# The Hashemite University

# Faculty of Engineering

# Department of Electrical Engineering

## Experiment Number ( 4 )

## “FM Modulation and Demodulation”

| Name | Student’s No. |
|---|---|
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## Objectives:

- ✓ Learn the main characteristics of an FM transmission system.
- ✓ Understand the operation of a Varactor Modulator.
- ✓ Understand the operation of a Reactance Modulator.
- ✓ Understand the principles of FM demodulation.

## Equipment:

- ✓ Trace oscilloscope-Dual.
- ✓ DC Power Supply.
- ✓ ANACOMM 2 Board.
- ✓ Function Generator.
- ✓ DMM.

## Theory:

### Definition of FM:

Frequency modulation (FM) is a technique or a process of encoding information on a particular signal by varying the carrier wave frequency in accordance with the frequency of the modulating signal, and in the case of FM, the amplitude of the modulated signal is kept, or it remains constant.

### Modulation:

Frequency modulation uses the information signal, $V_m(t)$ to vary the carrier frequency within some small range about its original value.
Here are the three signals in mathematical form:

Information: $V_m(t)$
Carrier: $V_c(t) = V_{co} \sin(2\pi f_c\, t + \phi)$
FM: $V_{FM}(t) = V_{co} \sin(2\pi\, [f_c + (\Delta f / V_{mo})\, V_m(t)]\, t + \phi)$

We have replaced the carrier frequency term, with a time-varying frequency. We have also introduced a new term: $\Delta f$, *the peak frequency deviation*. In this form, you should be able to see that the carrier frequency term: $f_c + (\Delta f/V_{mo})\ V_m\ (t)$ now varies between the extremes of $f_c - \Delta f$ and $f_c + \Delta f$. The interpretation of $\Delta f$ becomes clear: it is the farthest away from the original frequency that the FM signal can be. Sometimes it is referred to as the "swing" in the frequency.

We can also define a modulation index for FM, analogous to AM:

$$\beta = \Delta f/f_m ,$$

Where $f_m$ is the maximum modulating frequency used.

The simplest interpretation of the modulation index, $\beta$, is as a measure of the peak frequency deviation, $\Delta f$. In other words, $\beta$ represents a way to express the peak deviation frequency as a multiple of the maximum modulating frequency, $f_m$, i.e., $\Delta f = \beta\ f_m$

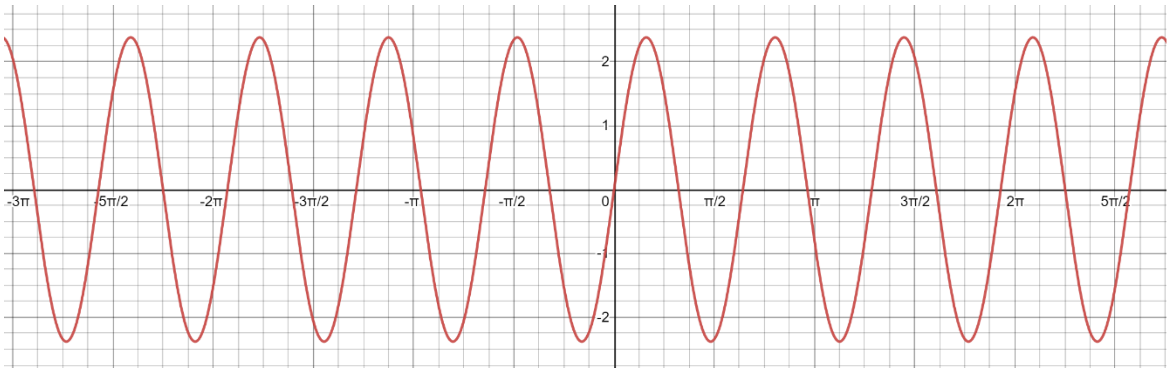
## Demodulation:

When there is modulation, usually we need to successfully demodulate it and at the same time recover the original signal. In such cases, FM demodulator also known as FM discriminator or FM detector is used. While there are several types of FM demodulator, the main functionality of these devices is to convert the frequency variations of the input signal into amplitude variations of the output signal. The demodulators are used along with an audio amplifier, or possibly a digital interface.

