EEE 3208

Communication Theory Lab

Experiment No: 03

Experiment Name: Study of Frequency Modulation

Submitted by,

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Section: C2

Objective:

The goal is to understand the basic ideas of Frequency Modulation (FM) and why it is important. It also includes learning how FM transmission and reception work and trying out modulation and demodulation methods.

Answer (1)

Microphone: The microphon captures sound (voice or music at 20Hz-20kHz) and changes it into electrical signal, which will be used for modulation.

AF Amplifier: The audio frequency amplifir amplifies the audio signal (20-20kHz) strength of signal coming from the microphone so that it is strong enough to control the modulation process.

DC Blocking Capacitor (C3): This capacitor blocks any unwanted DC component in the audio signal, allowing only the AC (audio signal) to pass through. We know $Xc=1/2\pi FC=1/0=\text{infinity}$ capacitance means the capacitor becomes open when DC wants to pass through it.

Radio Frequency Choke: RFC prevents the high frequency carrier signal from interfering with the modulating circuit's low frequency message signal. It ensures the carrier and the message signal remain in their respective paths without mixing in the wrong place. It works as $X_L=2\pi fL$

Voltage Divider: Varactor diode needs to be in reverse bias to work as variable capacitor. R1 and R2 voltage divider creates a stable voltage for biasing the varactor diode, in this way the Varactor diode remains always in reverse bias.

Varactor Diode (D1): The varactor diode is a mix of both capacitor and diode. We know C=εA/d where d= depletion layer. When the more the diode is in reverse bias, the more it's Capacitance increases due to dielectric properties and charge holding capacitance. It's capacitance changes depending on the voltage applied to it. This works as C2 capacitor with becomes C1+C2 with another capacitor C1. It helps to create a resonance frequency with inductor L. here F=1/2π$\sqrt{L(C1\ +\ C2)}$ when capacitance increases, frequency decreases. These variations in capacitance help to adjust the frequency of the carrier signal.

Capacitor (C2): The capacitor used here in series with the varactor diode works to prevent the message signal from directly mixing with the carrier. Its value is chosen big enough to make its reactance negligible. so, it is effectively behaving as if the varactor diode is directly connected with the tuned circuit.

Carrier Oscillator :
It generates high frequency carrier signal. It's frequency can be controlled by varactor diode as per intensity of the message signal.

Phase Detector:
The phase detector is the main element of FM demodulation.
It compares the phase of the incoming FM signal with a reference signal generated by the VCO (Voltage-Controlled Oscillator).

The difference in phase produces a voltage signal that replicates the frequency variations in the FM signal, thereby permitting recovery of the modulated information.

Voltage-Controlled Oscillator (VCO):
The VCO generates a signal whose frequency is directly controlled by the input voltage coming from the phase detector.
It continuously adjusts its frequency to maintain synchronization with the incoming FM signal. This synchronization is necessary in order to extract the original information accurately.

Low-Pass Filter (LPF):
The LPF removes high-frequency components and noise from the output of the phase detector.
It allows only the useful audio or modulating signal to go through for further processing.
This block is very crucial in providing a clean signal by removing unwanted frequencies.

Output Block:
That's where the final demodulated signal goes.
After filtering, the signal is a faithful reproduction of the original modulating signal, such as audio or data, and is ready for amplification or further processing as needed.

Answer (2)

