EEE 3208

Communication Theory Lab

Experiment No: 01

Experiment Name: Study of Amplitude modulation and Demodulation. [DSB transmission and Reception]

Submitted by,

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Semester: 2^{nd}

Section: C2

Objective: The goal of this experiment is to explore the concepts of amplitude modulation and its practical applications. It involves generating and analyzing Double-Side Band Amplitude Modulated (DSB-AM) and Double-Side Band Suppressed Carrier (DSBSC-AM) signals. Also, the experiment aims to understand the process of extracting information through the demodulation of DSB signals on the receiver side.

Answer (1)

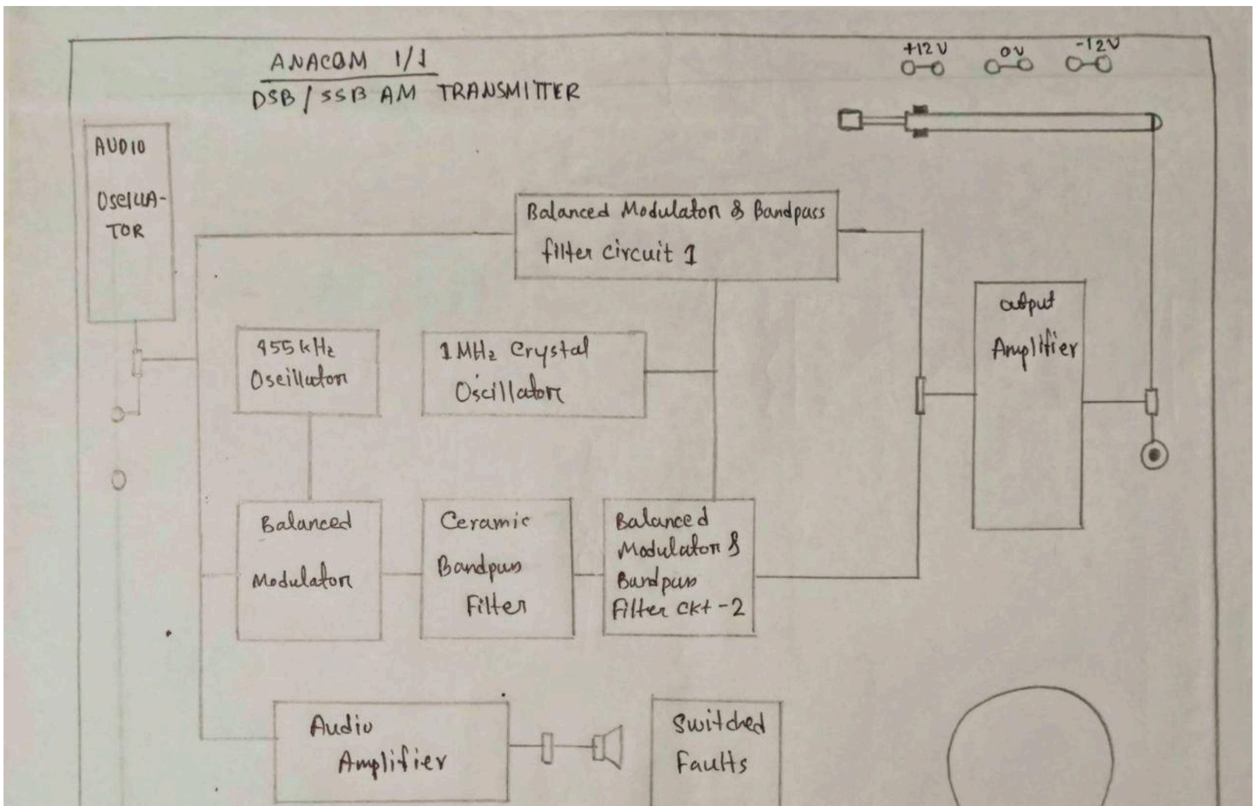


Fig: Block Diagram of Transmitter

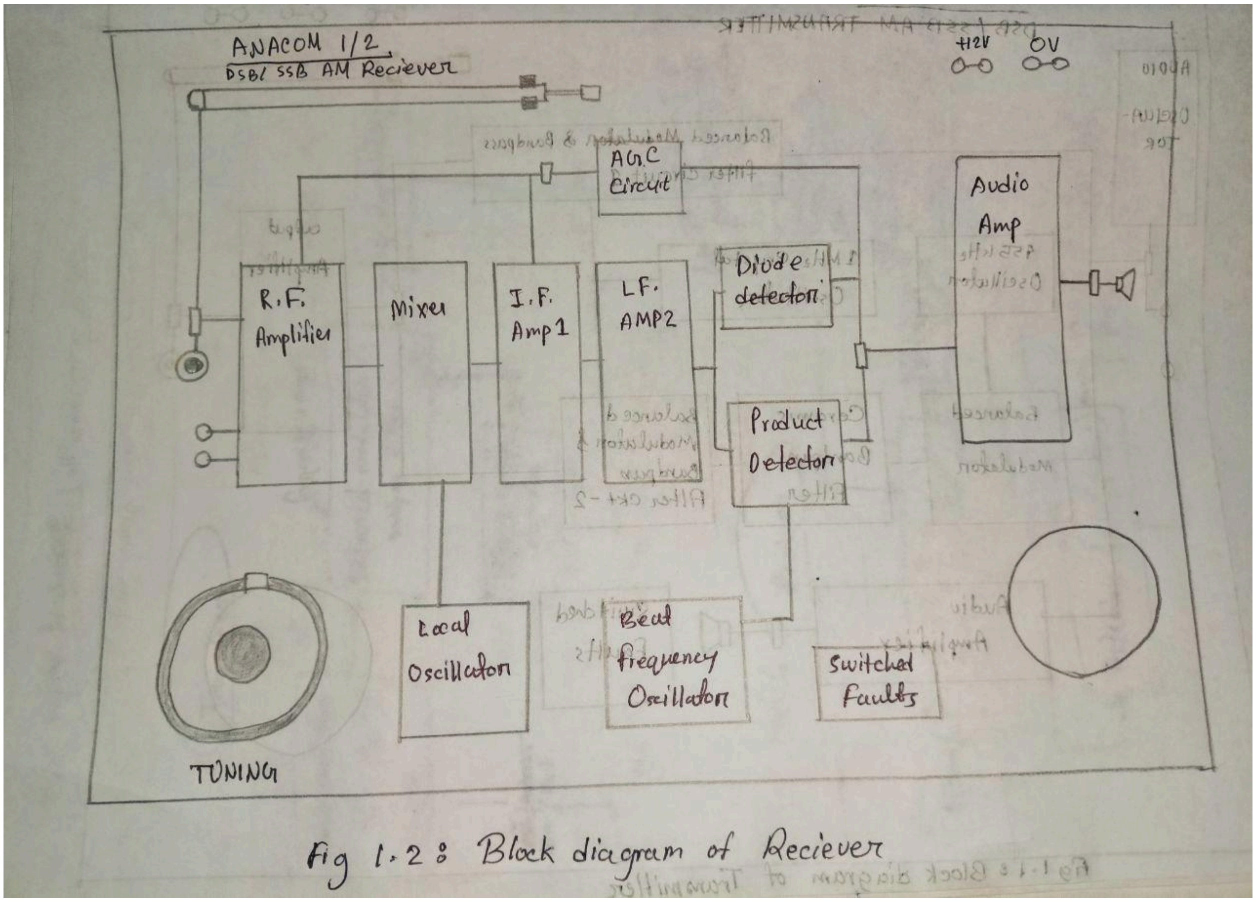


Fig: Block Diagram of Reciever

Answer (2)

Transmitter side blocks:

1. **Audio Oscillator:**
   The purpose of his block is to act as the input of the modulation process. We can also amplify the input signal manually if needed by turning the amplitude knob. There is another knob which can be used to change the modulation index as Full modulation from Overmodulation or Undermodulation. The audio oscillator generates a low-frequency audio signal as the message or modulating signal. This signal contains the information to be transmitted. The source can be internal (oscillator) or external (mic).

