PREMIER UNIVERSITY

Department of Computer Science & Engineering

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Course Title	:	**Communication Engineering Laboratory**
Report No	:	04
Name of Report	:	Frequency modulation using the Varactor Modulator
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Course Instructor	:	Sharith Dhar

Submitted By :

Name	:	**Mohammad Hafizur Rahman Sakib**
ID	:	**0222210005101118**
Section	:	**C**
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REMARKS

Experiment Name: Frequency modulation using the Varactor Modulator

Objective: To observe the frequency modulation using the Varactor Modulator

Required Instruments :

1. IT-4101 Trainer Board
2. 2 mm Patch Cords
3. Oscilloscope

Theory :

Frequency Modulation (FM) conveys information over the carrier wave by varying its frequency. In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. This modulation process does not affect the amplitude.

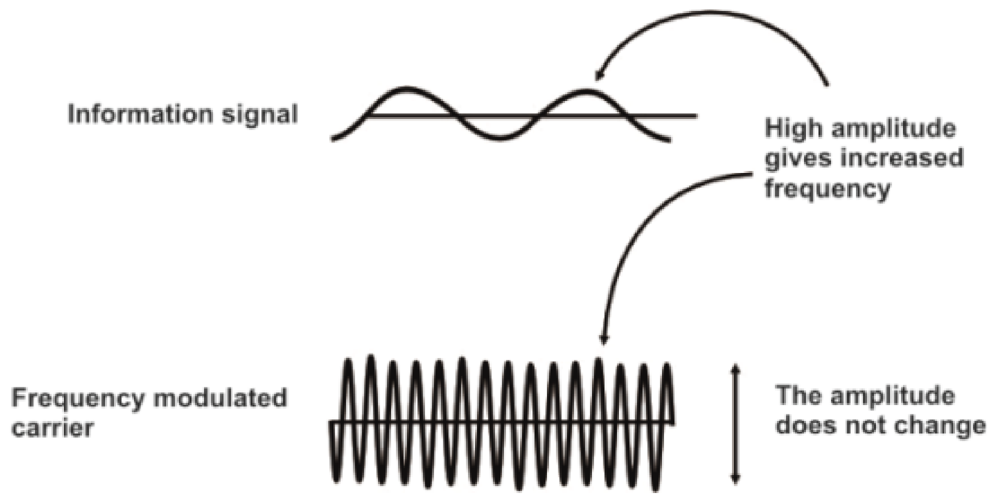

Fig 01: Frequency Modulation Procedure

There are some distinct advantages of frequency modulation in communication systems. One advantage is that frequency modulation has no effect on the amplitude of the carrier wave. The demodulator only needs to observe the change in the frequency and can ignore any changes in amplitude. Electrical noise that shifts the amplitude, therefore, has no or little effect on an FM communication system. Varactor Modulator: All FM transmitters function in much the same way. They include an RF oscillator to generate the carrier, and these oscillators employ a parallel-tuned circuit to determine the frequency of operation. A parallel resonant tank circuit is used, where the value of the inductance and capacitance determine the frequency of operation. The frequency of resonance is given by: f = 1 2π LC where L is the inductance and C is the capacitance. If we can vary the value of the capacitance according to the message signal, we can control the carrier frequency. A Varactor Diode is a way to do that. A varactor diode is a semiconductor diode that is designed to behave as a voltage-controlled capacitor. When a semiconductor diode is reverse biased, no current flows and a junction capacitance is associated with it. We can control the width of the depletion region by the applied reverse bias voltage, which in turn controls the capacitance. If the message signal is applied to the varactor diode, the capacitance will, therefore, be varied accordingly, and the frequency will change.