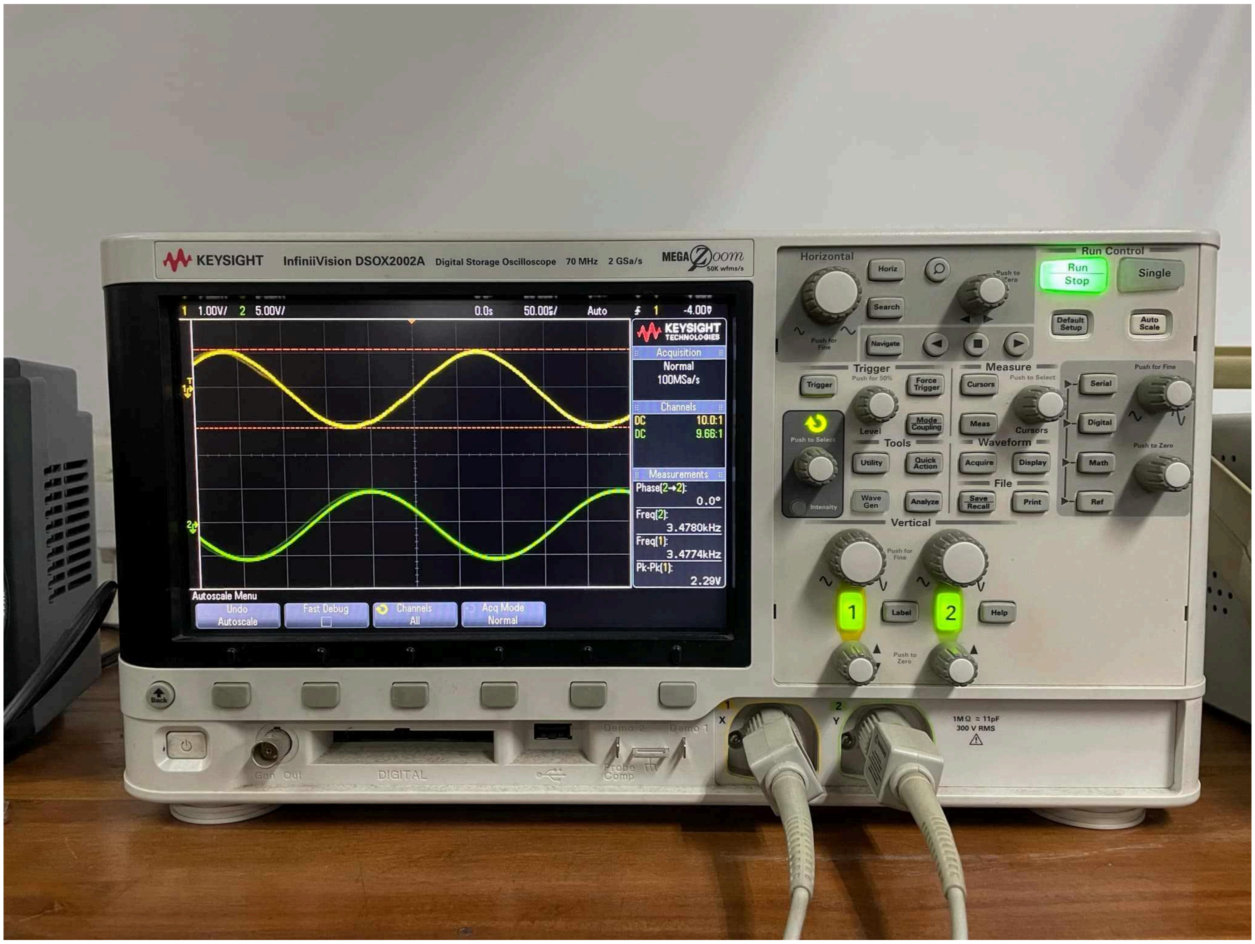


Fig-(1): Input Message signal (yellow) and Modulated Received Signal (Green)

