American International University- Bangladesh

Department of Computer Engineering

COE 3201: Data Communication Laboratory

Title: Study of Amplitude Modulator and Demodulator using MATLAB

Abstract:

This experiment is designed to-

1. To understand the AM modulation and demodulation theoretically,
2. The use of MATLAB to implement AM modulation and demodulation.

Introduction: Amplitude modulation (AM) is a one of the conventional techniques used to transmit message signals using a carrier wave. The amplitude or strength of the high frequency carrier wave is modified in accordance with instantaneous amplitude of the message signal.

AM Modulation:

Let us consider $m(t)$ is the message signal, and $c(t)$ is the high frequency carrier signal:

$$m(t) = A_m \sin(\omega_m t) = A_m \sin(2\pi f_m t)$$

$$c(t) = A_C \sin(\omega_c t) = A_c \sin(2\pi f_c t)$$

Then, AM modulated signal can be constructed as follows:

$$am(t) = [A_c + m(t)] \sin(\omega_c t) = [A_c + A_m \sin(\omega_m t)] \sin(\omega_c t)$$

$$= \left[A_c \left\{1 + \frac{A_m}{A_C} \sin(\omega_m t)\right\}\right] \sin(\omega_c t) = [A_c\{1 + \mu \sin(\omega_m t)\}] \sin(\omega_c t)$$

$$= A_c \sin(\omega_c t) + \mu A_c \sin(\omega_c t) \sin(\omega_m t)$$

$$= A_c \sin(\omega_c t) + \frac{\mu A_c}{2} [\cos\{(\omega_c - \omega_m)t\} - \cos\{(\omega_c + \omega_m)t\}]$$

Here, $\mu = \frac{A_m}{A_c}$ known as AM modulation index. The value of $0 \leq \mu \leq 1$. Thus, $A_m < A_c$.

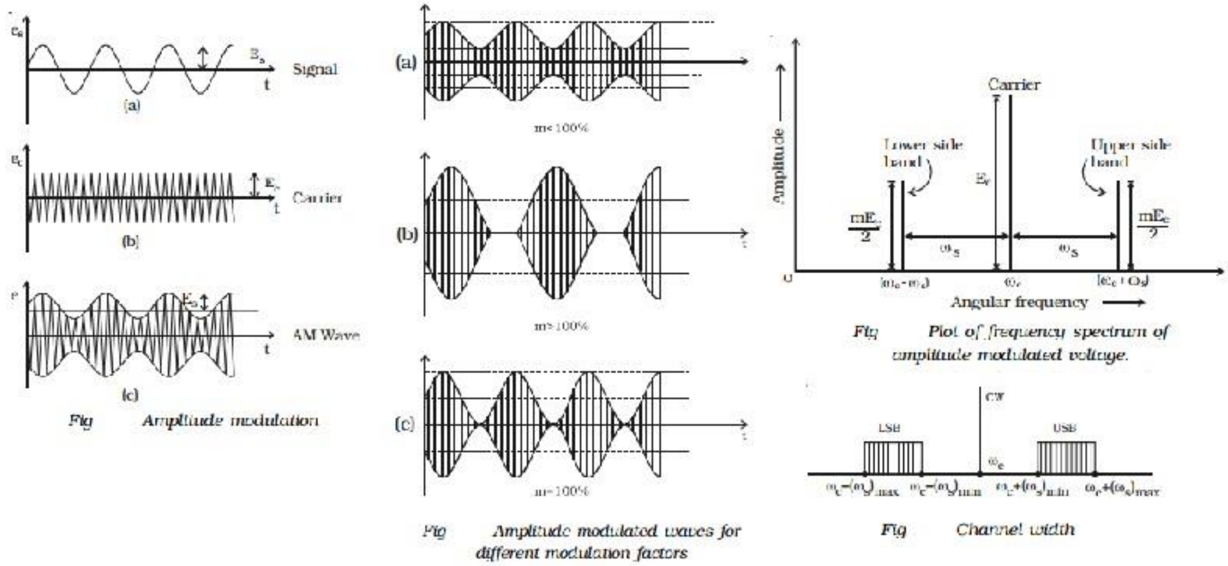

Fig. 1. AM modulated signal in time and frequency domain.