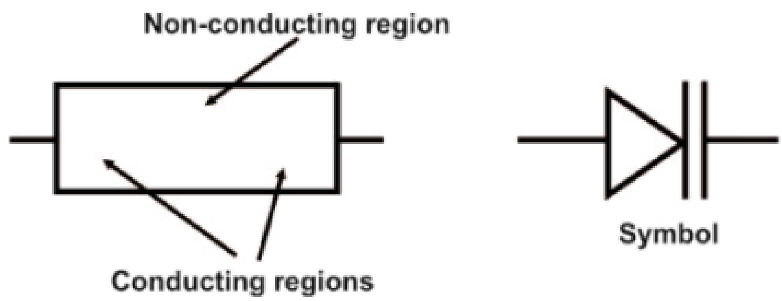

Fig 02: A Varactor Diode

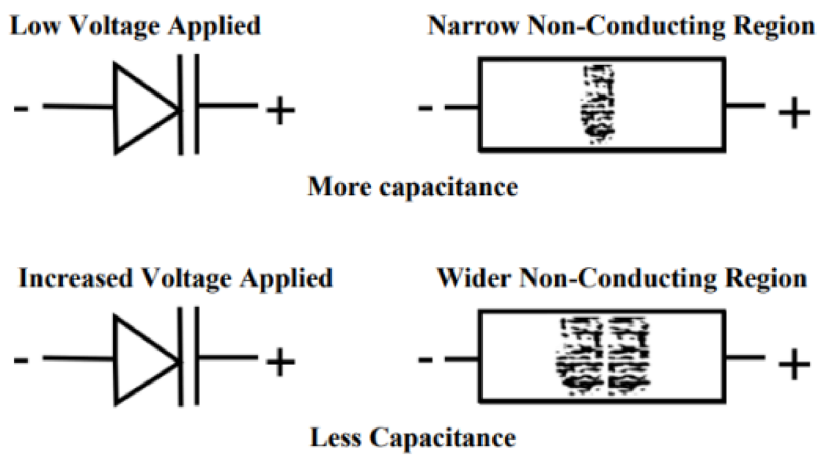

Fig 03: Operation of A Varactor Diode

Procedure :

1. Turn on the IT-4103 module

2. Connect Audio Generator O/P (TP1) to channel 1 of the Oscilloscope. This is the modulating wave. Check the output and adjust the Frequency knob to make the frequency around 1 kHz.

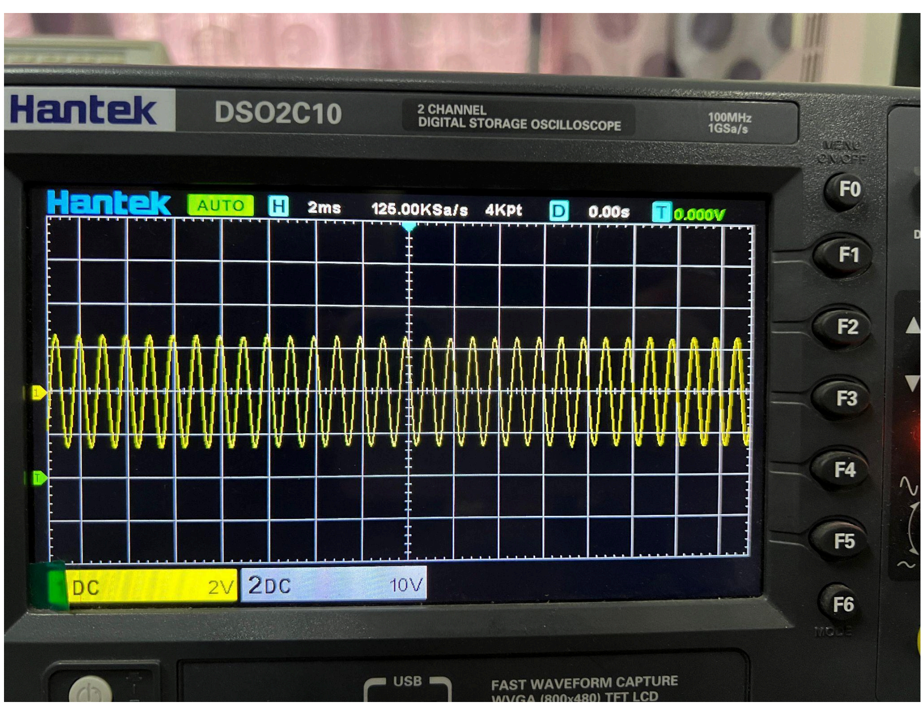

Fig 04: Message Signal

3. Connect the Varactor Modulator O/P (TP9) to channel 2 of the Oscilloscope. Observe the signal and calculate the frequency.