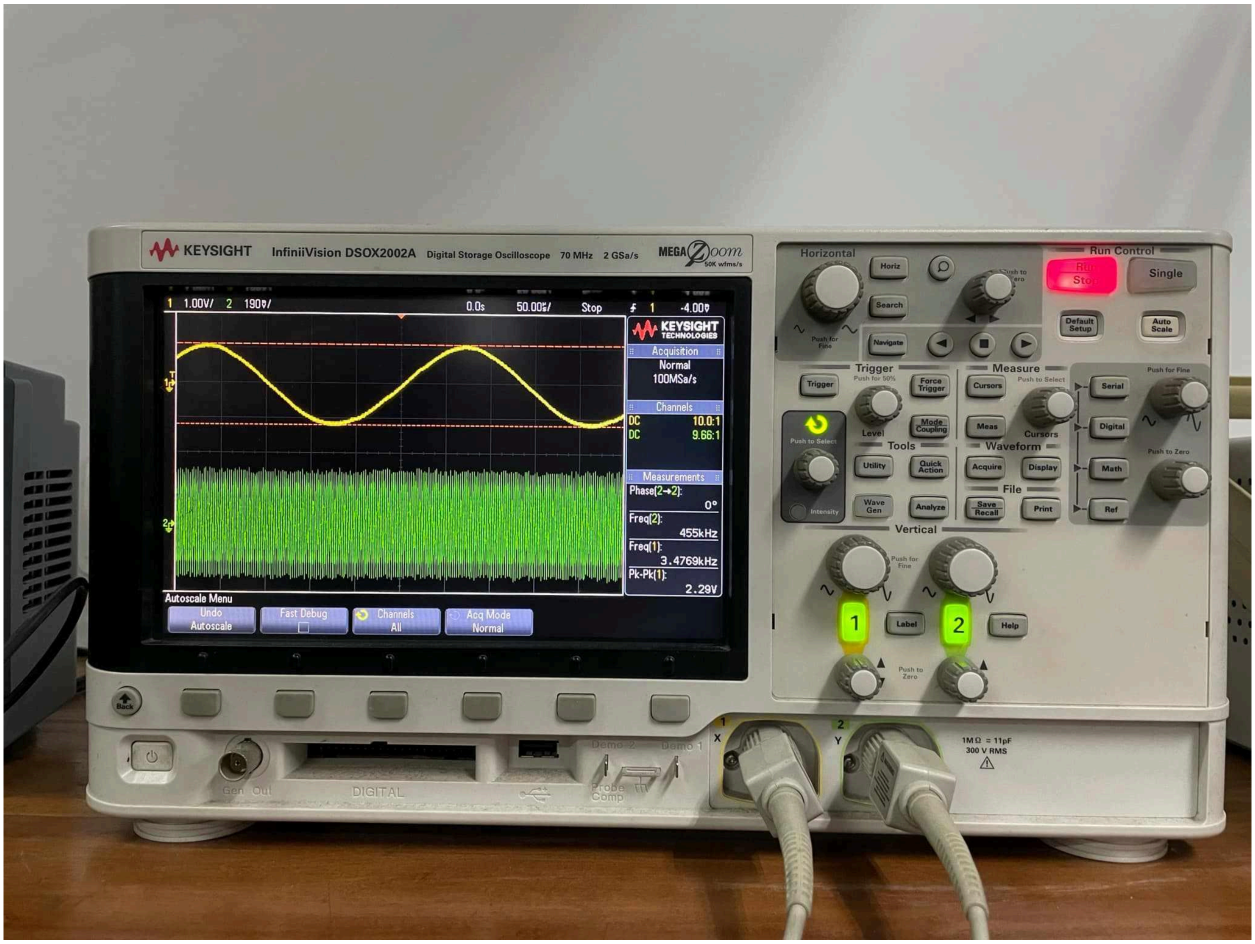


Fig-(1): Input Message signal (yellow) and Frequency Modulated Signal (Green)

