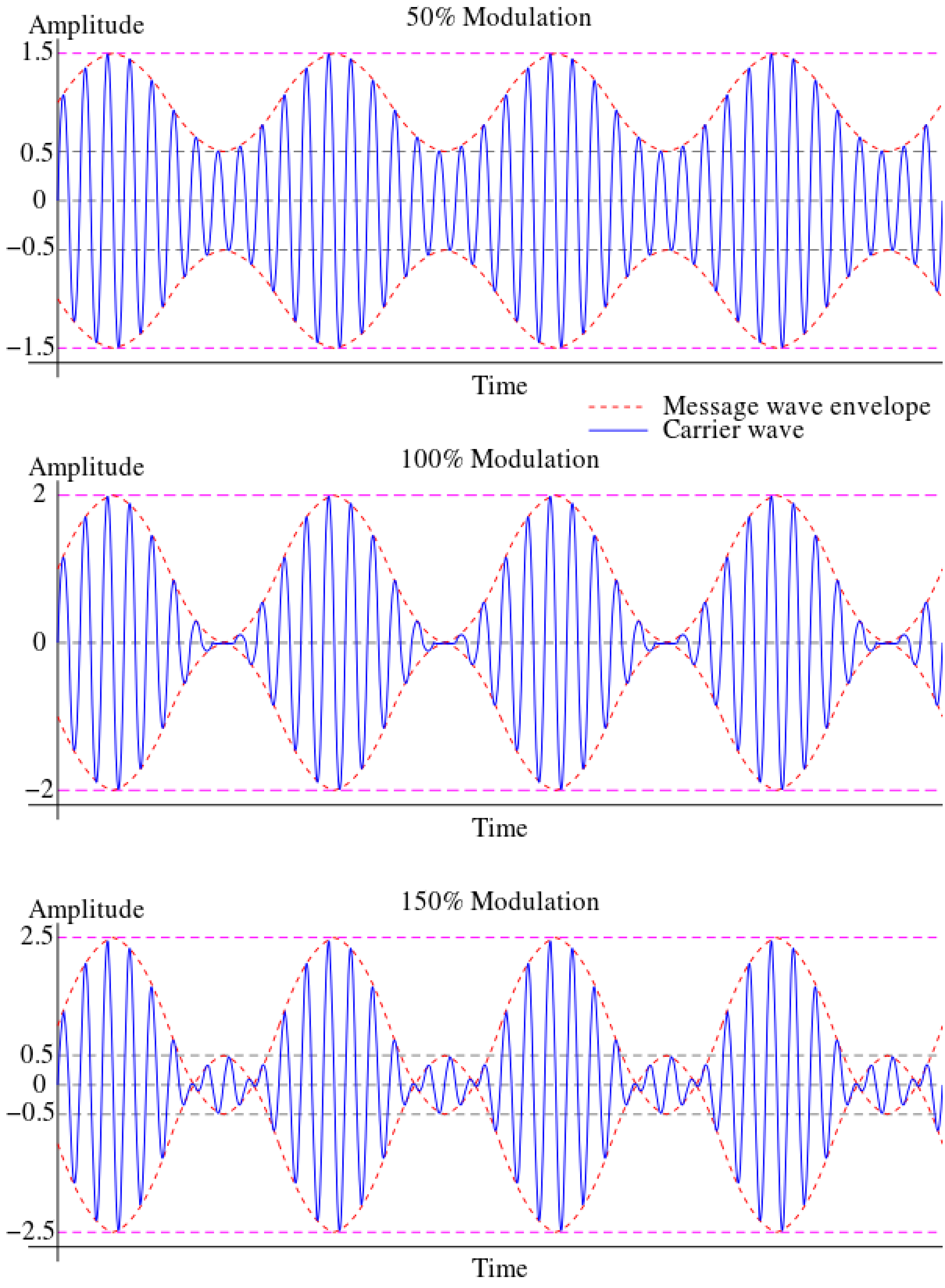
The source of the carrier signal c(t) is physically independent of the source responsible for generating the m(t). Then the amplitude modulated signal can be described as:

$$s(t) = A_c[1 + k_a m(t)]cos(2\pi F_c t)$$

Where ka= amplitude sensitivity of the modulator responsible for the generation of modulated signal s(t).

Now, when $\left|k_a m(t)\right| > 1$; the carrier wave becomes overmodulated resulting in carrier phase reversal whenever the factor $k_a m(t) + 1$ crosses zero i.e. recovered signal gets distorted. Therefore for proper amplitude modulation, $\left|k_a m(t)\right| \leq 1$ always.

$$Modulation\ index\ (\mu)\ = k_a|min[m(t)]| = k_a A_m$$



Reference: Wikipedia

APPROACH:

For our project, we have taken:
k_a (Amplitude Sensitivity)=1
A_c (Amplitude of Carrier Signal)=1
F_c=1000Hz; F_m=10Hz.
Since k_a=1, therefore modulation index will be $\mu=A_m$ (amplitude of message signal)

```
%% Inputs to produce AM wave
Ac=1; %Amplitude of Carrier Signal
Am=input('Enter message signal amplitude');
ka=1;% Amplitude Senstivity
m=Am*ka; %Modulation Index
%Fc>>Fm
Fc=input('Enter frequency of carrier wave (in Hz)');
Fm=input('Enter frequency of message wave (in Hz)');
```

```
%% Time specifications:
Fs = 8000;                 % samples per second
dt = 1/Fs;                 % seconds per sample
StopTime = 0.25;           % seconds
t1 = (0:dt:StopTime-dt)';
```