2. **Balanced Modulation and Bandpass Filter:**
   Here, the actual modulation takes place. The balanced modulator combines the audio signal with a high-frequency carrier, creating a Double-Side Band (DSB) signal. It can also change the modulation index from 0-100% from Over-modulation or Under-modulation by turning the knob. The bandpass filter ensures that the output only includes the desired sidebands by removing unnecessary components.

3. **1 MHz Crystal Oscillator:**
   This block generates a stable and precise carrier frequency, which is important for the modulation process. Its role is to ensure that the carrier remains consistent throughout the transmission, preventing frequency drift that could distort the signal.

4. **Output Amplifier:**
   This is the final step before transmission. The output amplifier boosts the signal's strength, ensuring that it can travel over long distances without losing quality or becoming too weak to be properly received. It has two options to transmit a signal by circuit wire or antenna.

Receiver side blocks:

1. **RF Amplifier:**
   This block amplifies the weak radio frequency (RF) signal received from the antenna/ wire. This amplifier catches AM range signal: 550-1600kHz. It also improves the signal-to-noise ratio (SNR) by amplifying the desired signal while suppressing unwanted noise from other frequencies.

2. **Mixer:**
   The mixer combines the amplified RF signal(f1) with a local oscillator signal(f2) to convert the high-frequency RF signal to a lower intermediate frequency (IF). The mixer always produces intermediate frequency of f1-f2=455kHz whatever of the station to which the reciever is tuned. The reason to lower the frequency is that it’s troublesome for the device to work at high frequency. This block is used along with an oscillator to work as a Super Heterodyne Receiver.

3. **Local Oscillator:**
   Generates a stable frequency signal that the mixer uses to convert the incoming RF signal into the intermediate frequency. The accuracy and stability of the local oscillator are ensured by properly tuning it so that the mixer can generate a 455kH signal.

4. **Intermediate Frequency (IF) Amplifier-1:**
   This is the first stage of IF amplification, designed to further increase the strength of the converted signal. It also helps in rejecting unwanted frequencies and improving the selectivity of the receiver.

5. **Intermediate Frequency (IF) Amplifier-2:**
   The second IF amplifier provides additional amplification and fine-tuning of the intermediate frequency signal. Together with IF-1, it ensures that the desired signal is isolated and amplified for demodulation.

6. **Automatic Gain Control (AGC) Circuit:**
   The AGC circuit automatically controls the gain of the RF amplifier, IF amplifier-1, and IF amplifier-2 to maintain a steady output signal. It adjusts for changes in the strength of the incoming RF signal, preventing distortion from signals that are too strong and ensuring the output remains clear and stable.

7. **Diode Detector:**
   Extracts the original audio signal (modulating signal) from the amplitude-modulated (AM) carrier wave. It only lets pass the positive half side of the signal. At 455kHz, the selectivity, sensitivity, and quality factor of the detector improve. It is used for signals with less than 100% modulation.

8. **Audio Amplifier**
   This block amplifies the recovered audio signal to a level suitable for driving a speaker or headphones. It then sends the signal to a speaker as an output.

Answer (3)

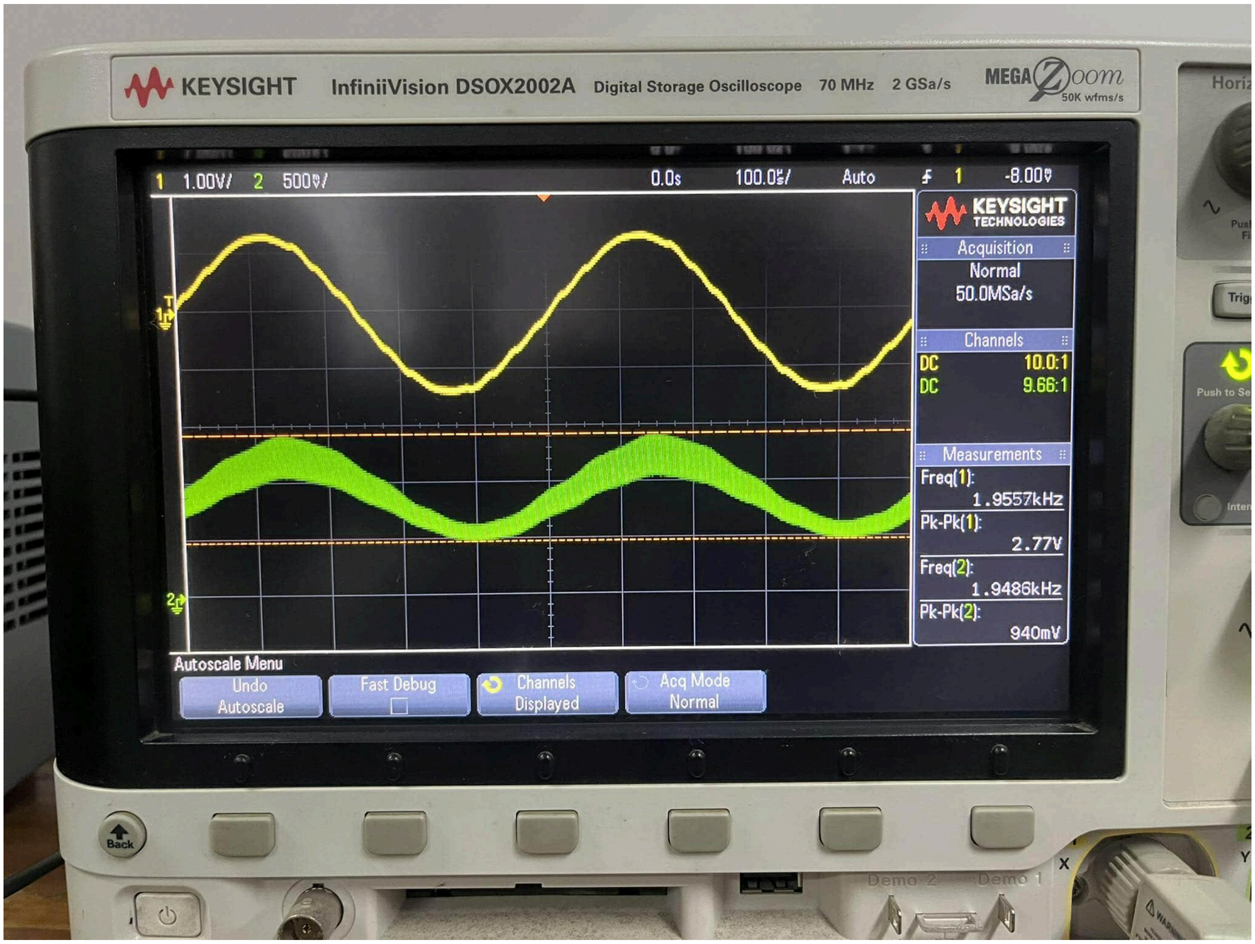


Fig-1: Oscilloscope showing modulated transmitted signal (yellow) and Demodulated Received signal (green). The received message signal seems to be denser due to noise addition during transmission. Both frequency almost matches which means AM is successful.