4. Connect the Audio Generator O/P (TP1) with the Varactor Modulator I/P (TP8). The connection should look like below:

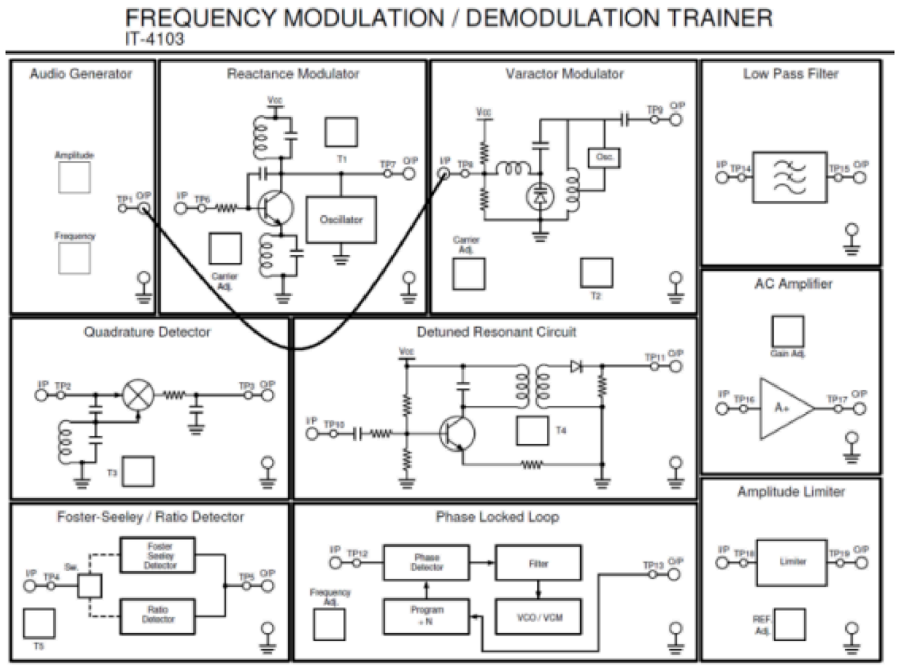

Fig 05: Circuit Diagram for Frequency Modulation

5. Observe the Varactor Modulator O/P (TP9) on the oscilloscope. Vary the audio signal's amplitude and observe the frequency variation

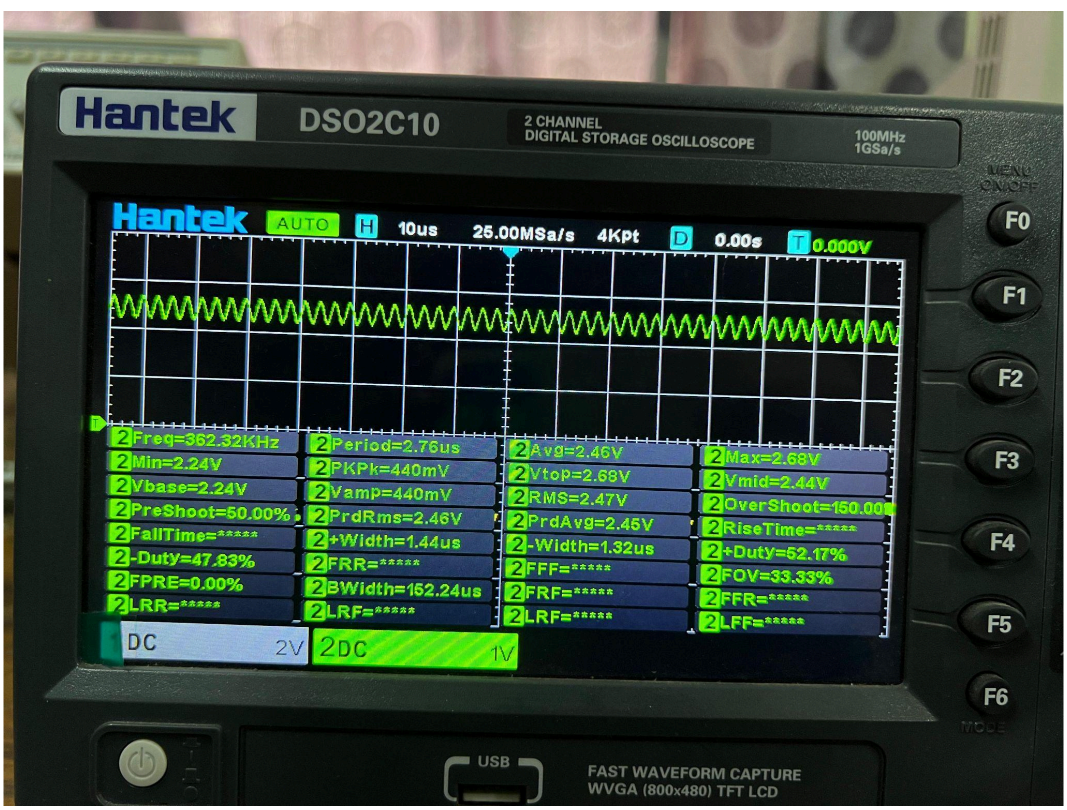

Fig 06: FM Wave

Experimental Data :