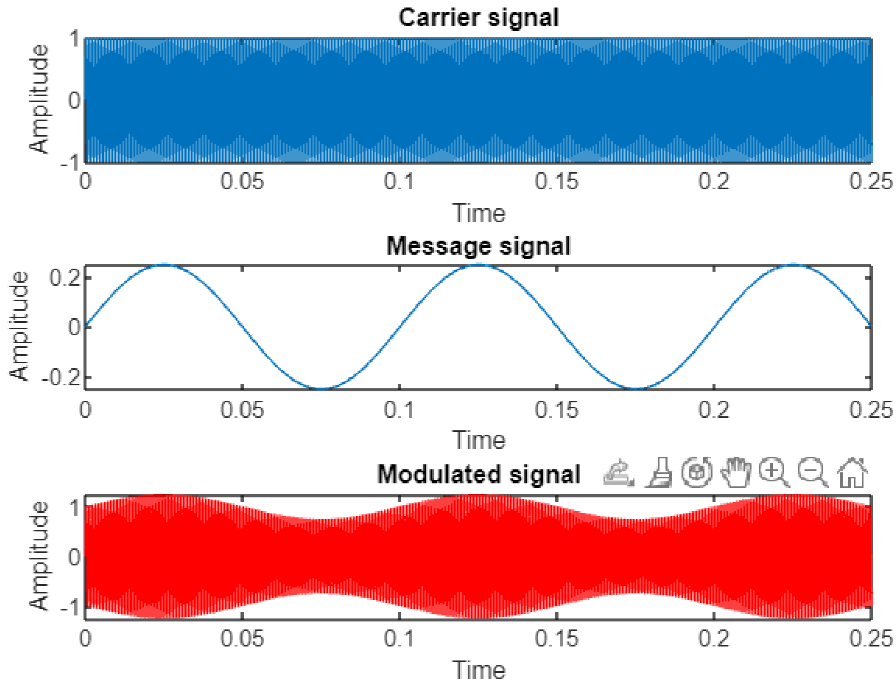
```
%% Equations
y1=Ac*sin(2*pi*Fc*t1); %Carrier Signal
y2=Am*sin(2*pi*Fm*t1); %Message Signal
eq=(1+m.*sin(2*pi*Fm*t1)).*(y1); %Amplitude Modulated Signal
```

```
%% Plots
subplot(311)
plot(t1,y1)
xlabel('Time')
ylabel('Amplitude')
title('Carrier signal')
subplot(312)
plot(t1,y2)
xlabel('Time')
ylabel('Amplitude')
title('Message signal')
subplot(313)
plot(t1,eq)
plot(t1,eq,'r')
xlabel('Time')
ylabel('Amplitude')
title('Modulated signal')
```

OUTPUTS OF THE CODE:

There are four diagrams for each modulation index: first is carrier signals, then message signal, then followed by modulated signal. The last figure is the zoomed in figure for the modulated signal.

For m=0.25



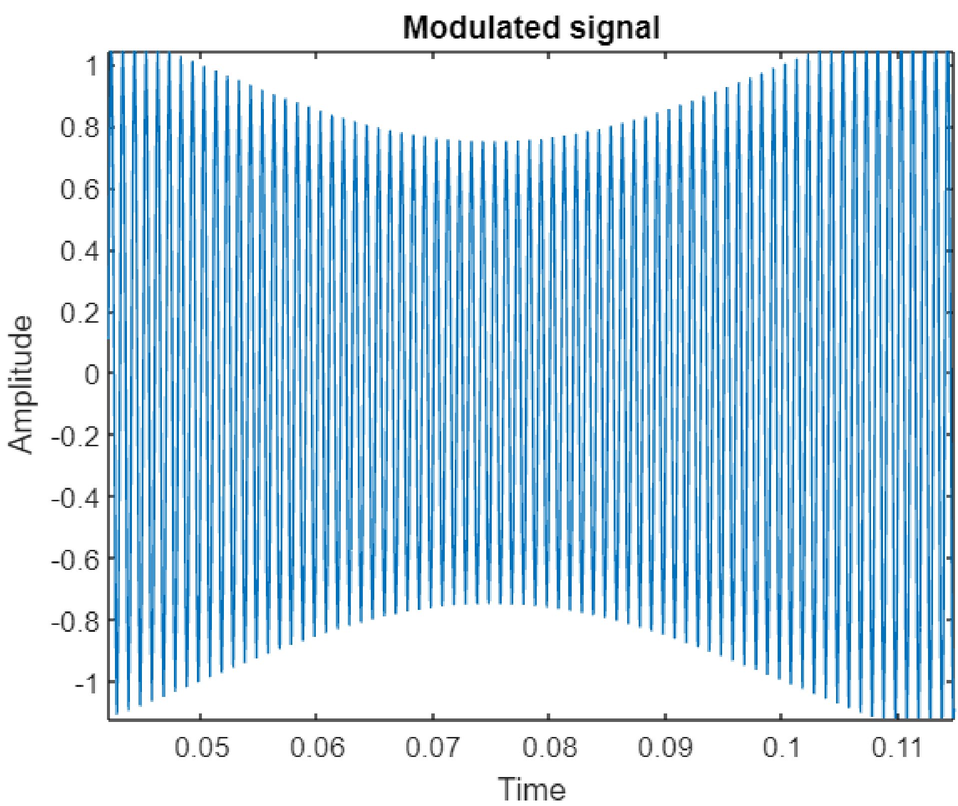
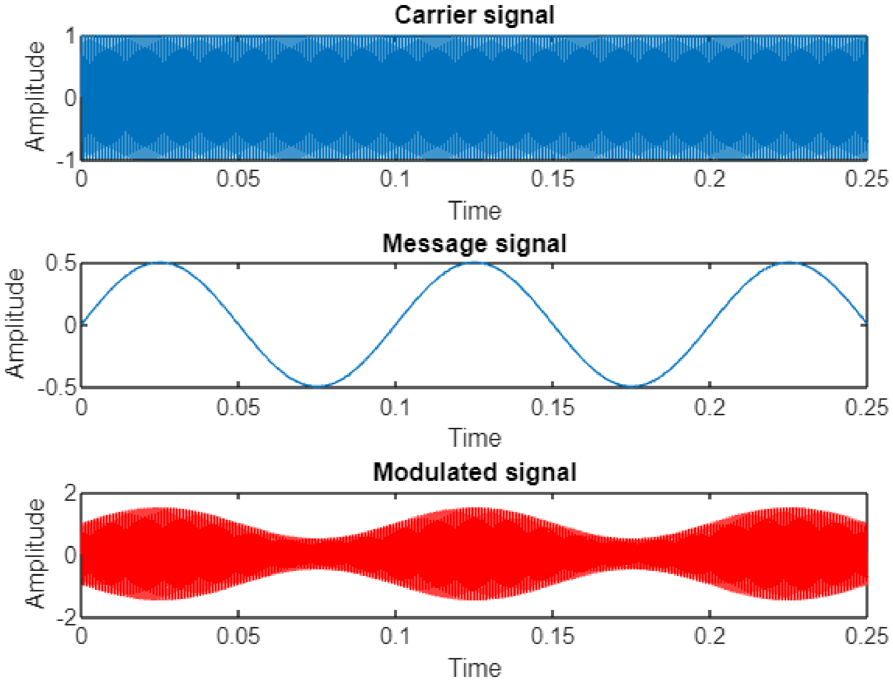