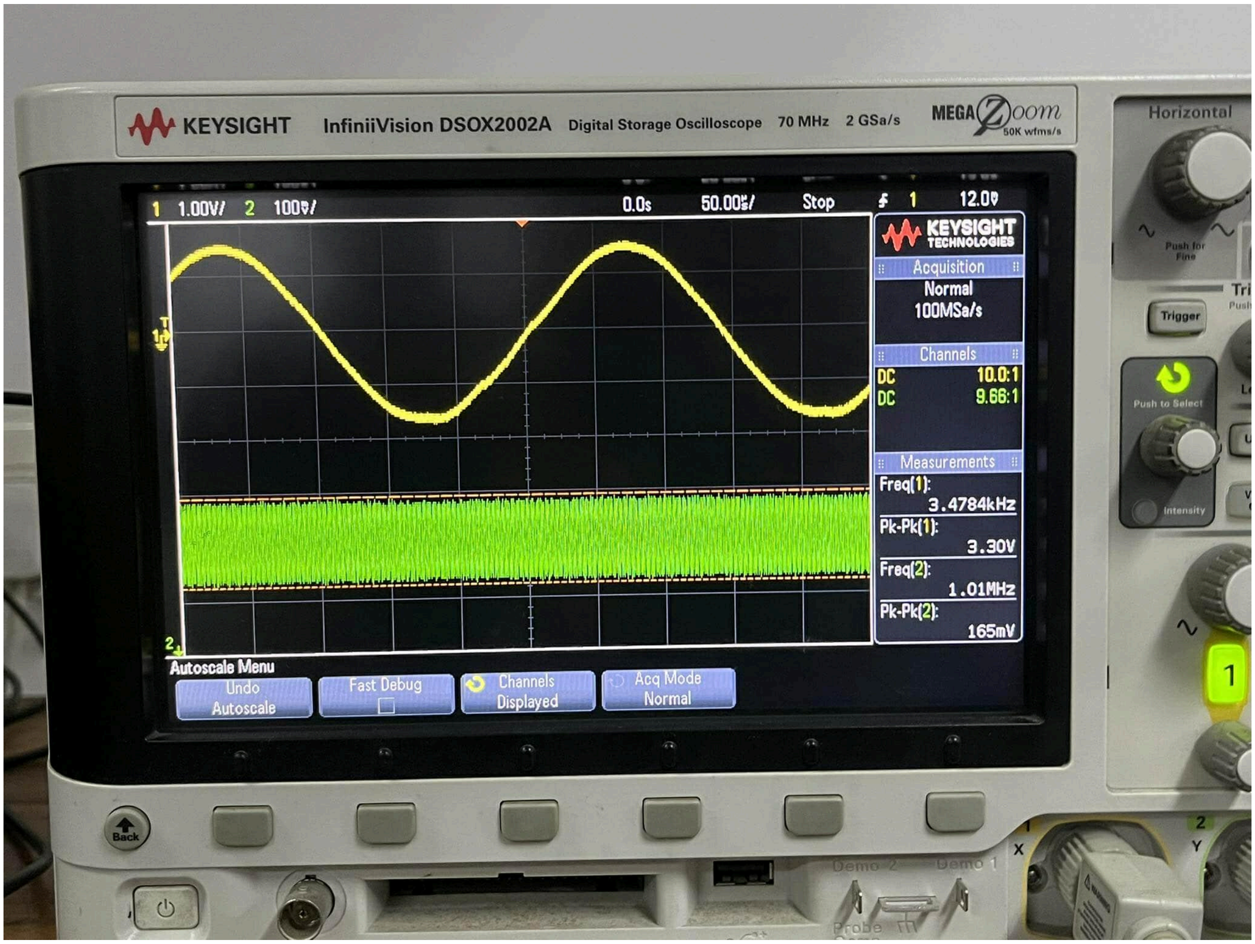


Fig-2: Message signal generated by Audio Oscillator 3.4kHz (yellow) and Carrier Signal generated by Crystal Oscillator 1MHz (Green)

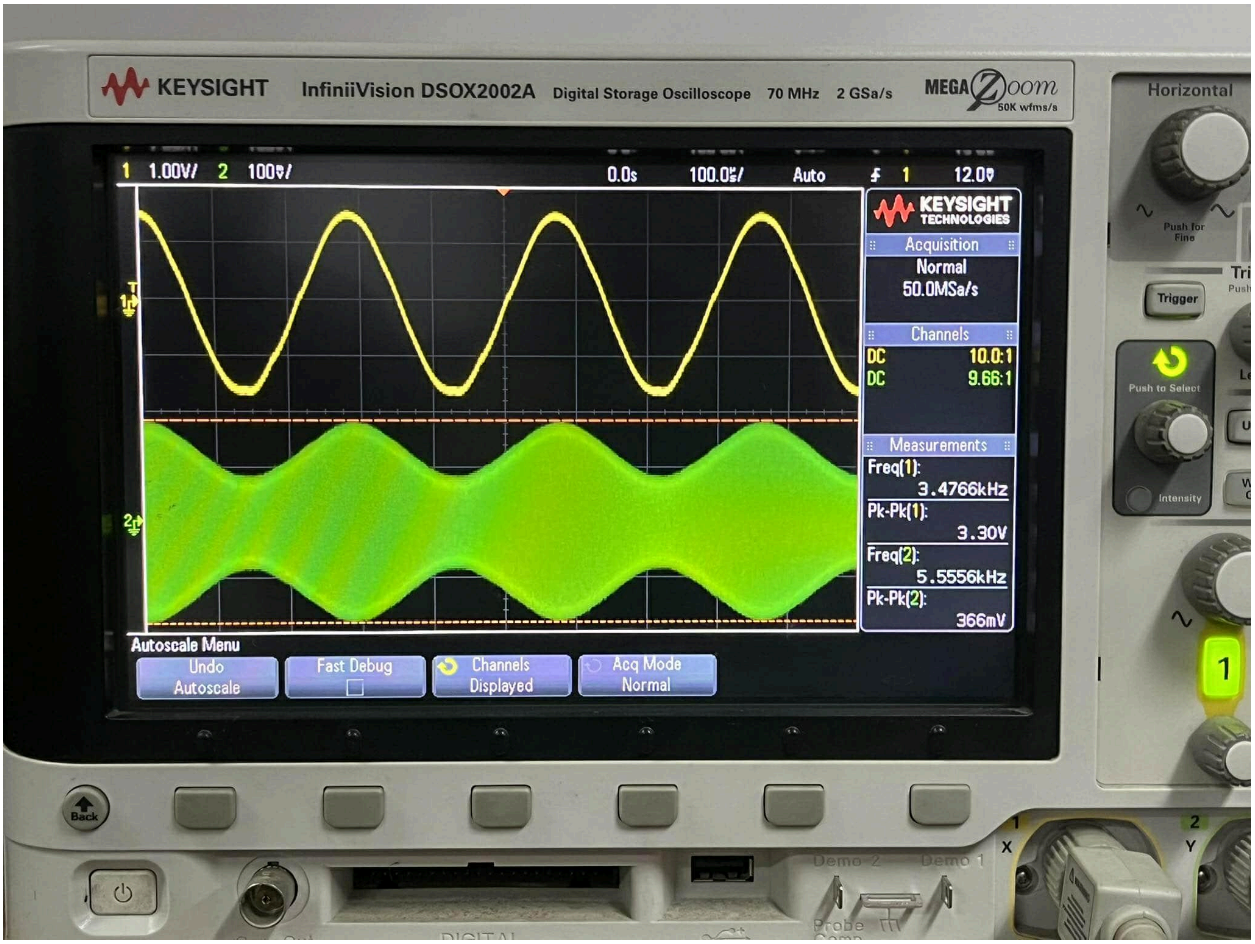


Fig-3: Amplitude Modulated Wave (green). Here Modulation index < 1 which is called Undermodulation