- **Procedure:**

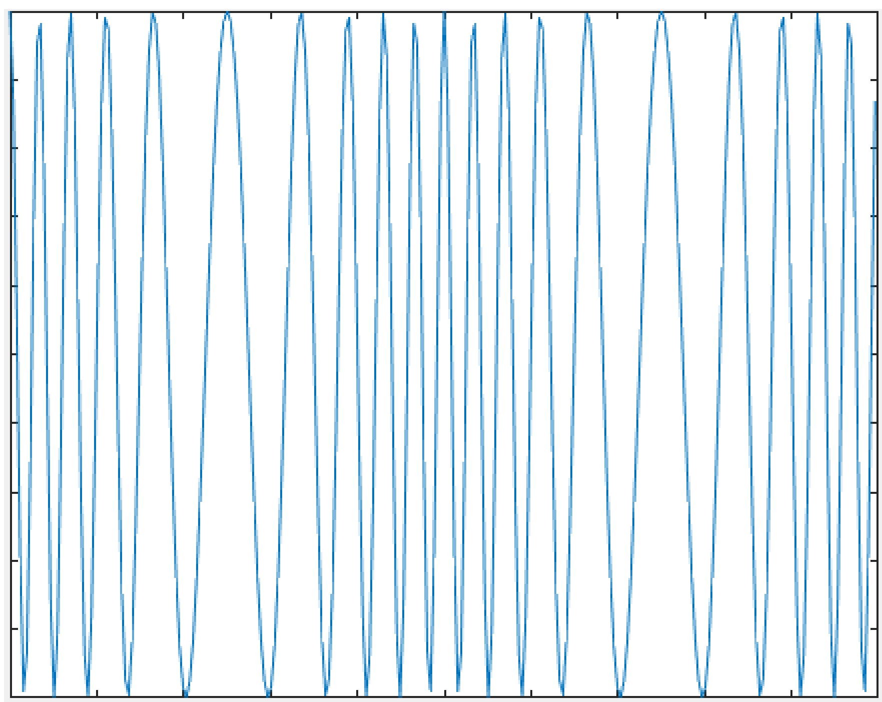
## Part (1)

1) The output from Audio Oscillator:




Amp.=2.38 V, Freq.=3.11kHz

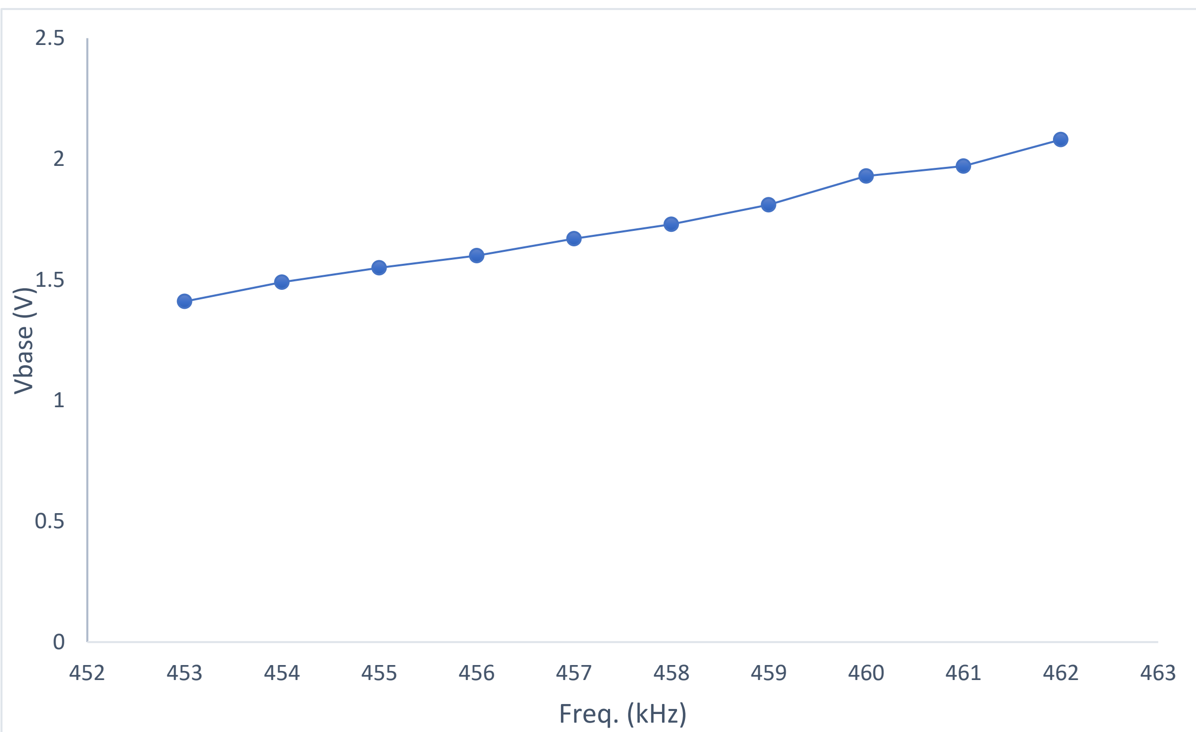
2) The FM signal from the Varactor modulator:



Amp.=1.12 V, Freq.=462.6 kHz

3) The relationship between the frequency and the base voltage:

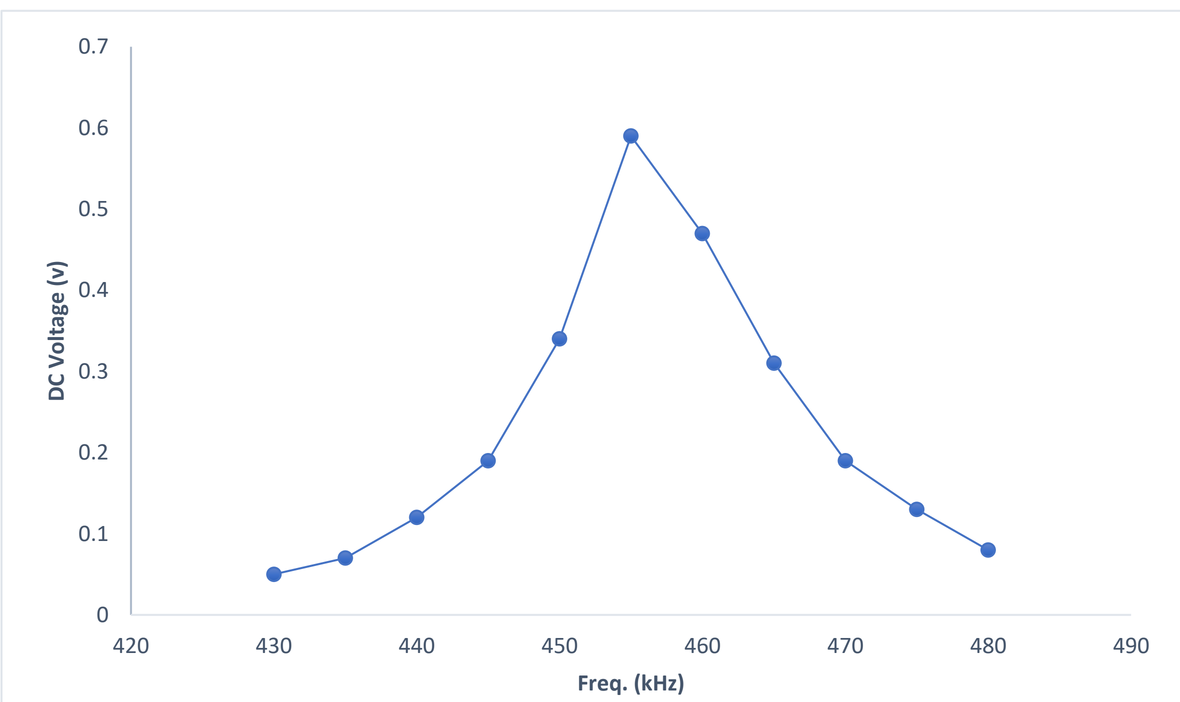
| Freq. (kHz) | $V_{base}$ (V) |
|---|---|
| 453 | 1.41 |
| 454 | 1.49 |
| 455 | 1.55 |
| 456 | 1.60 |
| 457 | 1.67 |
| 458 | 1.73 |
| 459 | 1.81 |
| 460 | 1.93 |
| 461 | 1.97 |
| 462 | 2.08 |