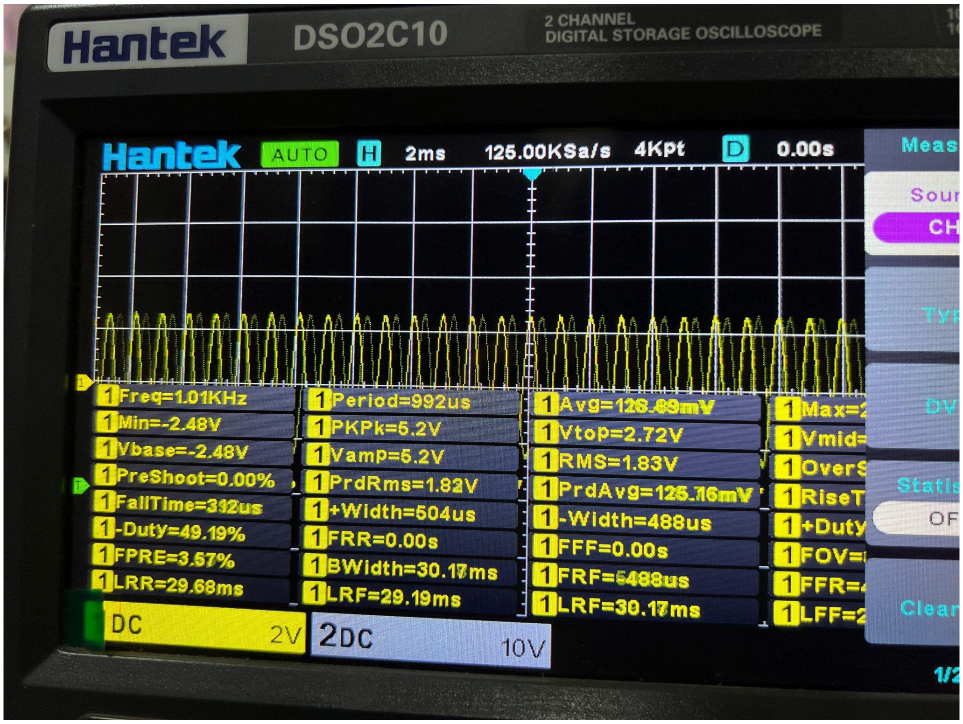

Fig 07: Experimental Data of Message Signal

Questions & Answers :

1. **Write down the mathematical formula of the frequency-modulated wave.**

The mathematical formula for a frequency-modulated wave can be expressed as:

$s(t)=Ac\cos(2\pi f ct+2\pi k f\int-\infty t m(\tau)\ d\tau)s(t)=Ac\cos(2\pi fct+2\pi kf\int-\infty tm(\tau)d\tau)$

where:

- $s(t)s(t)$ is the FM signal.
- $AcAc$ is the amplitude of the carrier wave.
- $f cfc$ is the carrier frequency.
- $k f kf$ is the frequency sensitivity factor.
- $m(t)m(t)$ is the modulating signal (message signal).
- $\int-\infty t m(\tau)\ d\tau\int-\infty tm(\tau)d\tau$ is the integral of the modulating signal up to time tt.

2. **What's the frequency sensitivity factor? Why is the frequency deviation negligible, as observed in the experiments?**

The frequency sensitivity factor, $k f kf$, determines how much the carrier frequency changes in response to the modulating signal. It is defined as the frequency deviation per unit amplitude of the modulating signal.

Why is the Frequency Deviation Negligible?

Frequency deviation might be negligible due to:

1. **Small Modulating Signal Amplitude**: Low $m(t)m(t)$ leads to small $\Delta f(t)\Delta f(t)$.
2. **Low Sensitivity Factor**: Small $kfkf$ results in minimal frequency changes.
3. **Measurement Limitations**: Instruments may lack the resolution to detect small deviations.
4. **Experimental Conditions**: Noise and precision limits might obscure small deviations.

Discussion:

The experiment on frequency modulation using the Varactor Modulator offered a thorough demonstration of FM principles and their real-world applications. Utilizing the IT-4101 Trainer Board, we successfully modulated the carrier wave frequency in response to an input signal. This was accomplished by exploiting the unique characteristics of the varactor diode, which adjusts its capacitance based on the applied voltage, thereby changing the circuit's resonant frequency. During the experiment, we connected the components using 2 mm patch cords and monitored the frequency variations with an oscilloscope. The oscilloscope enabled us to observe the carrier wave's real-time frequency changes, verifying that the carrier frequency was directly proportional to the instantaneous value of the input signal. This practical observation reinforced the theoretical understanding that FM transmits information through frequency variations rather than amplitude changes, offering advantages in noise reduction and signal integrity. The visual output on the oscilloscope underscored the efficiency of frequency modulation in maintaining a consistent carrier wave amplitude despite frequency changes. This property is particularly advantageous for applications requiring reliable signal transmission, such as radio broadcasting and telecommunications. Overall, the experiment not only deepened our understanding of FM principles but also highlighted the essential role of varactor modulators in modern communication systems.