Experiment 5

Amplitude Modulation and Demodulation

Objective:

By the end of this experiment, the student should be able to:

1. Demonstrate the Modulation and Demodulation of the AM.
2. Observe the relation between modulation index and AM signal envelope.
3. Measure the Modulation Index ,total power and power efficiency of the AM signal.

Introduction:

Amplitude modulation (**AM**) is defined as the process in which is the amplitude of the carrier wave is varied according the amplitude of the message signal . The envelope of the modulating wave has the same shape as the base band signal provided the following two requirements are satisfied:

1. The carrier frequency must be much greater than the highest frequency components of the message signal.
2. The modulation index must be less than unity. If the modulation index is greater than unity, the carrier wave becomes over modulated.

The amplitude modulated signal is defined as:

S(t) = Ac (1 + µ.cos2πfmt) cos2πfct……………………………………………………….. (1)

Where :
Ac: is carrier amplitude.
µ: is a constant, and it is called Modulation Index (also called modulation depth typically **µ** < 1).
fm: is the message frequency.
fc: is the carrier frequency.

Am Generation :
A block diagram, showing how equation (1) could be modelled with hardware, is shown in Figure 1 below.

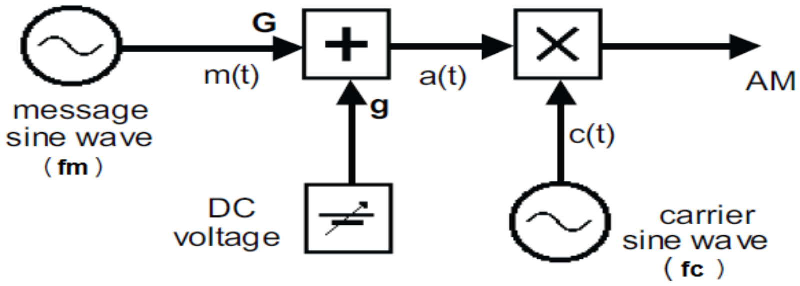

Figure .1 AM Generation Block Diagram

Modulation Index:

In AM, this quantity, also called modulation depth, indicates by how much the modulated signal varies around its 'original' level. For AM, it relates to the variations in the carrier amplitude.

The magnitude of '**μ**' can be measured directly from the AM display itself.
Thus:

$$\mu = \frac{P-Q}{P+Q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where **P** and **Q** are as defined in Figure 2

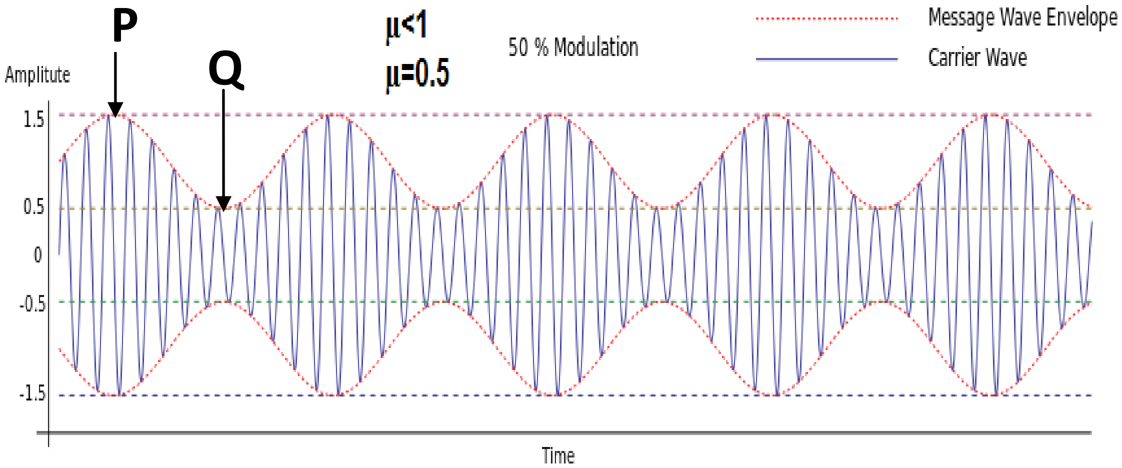

Figure 2. Modulation Index Measurement

AM Signal Envelop:

When we talk of the envelopes of signals we are concerned with the appearance of signals in the time domain. Qualitatively, the envelope of a signal is that boundary within which the signal is contained, when viewed in the time domain. It is an imaginary line. This boundary has an upper and lower part. You will see these are mirror images of each other. In practice, when speaking of the envelope, it is customary to consider only one of them as 'the envelope' (typically the upper boundary).

AM has three envelope shapes based on modulation index μ value:

1. **Under modulation μ <1.0**
   For example μ = 0.5, the carrier amplitude varies by 50% above and below its unmodulated level. This is Known as Under-Modulation
2. **Full modulation μ =1.0**
   In this case the carrier amplitude varies by 100%. With 100% modulation the wave amplitude sometimes reaches zero.
3. **Over modulation μ > 1.0**
   Modulation depth greater than 100% is generally to be avoided as it creates distortion. If μ =1.5 ,the carrier amplitude varies by 150% so the envelope of the output waveform is distorted. This is known as Over-modulation and should never occur in practice, because the

distorted envelope will result in a distorted output sound signal in the radio receiver see Figure 3.

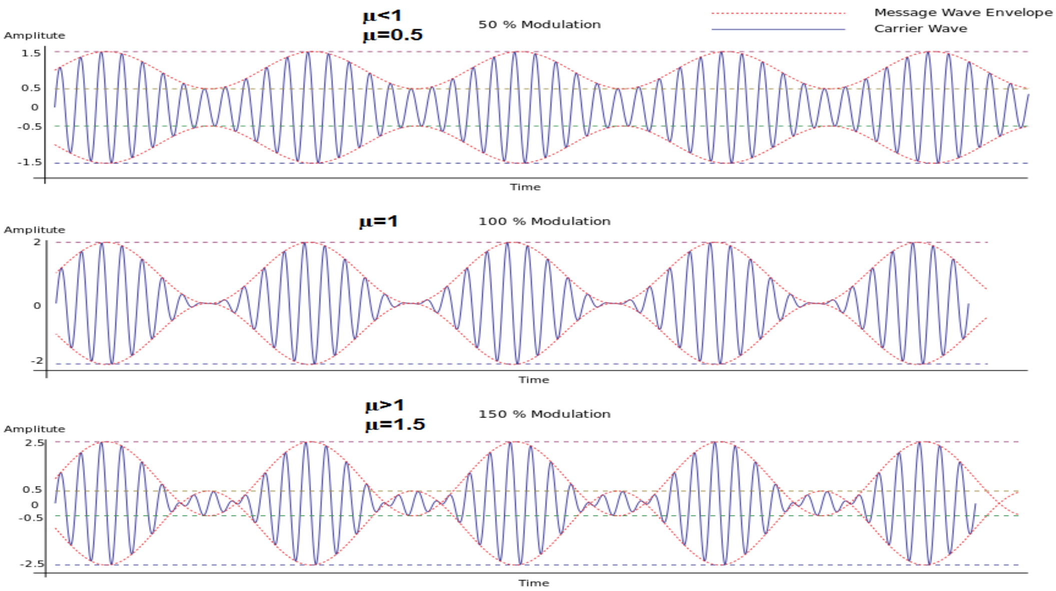

Figure 3. Envelopes shapes of AM signal

Spectral Analysis:

Analysis shows that the sidebands of the AM, when derived from a message of frequency fm Hz, are located either side of the carrier frequency, spaced from it by fc Hz .The bandwidth of the AM signal equal to **2fm**.