Fig-1

For m=0.5


Carrier signal
Amplitude
1
0
-1
0
0.05
0.1
0.15
0.2
0.25
Time
Message signal
Amplitude
0.5
0
-0.5
0
0.05
0.1
0.15
0.2
0.25
Time
Modulated signal
Amplitude
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
Time

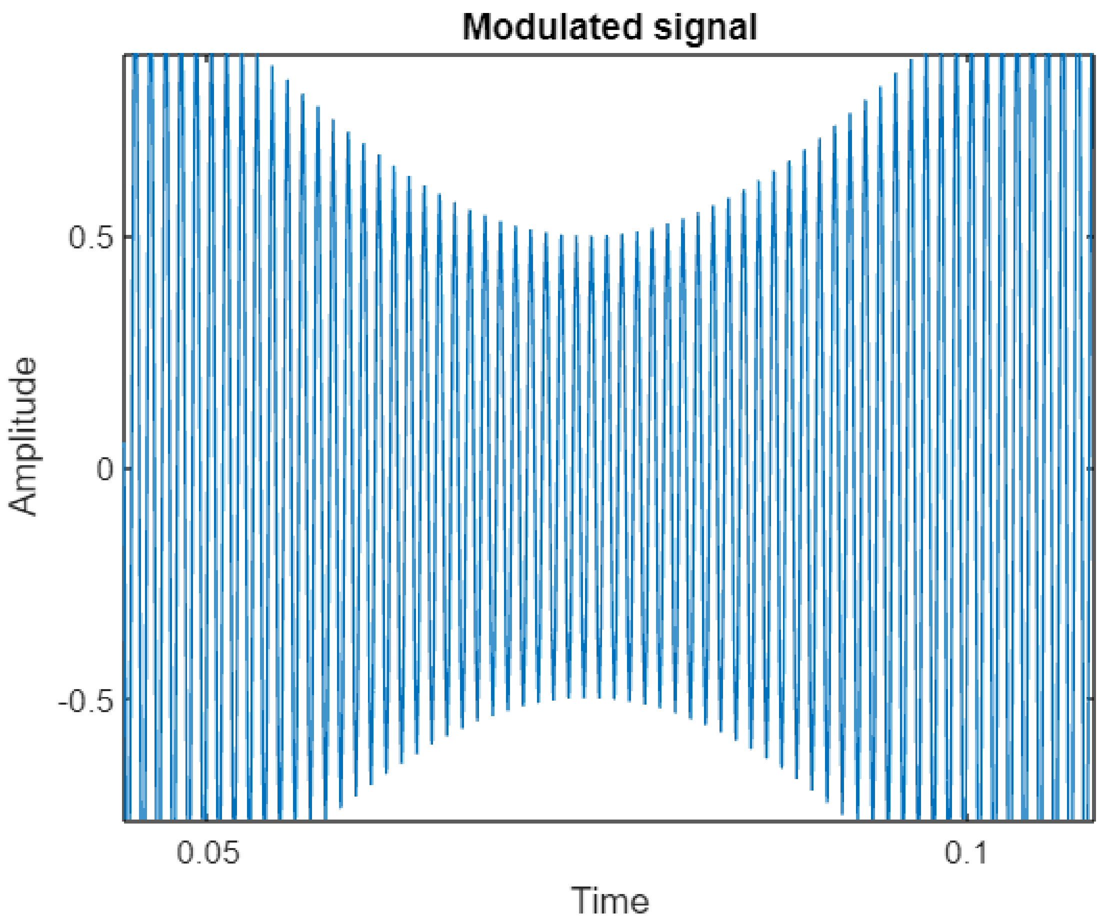
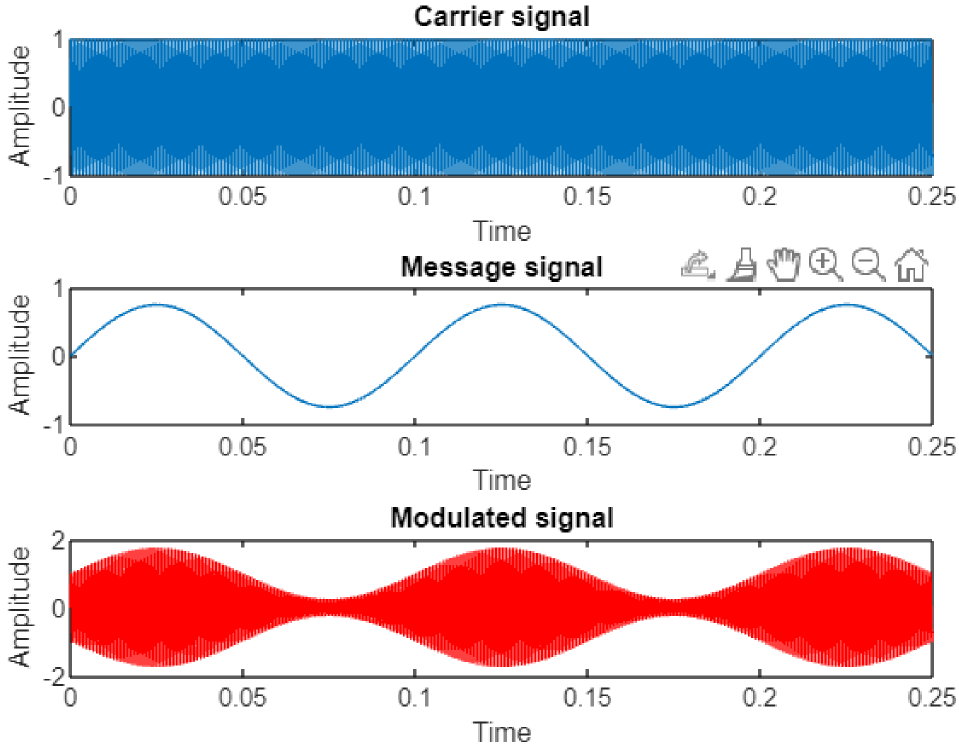