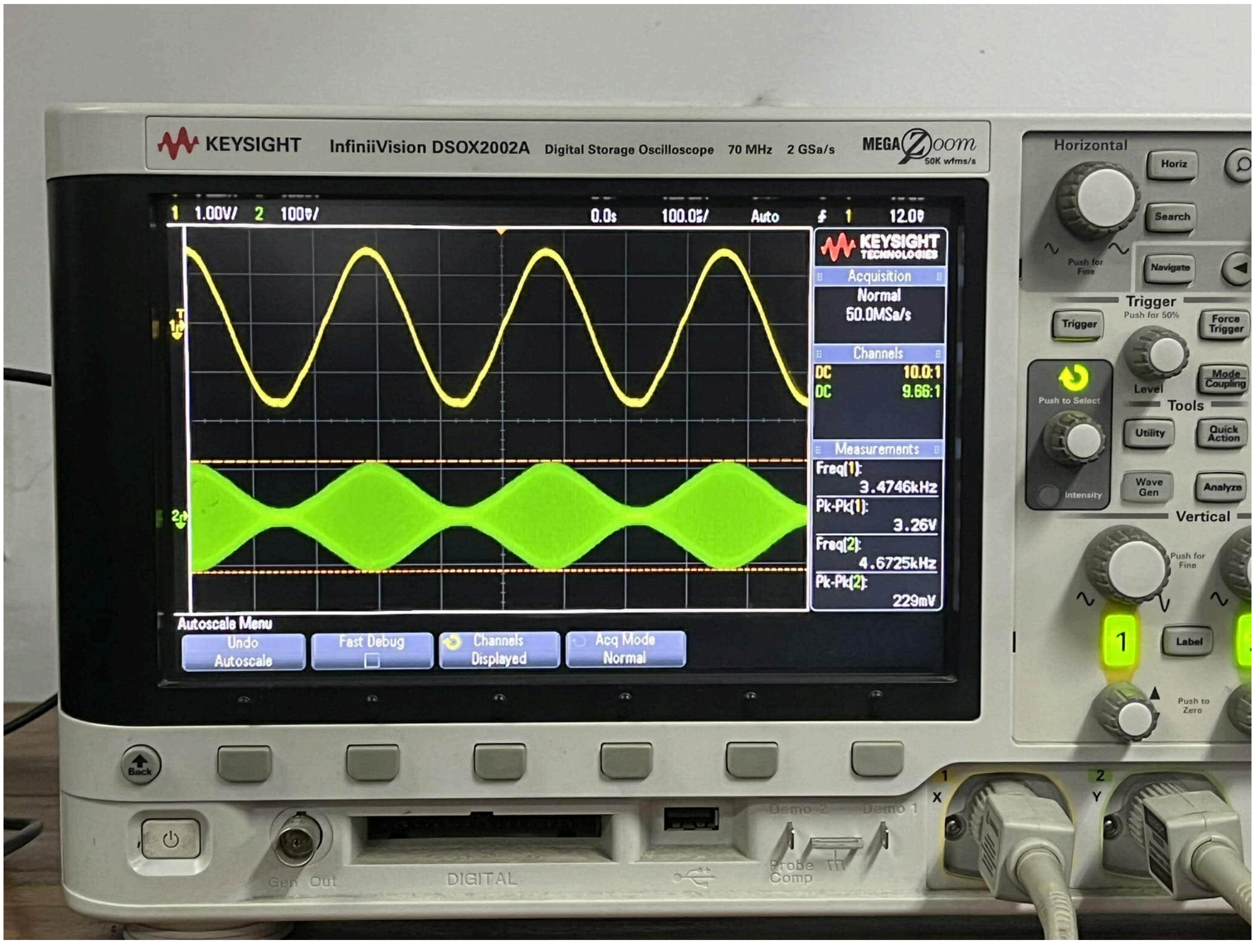


Fig-4: Changing the Modulation Index of AM wave to m=1 by changing the Balance modulation block (green)

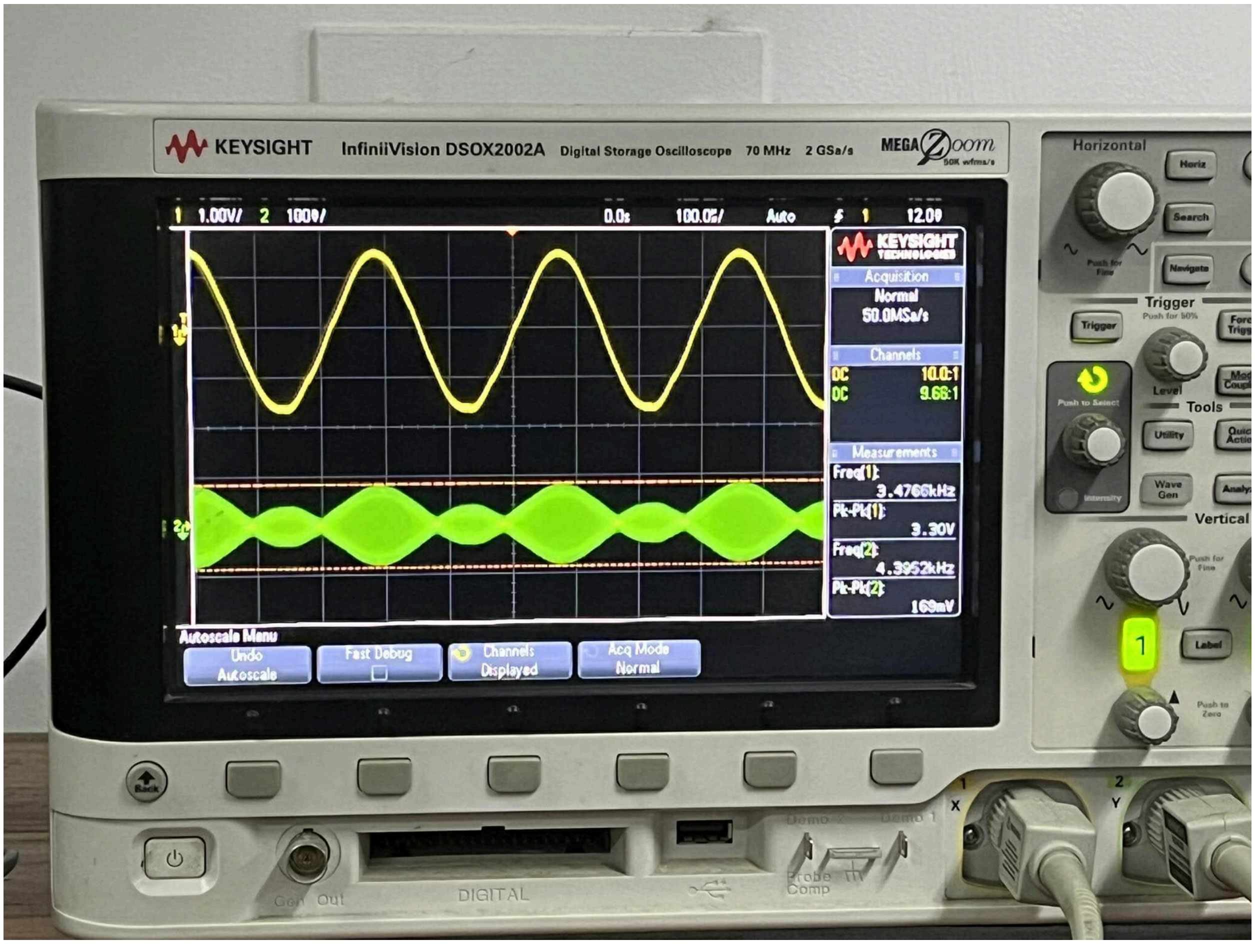


Fig-5: Changing Modulation Index of AM wave to m>1 Overmodulation (green)