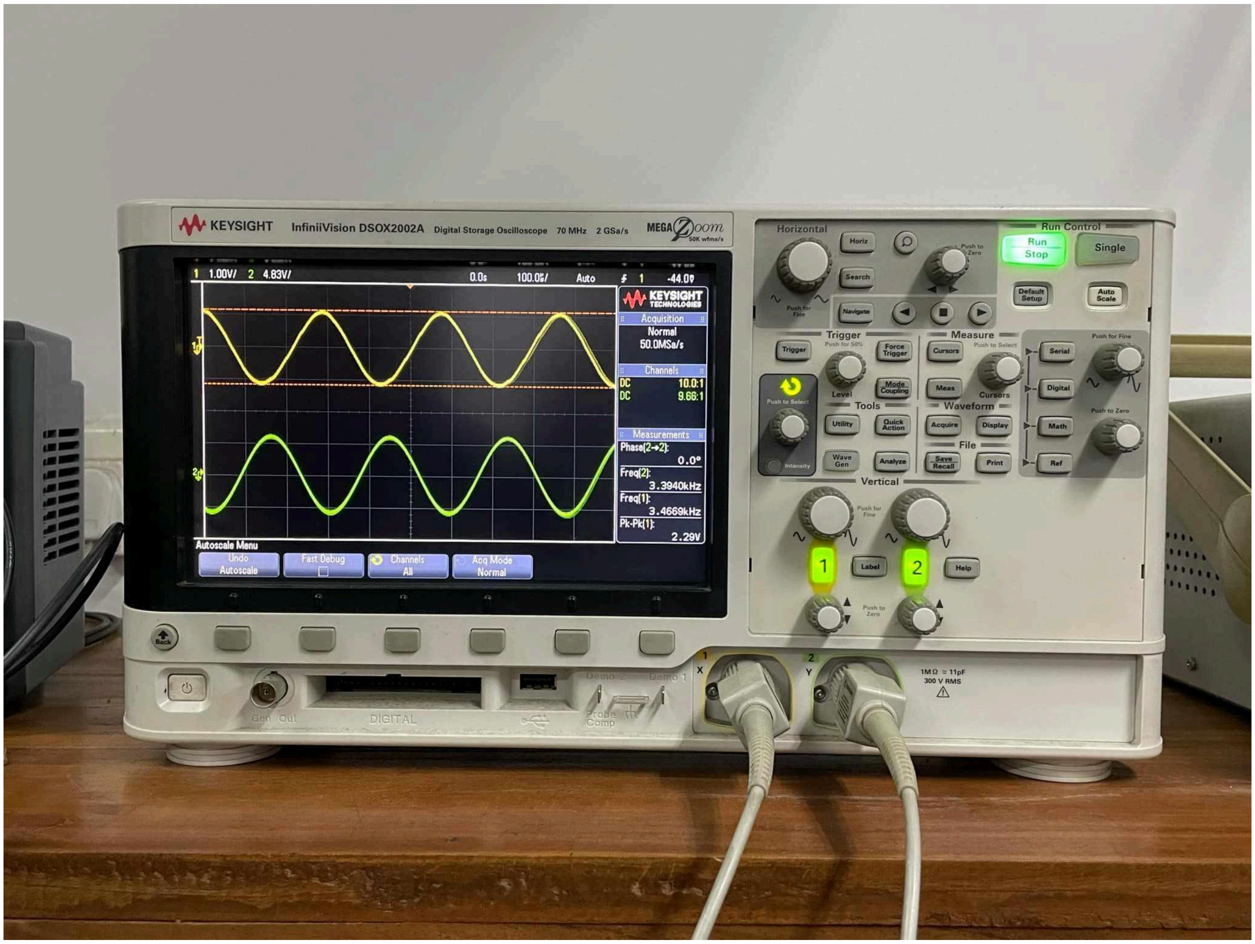


Fig-(1): Input Message signal (yellow) and Output Signal (Green)

Answer (3a)

AM (Amplitude Modulation)

- The amplitude of the carrier wave is varied based on the modulating signal.
- Narrower bandwidth (about twice the highest modulating frequency).
- More sensitive to noise as noise affects amplitude.
- Lower quality due to noise interference.
- Less efficient; more power is consumed in transmitting signals.
- Used in AM radio broadcasting and aviation communication.