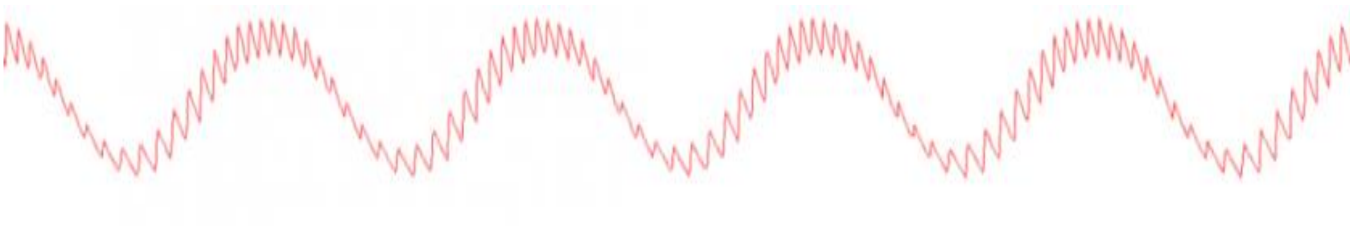
## Part (2)

1) Record the DC voltage at tp40 for incoming frequencies from 25 kHz below to 25 kHz above the resonance frequency of the tuned circuit. Take 10 readings each step increase frequency 5 kHz over the range from 430 kHz – 480 kHz.

| Freq. (kHz) | DC Voltge(V) |
|---|---|
| 430 | 0.05 |
| 435 | 0.07 |
| 440 | 0.12 |
| 445 | 0.19 |
| 450 | 0.34 |
| 455 | 0.59 |
| 460 | 0.47 |
| 465 | 0.31 |
| 470 | 0.19 |
| 475 | 0.13 |
| 480 | 0.08 |

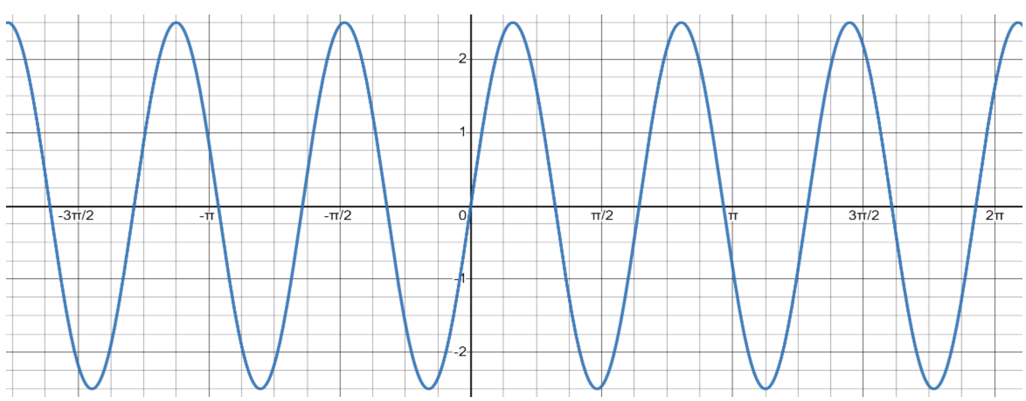


2) The output from the tuned circuit (Detector):



Vp-p=85 mV, Freq.=3.117 kHz

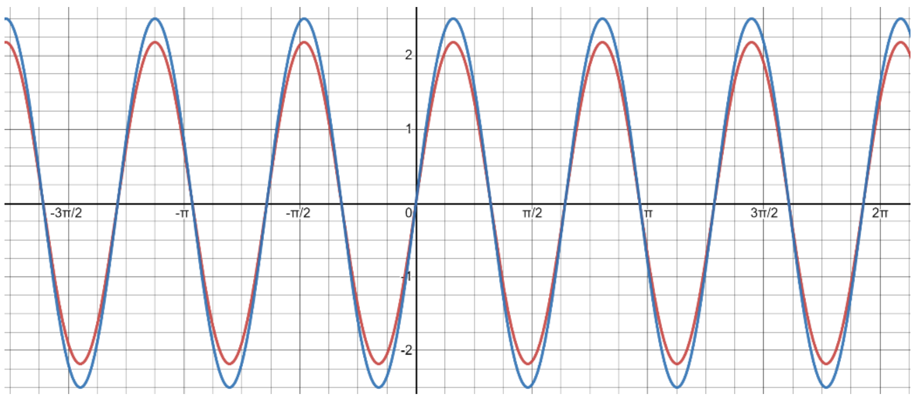
3) After filtering the signal by LPF amplifier, we will get the same message that we transmitted it by the Audio Oscillator (the same frequency of the message but it is not the same amplitude)