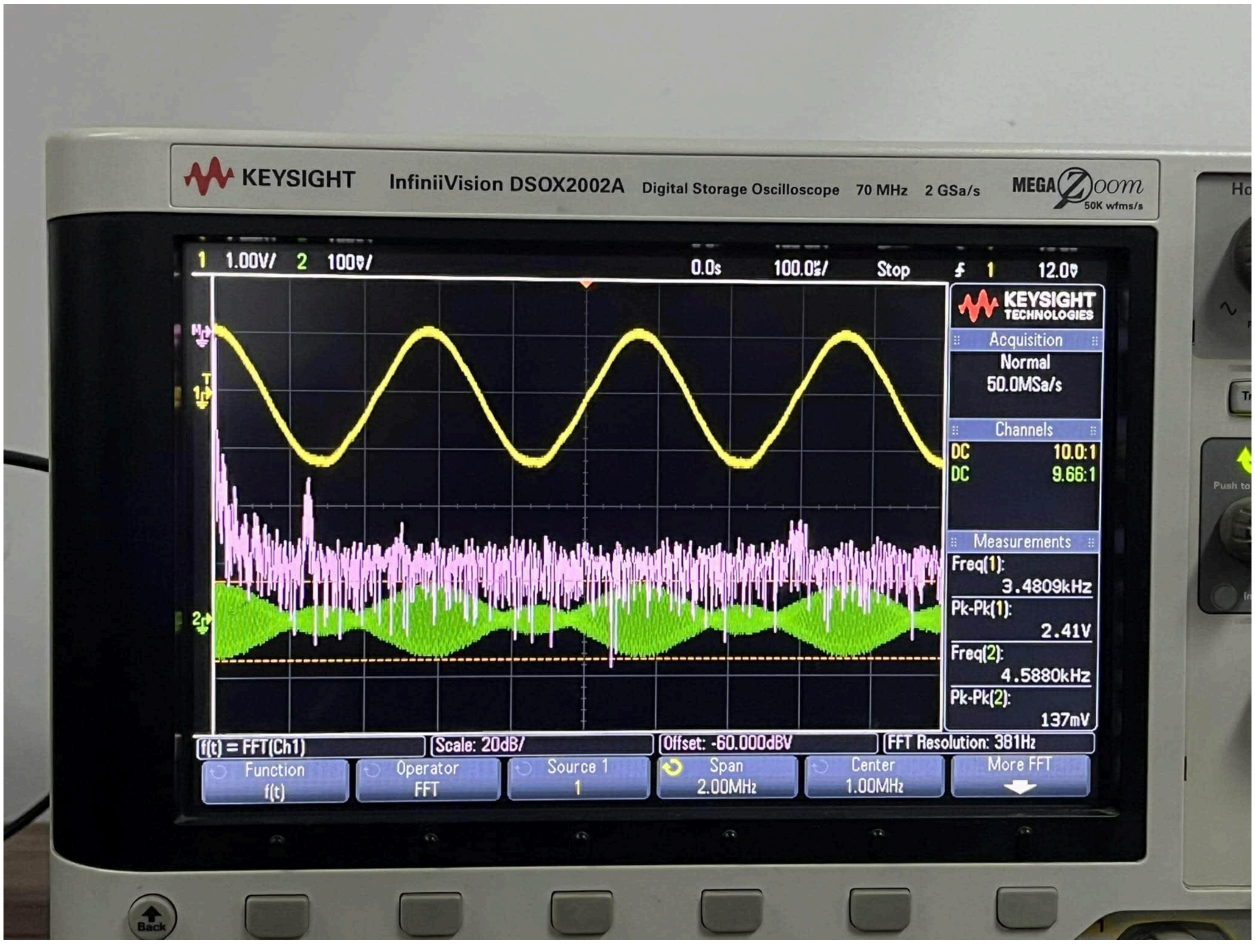


Fig-6: First Fourier transformation of the modulated signal at the positive half side due to the diode detector showing double sideband spikes (violet)

Answer (4)

From Oscilloscope figures 2,

Percentage of modulation:
M = Amplitude of Modulating Signal [Am]/ Amplitude of Carrier Signal [Ac]

= (366mV / 2) / (165mV/2) = 183/ 82.5= 2.2 or 220%

Answer (5)

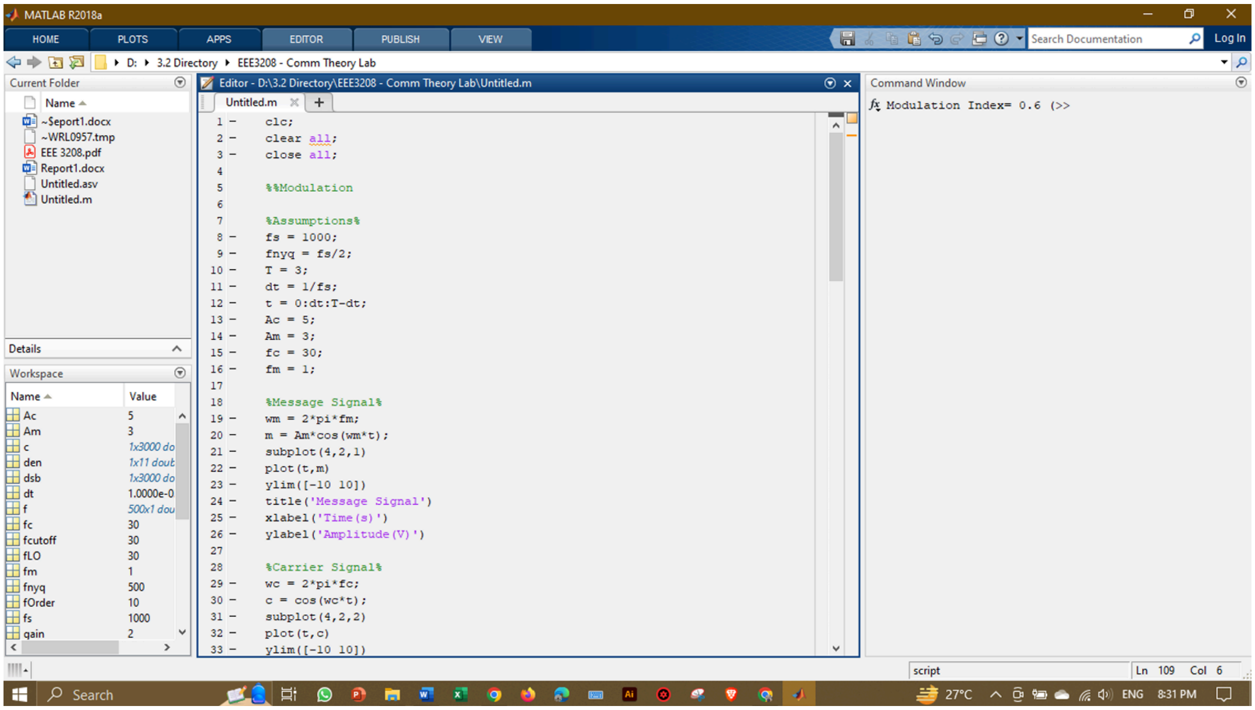
Amplitude Variation:

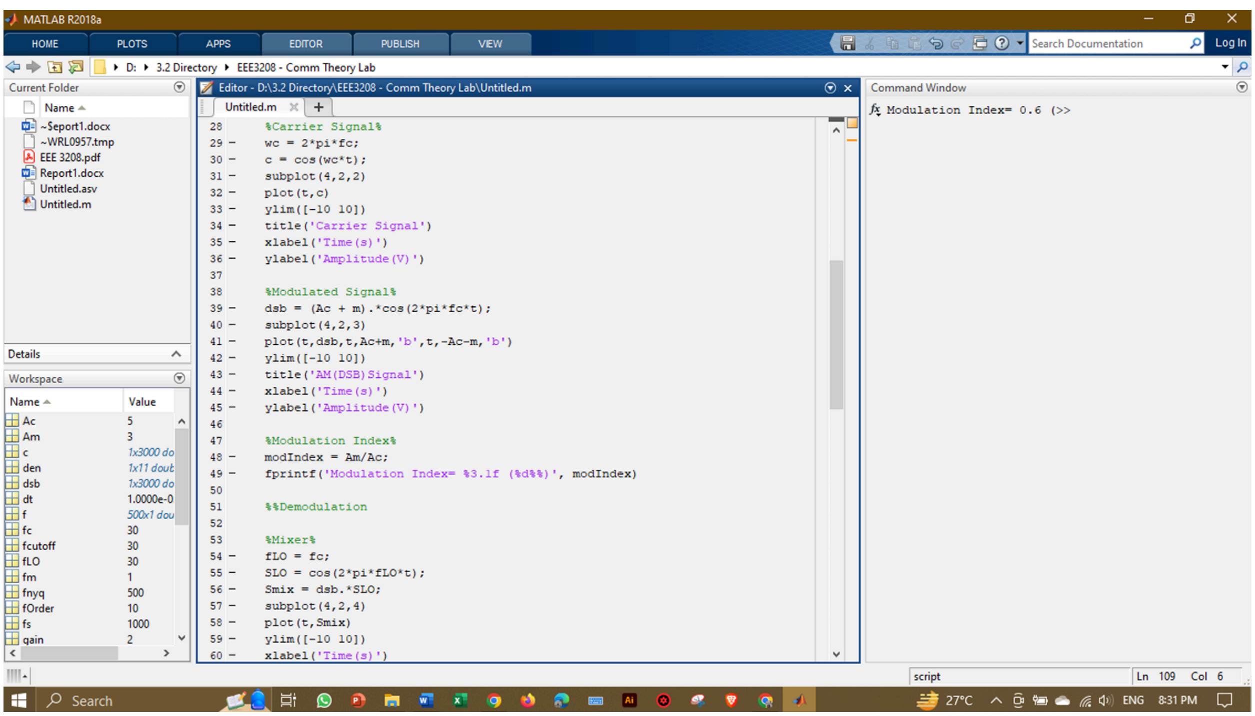
Higher audio amplitude increases the modulation index, but excessive values can cause overmodulation and distortion.
Lower audio amplitude leads to undermodulation, reducing efficiency.

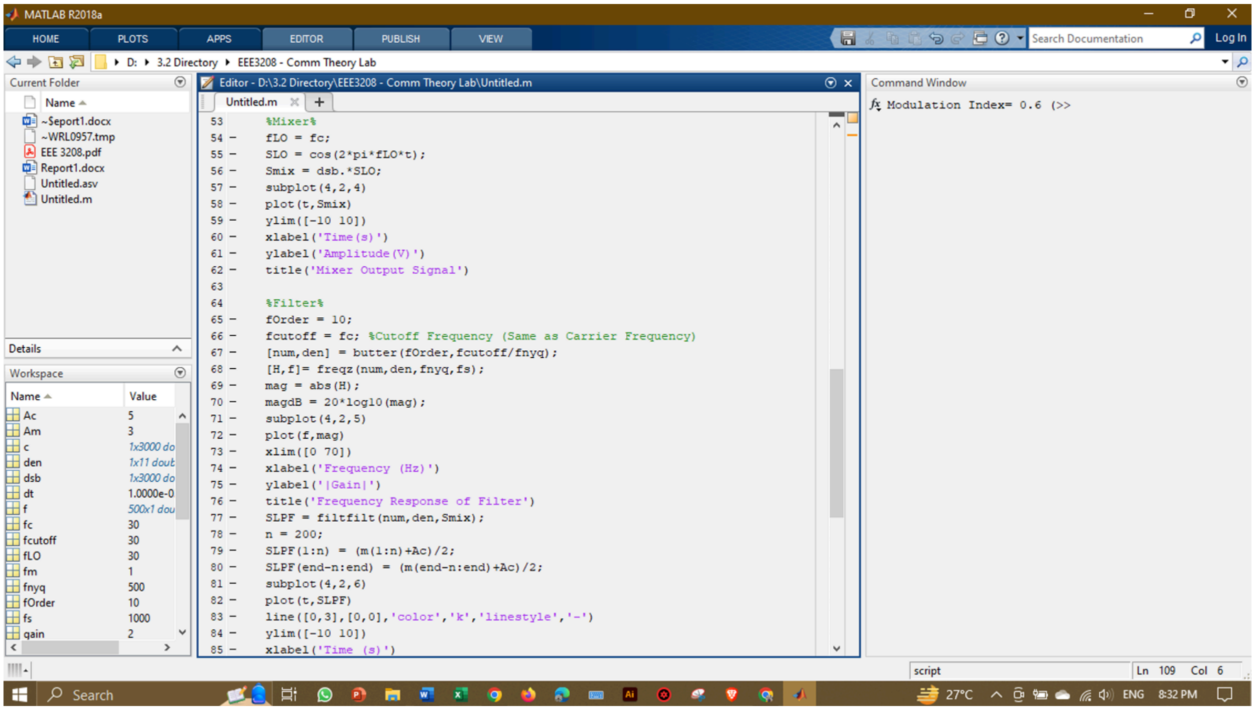
Frequency Variation:

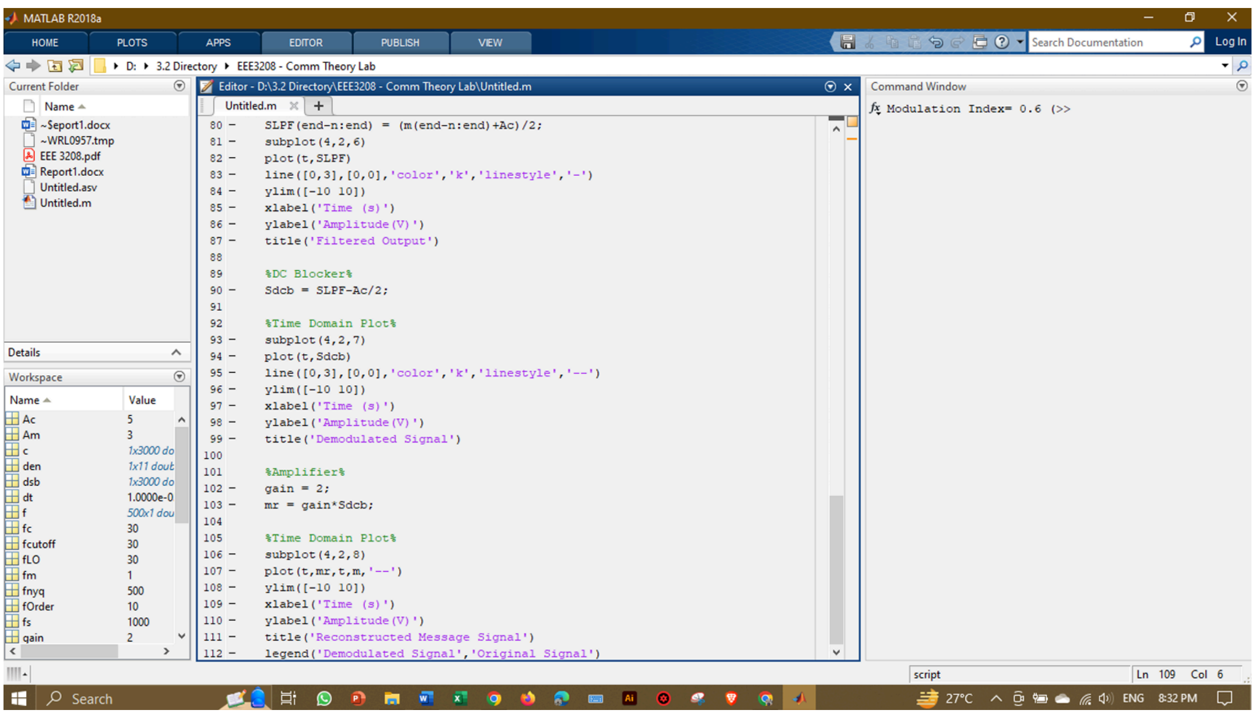
The DSB signal's bandwidth is increased by higher audio frequencies, which can enhance detail but may also exceed system capacity.
The bandwidth is reduced by lower audio frequencies, which lessens the likelihood of interference but may also degrade the quality of high-frequency content.

Answer (6)


MATLAB R2018a
HOME PLOTS APPS EDITOR PUBLISH VIEW
D: ▸ 3.2 Directory ▸ EEE3208 - Comm Theory Lab
Editor - D:\3.2 Directory\EEE3208 - Comm Theory Lab\Untitled.m
clc;
clear all;
close all;
%%Modulation
%Assumptions%
fs = 1000;
fnyq = fs/2;
T = 3;
dt = 1/fs;
t = 0:dt:T-dt;
Ac = 5;
Am = 3;
fc = 30;
fm = 1;
%Message Signal%
wm = 2*pi*fm;
m = Am*cos(wm*t);
subplot(4,2,1)
plot(t,m)
ylim([-10 10])
title('Message Signal')
xlabel('Time(s)')
ylabel('Amplitude(V)')
%Carrier Signal%
wc = 2*pi*fc;
c = cos(wc*t);
subplot(4,2,2)
plot(t,c)
ylim([-10 10])
Command Window
Modulation Index= 0.6 (>>


MATLAB R2018a
Editor - D:\3.2 Directory\EEE3208 - Comm Theory Lab\Untitled.m
%Carrier Signal%
wc = 2*pi*fc;
c = cos(wc*t);
subplot(4,2,2)
plot(t,c)
ylim([-10 10])
title('Carrier Signal')
xlabel('Time(s)')
ylabel('Amplitude(V)')
%Modulated Signal%
dsb = (Ac + m).*cos(2*pi*fc*t);
subplot(4,2,3)
plot(t,dsb,t,Ac+m,'b',t,-Ac-m,'b')
ylim([-10 10])
title('AM(DSB)Signal')
xlabel('Time(s)')
ylabel('Amplitude(V)')
%Modulation Index%
modIndex = Am/Ac;
fprintf('Modulation Index= %3.1f (%d%%)', modIndex)
%%Demodulation
%Mixer%
fLO = fc;
SLO = cos(2*pi*fLO*t);
Smix = dsb.*SLO;
subplot(4,2,4)
plot(t,Smix)
ylim([-10 10])
xlabel('Time(s)')
Command Window
Modulation Index= 0.6 (>>


MATLAB R2018a
Editor - D:\3.2 Directory\EEE3208 - Comm Theory Lab\Untitled.m
%Mixer%
fLO = fc;
SLO = cos(2*pi*fLO*t);
Smix = dsb.*SLO;
subplot(4,2,4)
plot(t,Smix)
ylim([-10 10])
xlabel('Time(s)')
ylabel('Amplitude(V)')
title('Mixer Output Signal')
%Filter%
fOrder = 10;
fcutoff = fc; %Cutoff Frequency (Same as Carrier Frequency)
[num,den] = butter(fOrder,fcutoff/fnyq);
[H,f]= freqz(num,den,fnyq,fs);
mag = abs(H);
magdB = 20*log10(mag);
subplot(4,2,5)
plot(f,mag)
xlim([0 70])
xlabel('Frequency (Hz)')
ylabel('|Gain|')
title('Frequency Response of Filter')
SLPF = filtfilt(num,den,Smix);
n = 200;
SLPF(1:n) = (m(1:n)+Ac)/2;
SLPF(end-n:end) = (m(end-n:end)+Ac)/2;
subplot(4,2,6)
plot(t,SLPF)
line([0,3],[0,0],'color','k','linestyle','-')
ylim([-10 10])
xlabel('Time (s)')
Command Window
Modulation Index= 0.6 (>>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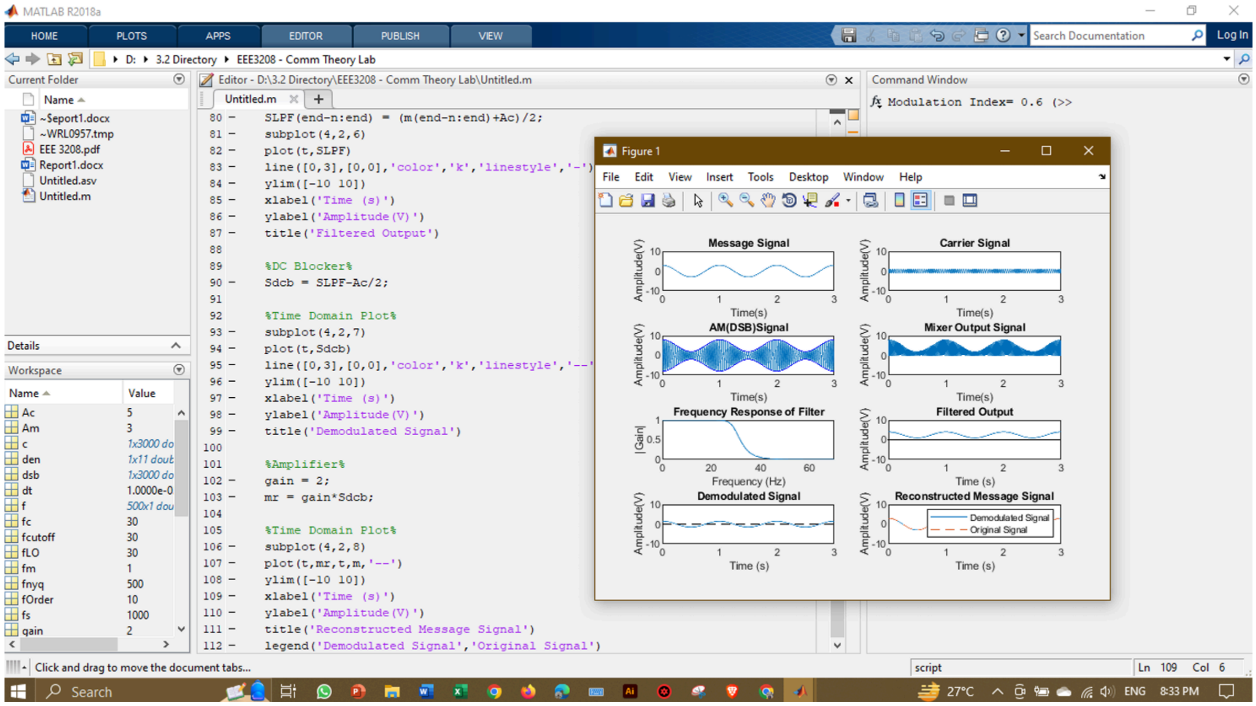
SLPF(end-n:end) = (m(end-n:end)+Ac)/2;
subplot(4,2,6)
plot(t,SLPF)
line([0,3],[0,0],'color','k','linestyle','-')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Filtered Output')
%DC Blocker%
Sdcb = SLPF-Ac/2;
%Time Domain Plot%
subplot(4,2,7)
plot(t,Sdcb)
line([0,3],[0,0],'color','k','linestyle','--')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Demodulated Signal')
%Amplifier%
gain = 2;
mr = gain*Sdcb;
%Time Domain Plot%
subplot(4,2,8)
plot(t,mr,t,m,'--')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Reconstructed Message Signal')
legend('Demodulated Signal','Original Signal')
Command Window
Modulation Index= 0.6 (>>