FM (Frequency Modulation)

- The frequency of the carrier wave is varied based on the modulating signal.
- Wider bandwidth (up to 10 times the modulating frequency).
- Less affected by noise since noise doesn’t change frequency significantly.
- Higher quality sound with better noise immunity.
- More efficient; better use of power for transmitting information.
- Common in FM radio broadcasting, TV sound transmission, and high-fidelity audio systems.

Answer (3b)

1. **Radio Broadcasting: FM is utilized in the broadcasting of music and high-sounding speech because of its nature of resisting noise and giving good quality sound.**
2. **Two-way radio communication: Applied in walkie-talkies, police radios, and every other system wherein clear audio is required.**
3. **Television Audio Transmission: FM is utilized in the audio part of television transmission.**
4. **Satellite Communication: FM is used in certain satellite systems due to its ability to carry high-fidelity signals.**
5. **Mobile Communication: FM is used in a number of older analog systems in cellular networks for voice transmission.**

Answer (3c)

When the modulating signal frequency is increased:

The rate of change of the carrier frequency will also increase. Within the same time, the carrier wave will undergo more frequent changes in frequency. This leads to an increased rate of frequency deviation, though the magnitude of deviation remains the same.

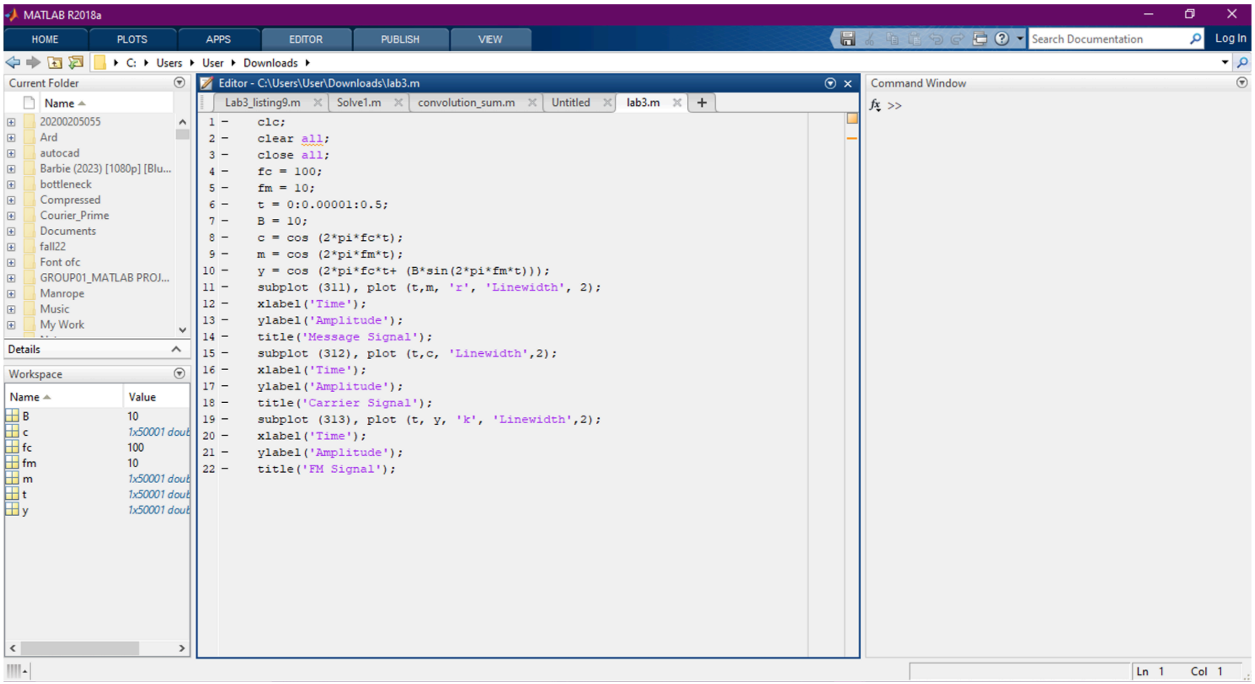
When the frequency reduces: The carrier wave changes its frequency at a lesser speed, hence a smaller deviation rate.