Modulated signal
Amplitude
0.5
0
-0.5
0.05
0.1
Time

Fig-2

For m=0.75



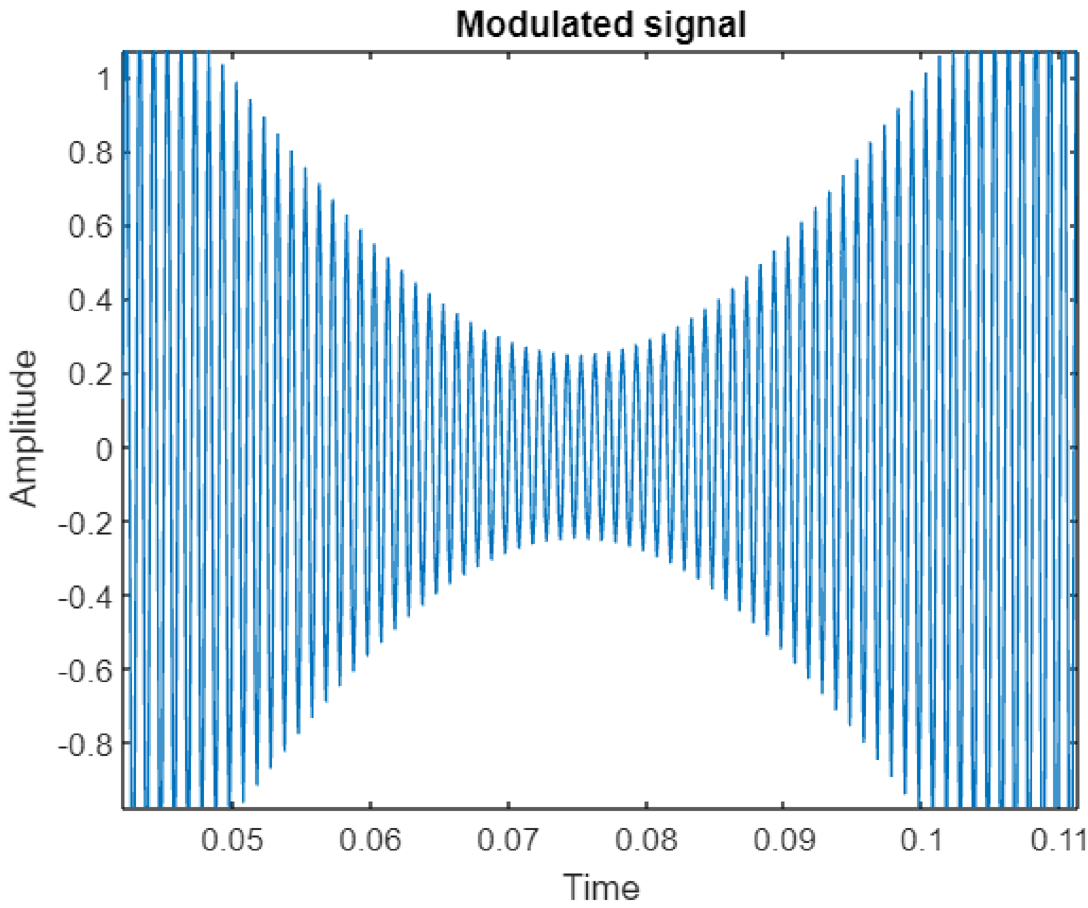
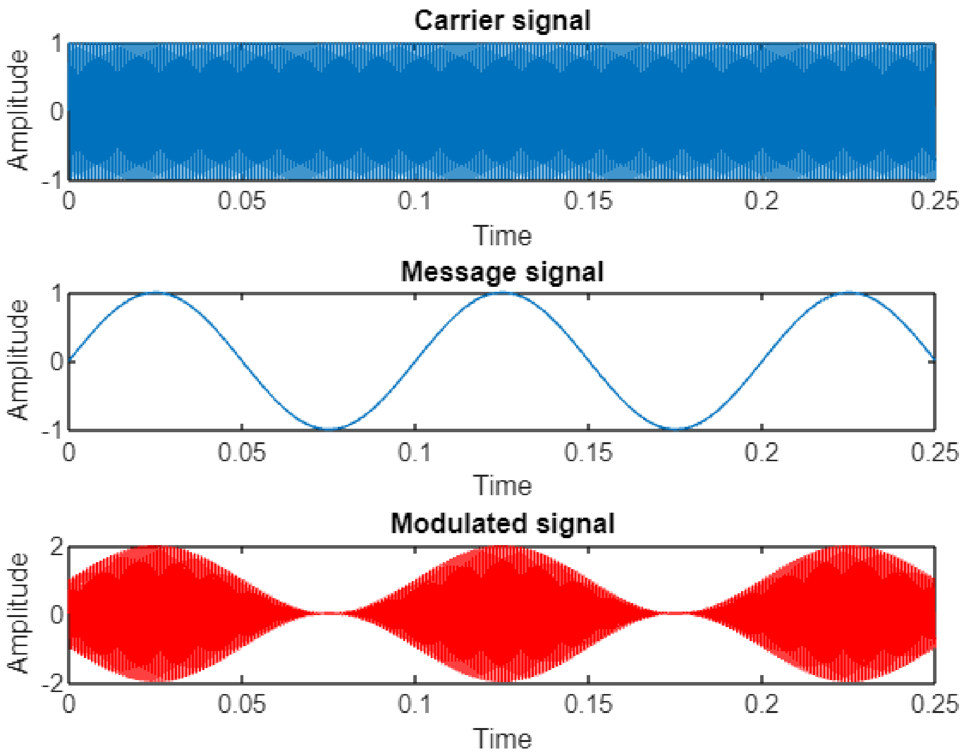