MATLAB R2018a
Editor - D:\3.2 Directory\EEE3208 - Comm Theory Lab\Untitled.m
SLPF(end-n:end) = (m(end-n:end)+Ac)/2;
subplot(4,2,6)
plot(t,SLPF)
line([0,3],[0,0],'color','k','linestyle','-')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Filtered Output')
%DC Blocker%
Sdcb = SLPF-Ac/2;
%Time Domain Plot%
subplot(4,2,7)
plot(t,Sdcb)
line([0,3],[0,0],'color','k','linestyle','--')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Demodulated Signal')
%Amplifier%
gain = 2;
mr = gain*Sdcb;
%Time Domain Plot%
subplot(4,2,8)
plot(t,mr,t,m,'--')
ylim([-10 10])
xlabel('Time (s)')
ylabel('Amplitude(V)')
title('Reconstructed Message Signal')
legend('Demodulated Signal','Original Signal')
Command Window
Modulation Index= 0.6
Figure 1
Message Signal
Carrier Signal
AM(DSB)Signal
Mixer Output Signal
Frequency Response of Filter
Filtered Output
Demodulated Signal
Reconstructed Message Signal

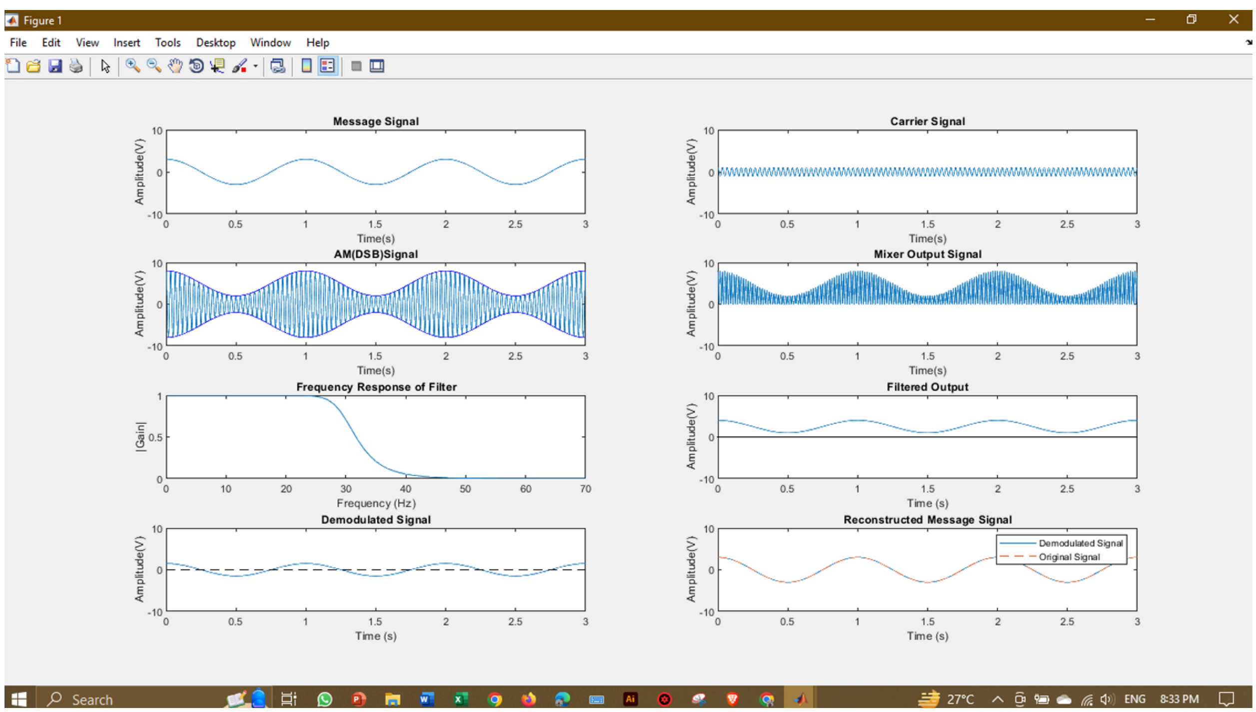


Figure 1
Message Signal
Carrier Signal
AM(DSB)Signal
Mixer Output Signal
Frequency Response of Filter
Filtered Output
Demodulated Signal
Reconstructed Message Signal
Demodulated Signal
Original Signal
Time(s)
Time (s)
Amplitude(V)
Frequency (Hz)
|Gain|

Discussion:

This experiment uses a double sideband to study and analyze amplitude modulation. A very important method for wireless long-distance communication is amplitude modulation. We generated a message signal (3.47kHz, 1.1V) from the audio oscillator and modulated it with the carrier signal generated from the Crystal oscillator (1MHz, 0.825V). We received a similar 3.45kHz signal on the receiver side which means AM is successful. There were 3 types of modulation based on the modulation index. m=1 full modulation, m<1 undermodulation , m>1 overmodulation. These indexes can be changed by both Balance modulator or the Audio oscillator Amplitude knob. There are 3 types of carriers and we used DSB-TC which shows carrier signal and sidebands in First Fourier transform on the oscillator. We used Super Heterodyne Reciever system instead of Straight radio receiver because the Straight radio receiver has a problem selecting Sation which generates unnecessary noise. Super Heterodyne Reciever mixes message signal and oscillator signal and makes sure the output is 455kHz. Between fc-fs and fc+fs we use fc-fs because it’s convenient for the machine to work on lower frequencies. Also at 455kHz, it improves the selectivity, sensitivity, and quality factor of the detector. Product detector is better than Diode detector because the Diode detector neglects the negative side of the signal but the Product detector lets both the +ve and -ve sides of the signal.