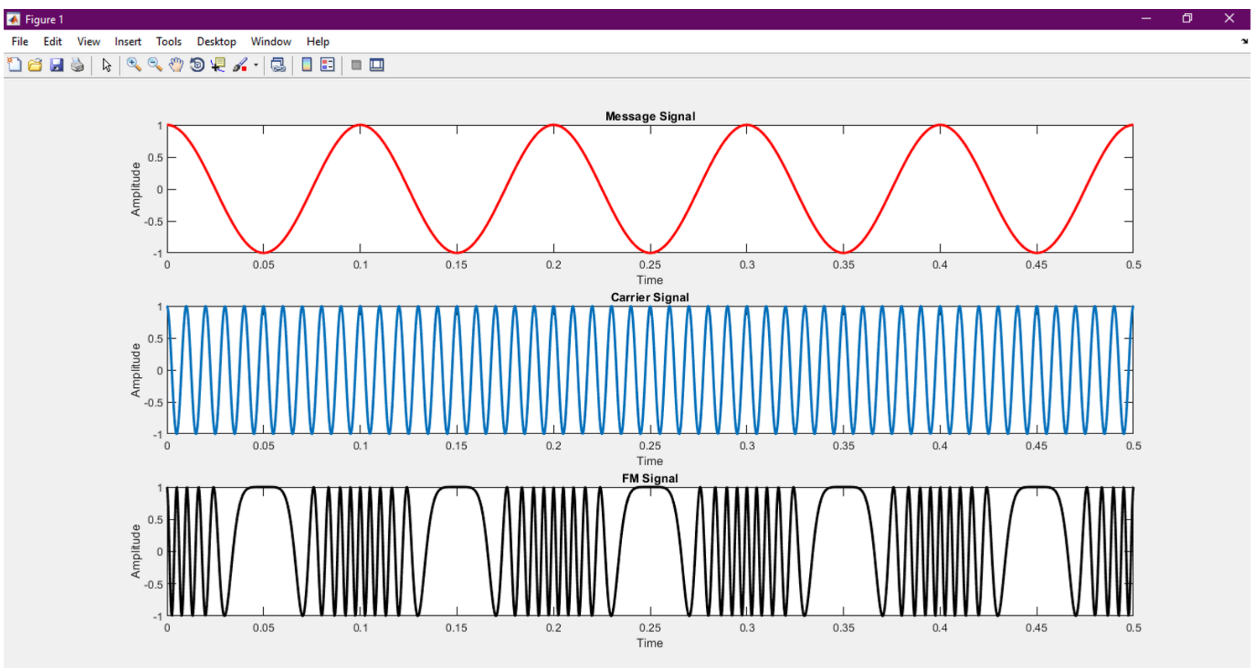
Answer (3d)

When the amplitude of the modulating signal is increased:
It increases the frequency deviation of the carrier wave. In this case, the frequency of the carrier shifts further from its unmodulated value because frequency deviation is directly proportional to the amplitude of the modulating signal.
When the amplitude reduces:
The frequency deviation decreases and the frequency of the carrier wave changes less from the original frequency.
Changes in the amplitude of the modulating signal have no effect on the amplitude of the FM wave since FM depends only on frequency variation for encoding information.

Answer (4)

Matlab codes for FM:





DISCUSSION:

In Frequency modulation, we modulated the message signal with carrier signal's variable frequency with respect to the intensity of message signal. FM is better than AM in terms of power, bandwidth, and noise elimination. We can easily cut the noise from frequency rather than amplitude. We used Varactor modulator in this lab for frequency modulation. Varactor modulator works as a variable capacitor by powering a diode in reverse bias. This variable capacitance helps the frequency to be able to change with respect to input signal's strength. The more the strength, the more voltage is gets in reverse bias which decreases the capacitance and increases frequency and vice-versa. In demodulattor, VCO balances the frequency to get back into original message signal in phase lock loop.