Amp.=2.52 V, Freq.=3.11kHz

4) Compare between the message signal from audio oscillator and the output signal from LPF amplifier:

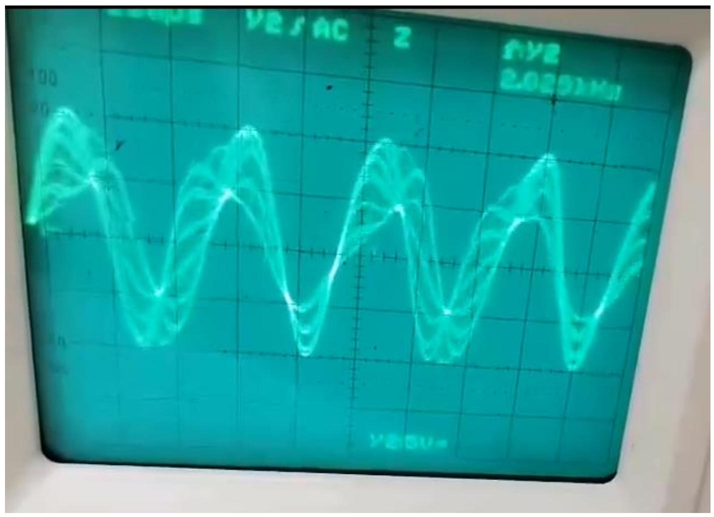
both have the same frequency (3.11 kHz), and they have deferent amplitude; (2.38 V) for message signal and (2.5 V) for the output signal from LPF amplifier.



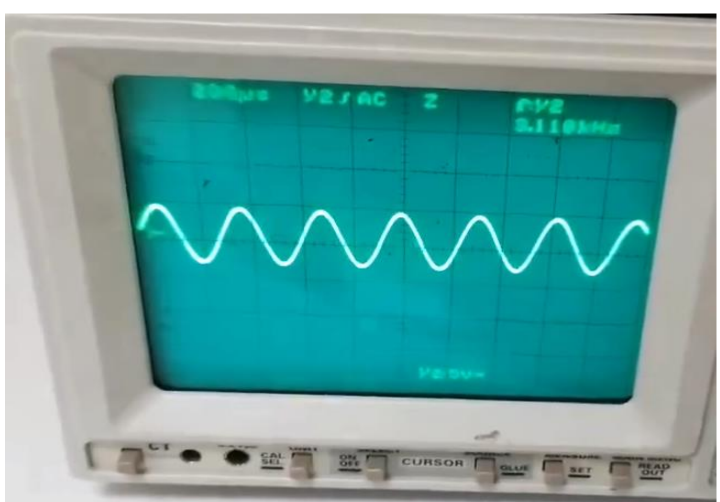

Also, we can note small phase shift due to the time takes to do modulating and demodulating.

## Part (3)

1) In FM, the effect of noise to message signal is small, that is because when the message signal get noise it will affect to the amplitude and the information inside it will not affect because the information is carried in the frequency.
2) So, if we have noise entered to the channel, we will demodulate signal added to it amplitude.



3) So, we note from the above figure that noise does not affect frequency and do have affects the amplitude.
4) In order to remove the noise, we put the signal into amplitude limiter circuit to remove the noise in the amplitude then we send the output from it to the detecting then the rest of procedure.



## Conclusion:

1) In Frequency Modulation, the message signal has the same frequency as the demodulating signal, that is because we carry the message into frequency.
2) We can use LPF Amplifier to remove the DC offset and the ripple from the demodulated FM signal.
3) FM signals usually have low amplitude and therefore the carrier does not require much power, and almost all the power goes into the sideband where the information is.
4) Frequency modulation circuits is more complex than Amplitude Modulation circuits.