AMERICAN INTERNATIONAL UNIVERSITY–BANGLADESH (AIUB)

FACULTY OF ENGINEERING

Course name: Data Communication

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Section: H

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Group-04

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Experiment No : 07

Experiment name: **Study of Amplitude Modulator and Demodulator using MATLAB**

Submission date: April 26^{th}, 2024

Performance Task for 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 $m(t) = 20 \sin(10\pi t)$.

ANSWER OF QUESTION 1

Modulation is the process of varying one or more properties of a carrier signal in accordance with the information-bearing signal (also known as the modulating signal), for the purpose of transmitting that signal over a communication channel. The carrier signal typically has a higher frequency compared to the modulating signal, allowing it to carry the modulating signal efficiently.

AM modulation, specifically, refers to Amplitude Modulation, where the amplitude of the carrier signal is varied in proportion to the instantaneous amplitude of the modulating signal. In other words, the strength or power of the carrier signal is modified to encode the information from the modulating signal. AM modulation is commonly used in radio broadcasting.

Modulation is necessary in communication for several reasons:

1. Signal Propagation: Different types of signals propagate through a communication channel more effectively at different frequencies. By modulating a signal onto a carrier wave, we can take advantage of the favorable propagation characteristics of the carrier frequency.

2. Bandwidth Efficiency: Modulation allows us to transmit signals in a more compact form, utilizing a smaller range of frequencies compared to the original signal. This is particularly important for efficient use of the available frequency spectrum, especially in situations where multiple signals need to be transmitted simultaneously without interfering with each other.

3. Noise Immunity: Modulation techniques can enhance the robustness of a signal against noise and interference during transmission. By spreading the signal across a wider frequency range or

by using techniques like frequency or phase modulation, it's possible to mitigate the impact of noise and improve the signal-to-noise ratio (SNR) at the receiver.

4. Multiplexing: Modulation enables multiple signals to be combined and transmitted simultaneously over the same channel, a technique known as multiplexing. This allows for more efficient use of the communication medium, enabling several users to share the available bandwidth.

Overall, modulation plays a crucial role in modern communication systems by enabling efficient, reliable, and high-quality transmission of information over various communication channels.

ANSWER OF QUESTION 02

Sure, let's start with the expression for an amplitude modulated (AM) signal:

$$s(t) = (A_C + A_m \cdot m(t)) \cdot \sin(\omega_c t)$$

Where:

- A_c is the amplitude of the carrier signal.
- A_m is the amplitude of the message signal.
- $m(t)$ is the message signal.
- ω_c is the angular frequency of the carrier signal.

We're given that the message signal is $m(t) = A_m \sin(\omega_m t)$.

Now, we can rewrite the AM signal expression substituting $m(t)$:

$$s(t) = (A_C + A_m \cdot A_m \sin(\omega_m t)) \cdot \sin(\omega_c t)$$

Expanding this, we get:

$$s(t) = A_C \cdot \sin(\omega_c t) + A_m \cdot A_C \cdot \sin(\omega_c t) + A_m \cdot A_m \cdot \sin(\omega_m t) \cdot \sin(\omega_c t)$$

The modulated signal has three frequency components:

1. The carrier frequency (ω_c).
2. The sum of the carrier frequency and the message frequency ($\omega_c + \omega_m$).
3. The difference between the carrier frequency and the message frequency ($\omega_c - \omega_m$).

So, the three frequency components are at ω_c, $\omega_c + \omega_m$, and $\omega_c - \omega_m$.

The bandwidth of the AM modulated signal can be calculated as twice the highest frequency component, which is $\omega_c + \omega_m$. So, the bandwidth (B) is:

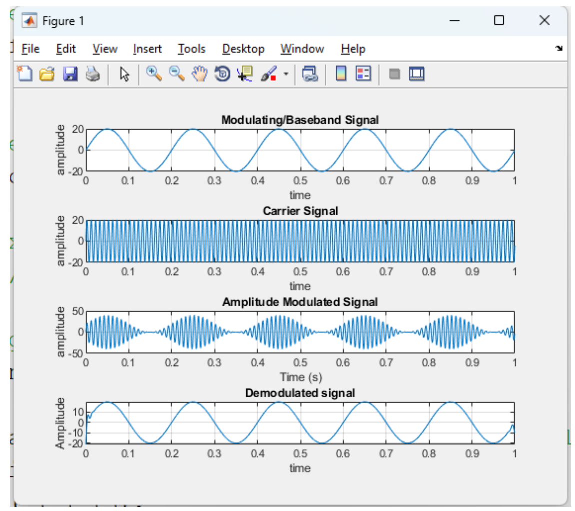
$$B = 2(\omega_c + \omega_m)$$

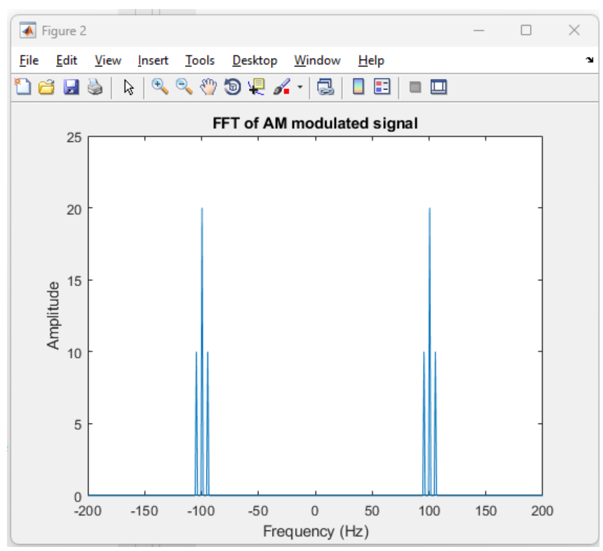
Given $\omega_c = 2\pi f_c$ and $\omega_m = 2\pi f_m$, where f_c is the carrier frequency and f_m is the message frequency, we can substitute these values into the bandwidth equation to get the final expression.

ANSWER OF QUESTION 03

MATLAB Code	Output Figure

```
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=20; % 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');
```





<pre>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');</pre>	