AM demodulation:

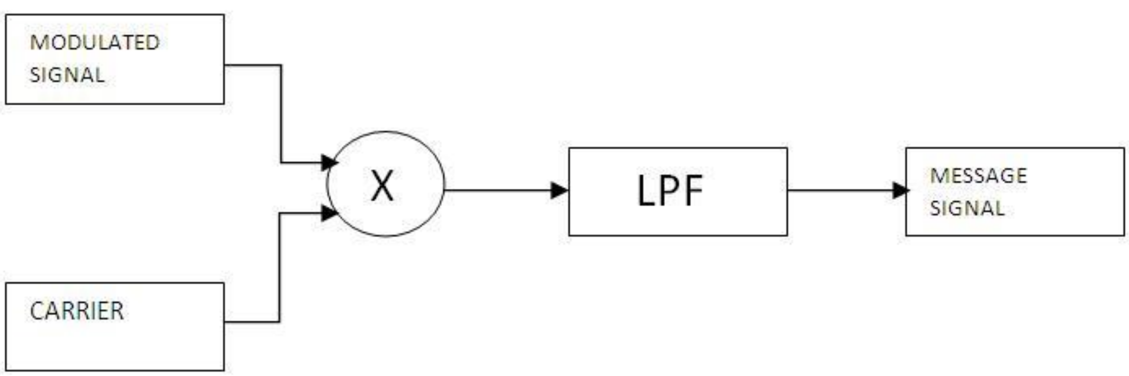

Fig. 2. AM demodulation process.

Thus, if we multiply the AM modulated signal with the carrier signal again in the demodulation process, one component becomes higher frequency $2\omega_c$ and other component becomes the low frequency baseband/modulating signal frequency ω_m as shown below:

$$A_C \cos\{(\omega_c - \omega_m)t\} \sin(\omega_c t) = \frac{A_c}{2}[\sin\{(\omega_c - \omega_m + \omega_c)t\} - \sin\{(\omega_c - \omega_m - \omega_c)t\}]$$
$$= \frac{A_c}{2}[\sin\{(\boldsymbol{2\omega_c} - \omega_m)t\} + \sin\{(\boldsymbol{\omega_m})t\}]$$

As a result, if we use a low pass filter to remove the higher frequency component, then we can recover the low frequency baseband signal in the demodulation process.

MATLAB code:

```
clc;
clear;
fs=3000;
t = 0:1/fs:1-1/fs;
fm=5; %frequency of your modulating signal/baseband signal (orginal information
signal frequency)
fc=100; % frequency of your carrier signal, we will use for AM modulation

% Baseband Signal (Modulating Signal)
Am=10; % amplitude of your baseband signal
m = Am.*sin(2*pi*fm*t);

% Carrier Signal
Ac=20; % amplitude of your carrier singal
c= Ac.*sin(2*pi*fc*t);

% modulation index
mu=Am/Ac; % mu=10/20=0.5

% AM Modulated Signal
cam=(Ac.*(1+mu*sin(2*pi*fm*t))).*sin(2*pi*fc*t);

fftSignal = fft(cam); % This is frequency response of amplitude modulated signal
(cam).
fftSignal = fftshift(fftSignal)/(fs/2);
f = fs/2*linspace(-1,1,fs);

% AM demodulatation part
%am_demodulated = abs(hilbert(cam))-20;

%multiplying the am modulated signal with carrier signal
am_demodulated =cam.*c;
%Applying Low-Pass filter
[k,l] = butter(6,(100).*2/fs);
filtered_signal = filtfilt(k,l,(am_demodulated-200)./10) ;

% Plot the signals
figure;
subplot(4,1,1);
plot(t,m);
ylabel('amplitude');xlabel('time');
title('Modulating/Baseband Signal');
grid on

subplot(4,1,2);
plot(t,c);
ylabel('amplitude');xlabel('time');
title('Carrier Signal');
grid on

subplot(4,1,3);
plot(t,cam);
ylabel('amplitude');xlabel('time');
```

```
title('Amplitude Modulated Signal');
xlabel('Time (s)');
grid on

subplot(4,1,4);
%plot(t,am_demodulated);
plot(t,filtered_signal);
ylabel('Amplitude');xlabel('time');
title('Demodulated signal');
grid on

figure;
plot(f, abs(fftSignal));
axis([-200 200 0 25]);
title('FFT of AM modulated signal');
xlabel('Frequency (Hz)');
ylabel('Amplitude');
```

Task to write lab report:

1. Define modulation and AM modulation. Why modulation is necessary in communication.
2. Mathematically proved that for the message signal $m(t) = A_m \sin(\omega_m t)$ and carrier signal $c(t) = A_c \sin(\omega_c t)$, AM modulated signal is a composite signal consisting of three frequency components. Then, produce the equation for Bandwidth for AM modulated signal.
3. Write a MATLAB code to generate AM modulated and demodulated signal for baseband signal $m(t) = 20\sin(10\pi t)$.