Fig-3

For m=1



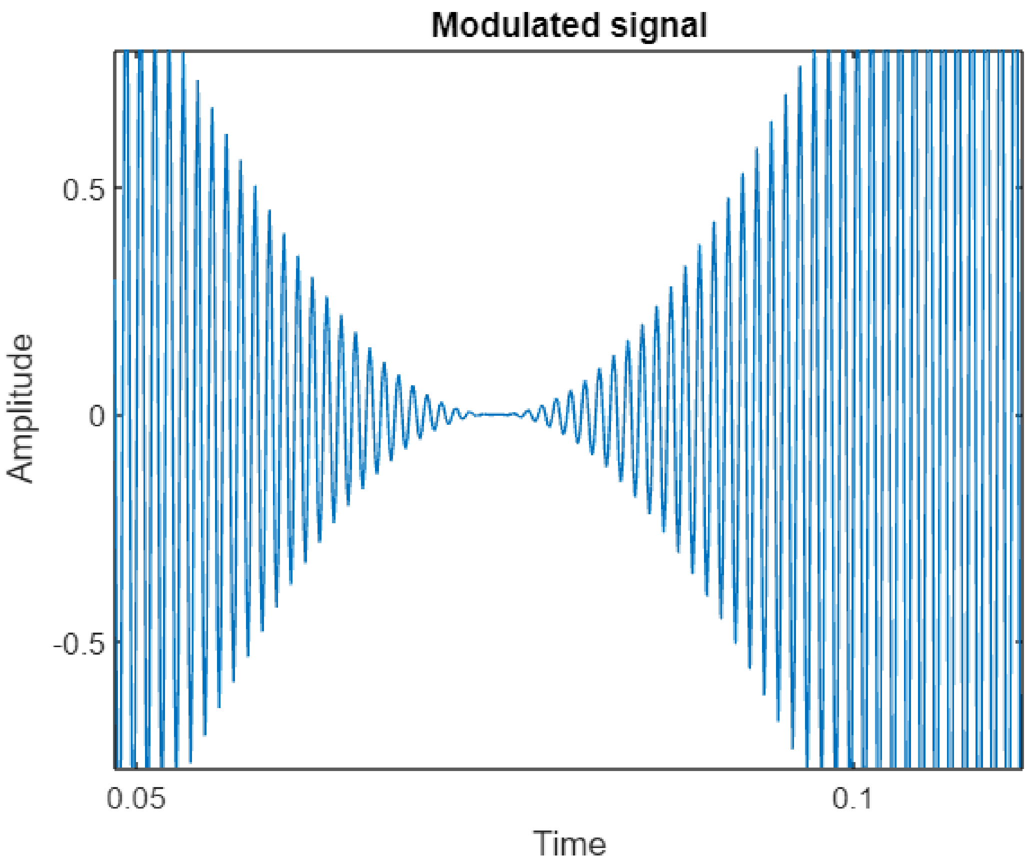


Fig-4

For m=1.25

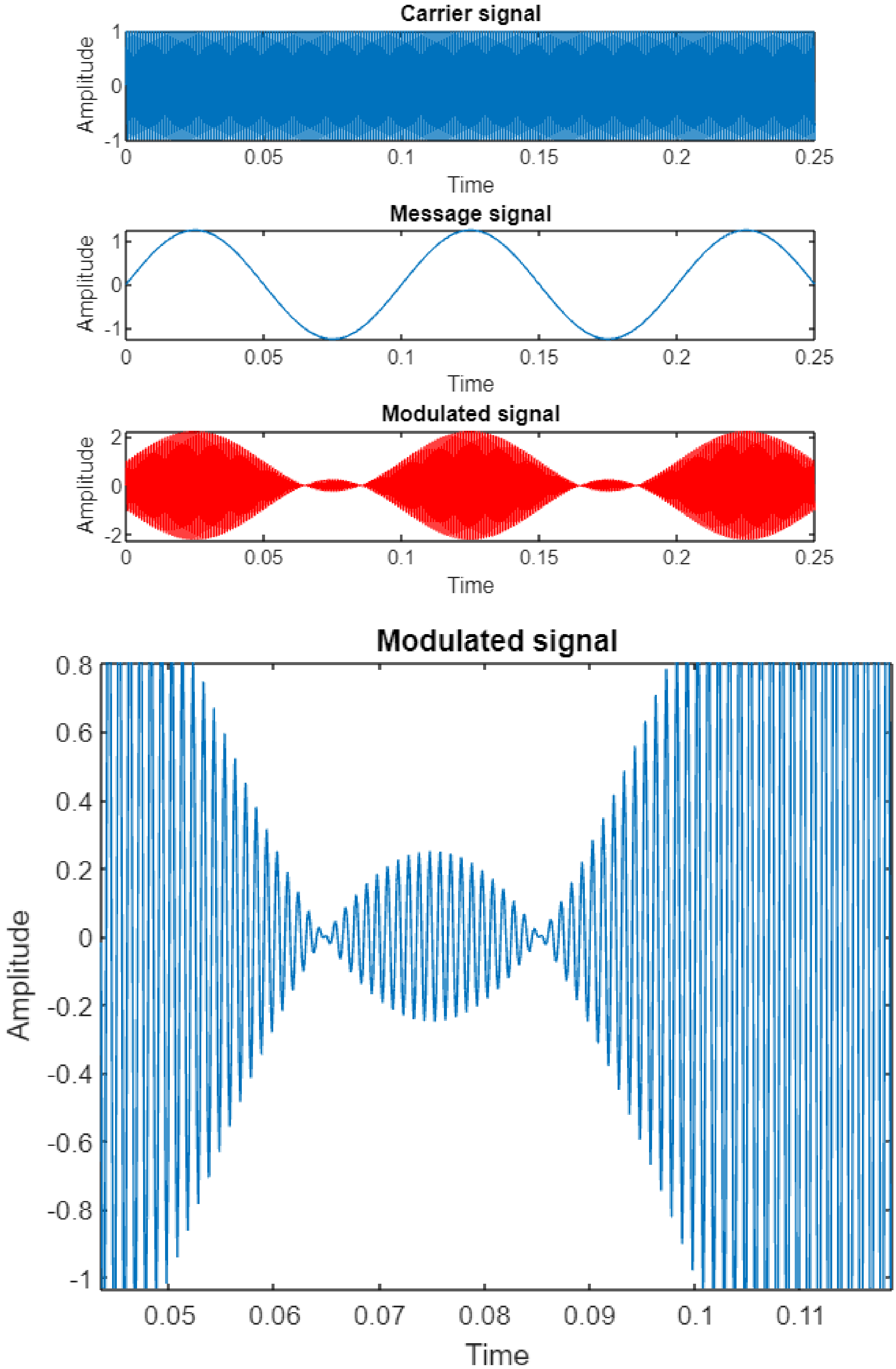
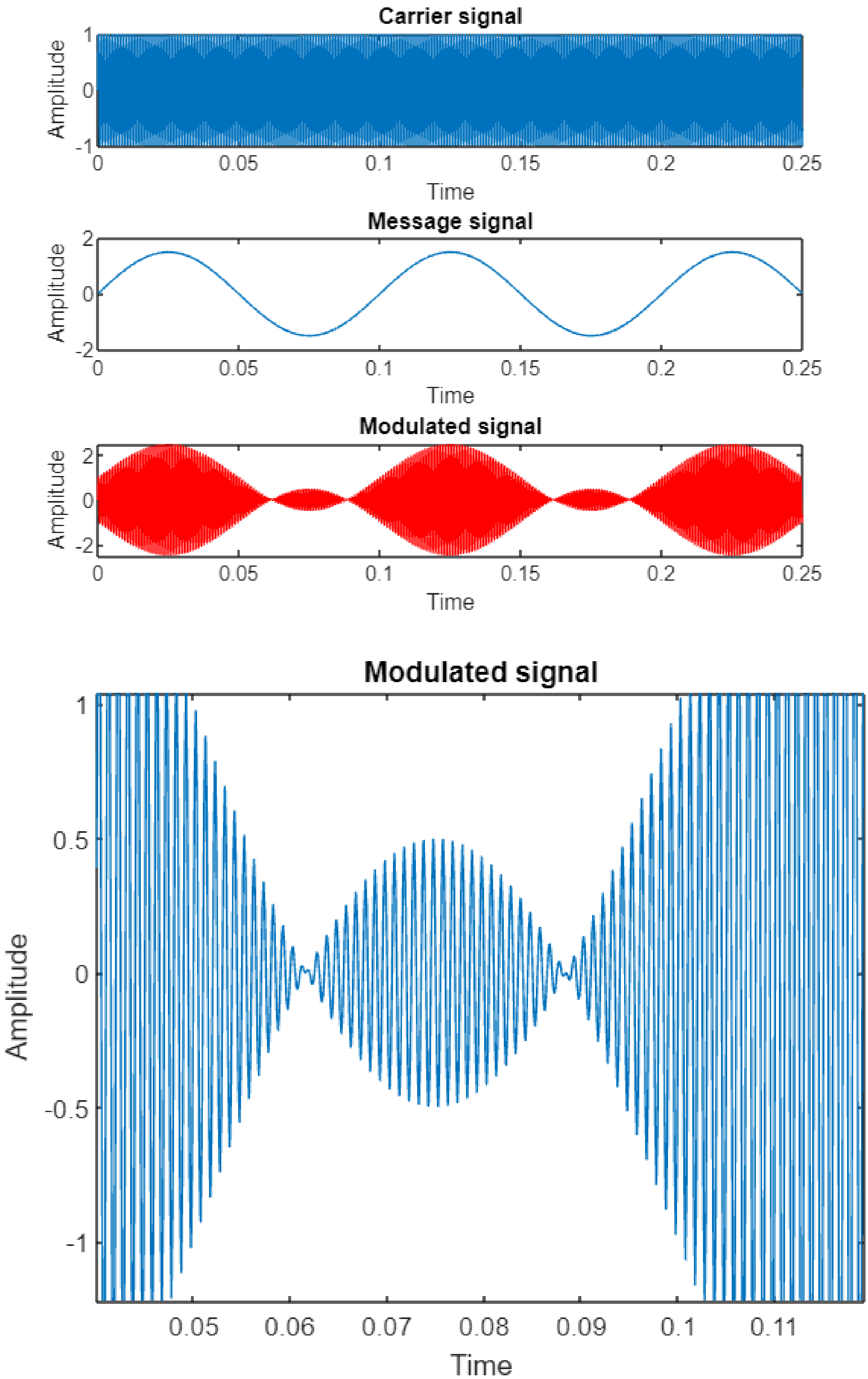


Fig-5

For m=1.5



Carrier signal
Amplitude
1
0
-1
0
0.05
0.1
0.15
0.2
0.25
Time
Message signal
Amplitude
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
Time
Modulated signal
Amplitude
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
Time
Modulated signal
Amplitude
1
0.5
0
-0.5
-1
0.05
0.06
0.07
0.08
0.09
0.1
0.11
Time

Fig-6

For m=1.75

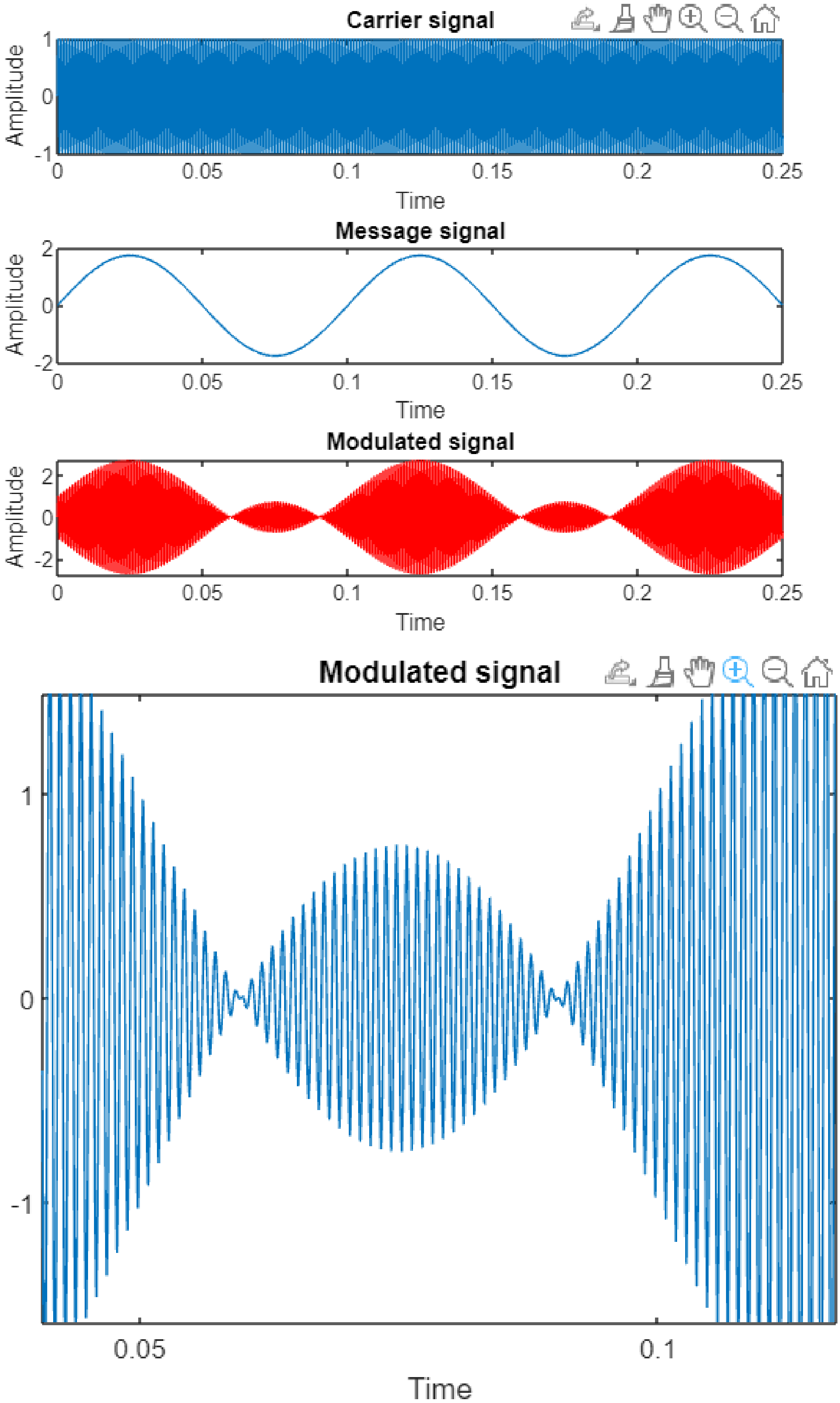
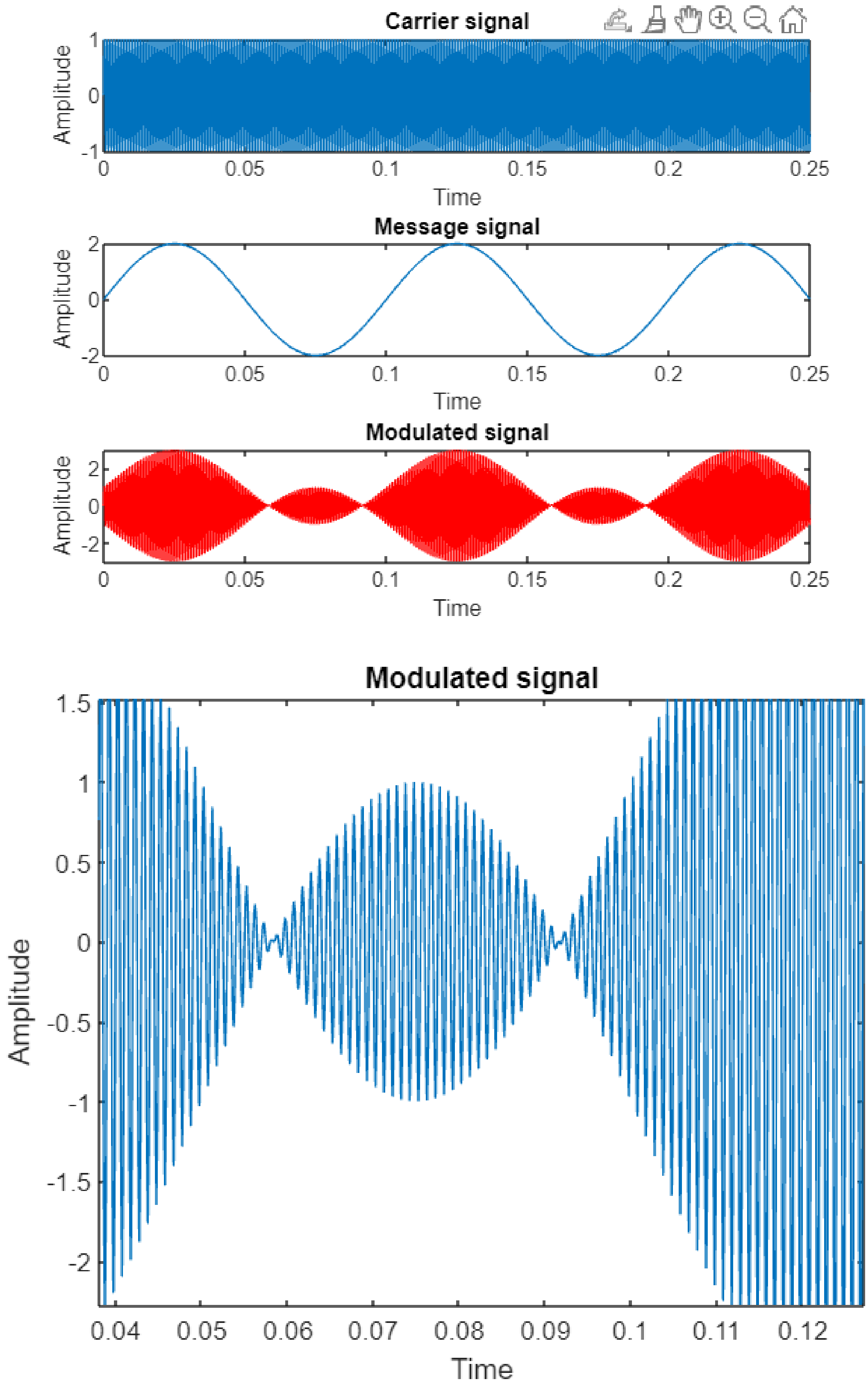


Fig-7

For m=2



Carrier signal
Amplitude
1
0
-1
0
0.05
0.1
0.15
0.2
0.25
Time
Message signal
Amplitude
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
Time
Modulated signal
Amplitude
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
Time
Modulated signal
Amplitude
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.11
0.12
Time

Fig-8

CONCLUSION: We can clearly see that as we keep increasing the modulation index, the carrier wave comes closer to the zero and as soon as μ becomes greater than 1, it crosses the zero line and the phase reversal happens (as shown in the zoomed in figure-11 of modulated signal) and becomes overmodulated and cannot be detected with the help of an envelope detector.

For m<1

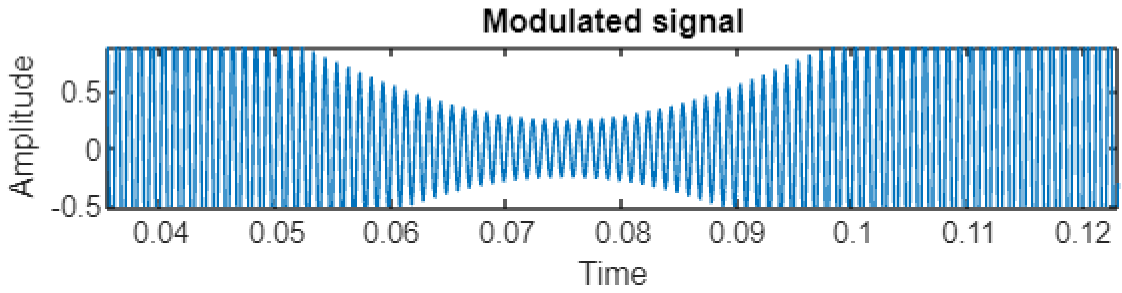


Fig-9

For m=1

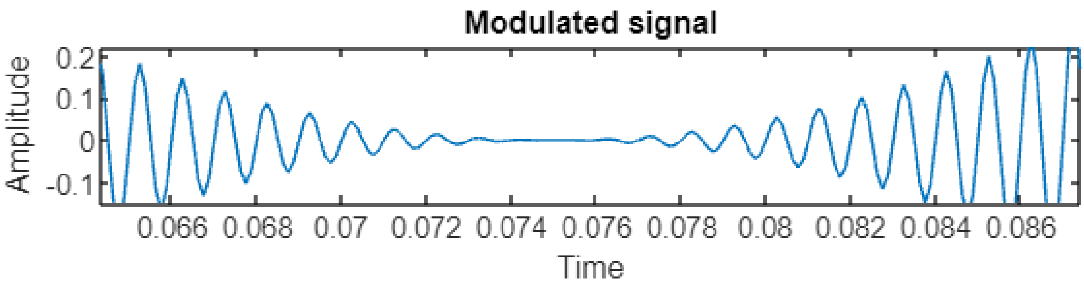


Fig-10

For m>1

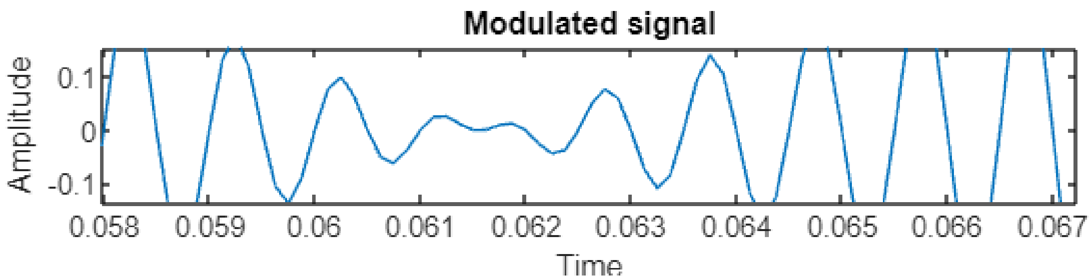


Fig-11

INFERENCE: We can infer from the above project that if we want to send message signal using amplitude modulation and extract the information using envelope detector, we need to assure that the modulation index is not greater than 1, so that overmodulation do not occur and information is not lost in this process because whenever overmodulation happens phase reversal happens and recovered signal is distorted.

APPLICATION IN REAL LIFE:

1. **Broadcast Transmissions:** AM is used in broadcasting transmission over the short, medium and long wavebands. Since AM is easy to demodulate, radio receivers for amplitude modulation are therefore easier and cheaper to manufacture.
2. **Air-band radio:** AM is used in the VHF transmissions for many airborne applications such as ground-to-air radio communications or two-way radio links for ground staff personnel.
3. **Single sideband:** Amplitude modulation in this form is used for HF radio links or point-to-point HF links. AM uses a lower bandwidth and provides more effective use of the transmitted power.
4. **Quadrature amplitude modulation:** AM is used extensively in transmitting data in several ways, including short-range wireless links such as Wi-Fi to cellular telecommunications and others.