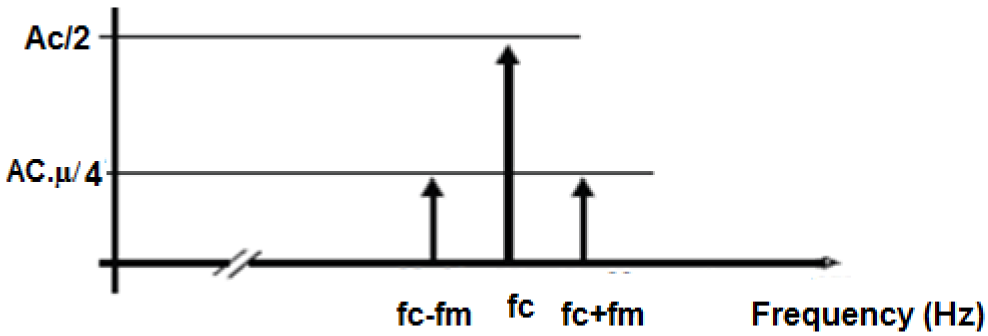

Figure 4. Spectral Components of AM modulation

AM-Demodulation

Envelope Detector:

An AM signal can be demodulated using either **synchronous** or **asynchronous** detection methods. While synchronous methods are more precise and offer exceptional results, asynchronous methods are simple and economical. Asynchronous, also known as **envelope detectors**, can only be used for full carrier AM. A simple envelope detector circuit and the signals involved are shown in Figure 5.

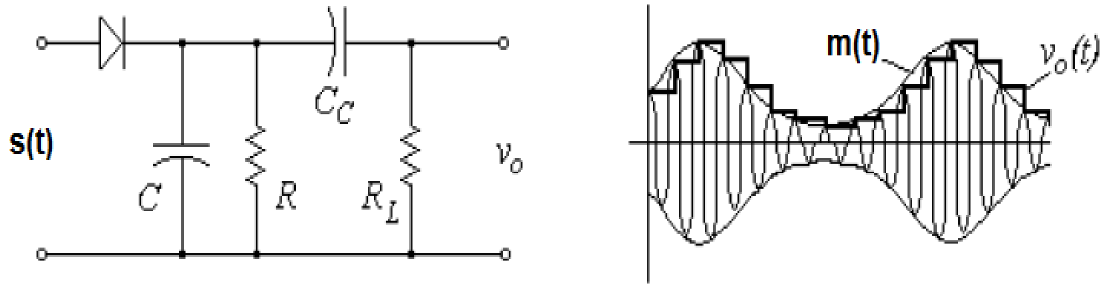

Figure 5. The Circuit of envelope detector and its signals.

The ideal envelope detector is a circuit which consists of two parts, the first part is a rectifier to take the absolute value of the signal, while the second part is LPF to remove unwanted component generated by rectification operation and signal smoothing see figure 6.

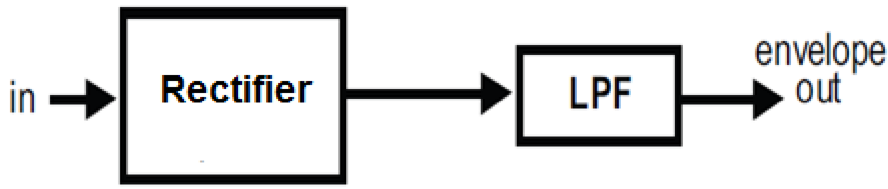

Figure .6 The Block diagram of envelope detector.

Lab Work:

This experiment consists of two parts , the part l studyies AM signal generation, envelops types, and power efficiency, While the second part ,Part ll, talks about AM demodulation.

Modules:

The following plug-in modules will be needed to run this experiment: Audio Oscillator, Multiplier, Adder, Utilities, Tunable LPF,RMS True Meter.

Part1. Am Generation :

Procedure:

1. Construct The block diagram of Figure 1, which models the AM equation, by using TIMS as shown in figure 7.

2. Use the Frequency Counter to set the Audio Oscillator to about 1 kHz.

3. Switch the Scope Selector to CH1-B, and look at the message from the Audio Oscillator. Adjust the oscilloscope to display two or three periods of the sine wave then draw the displayed signal in your lab sheets.

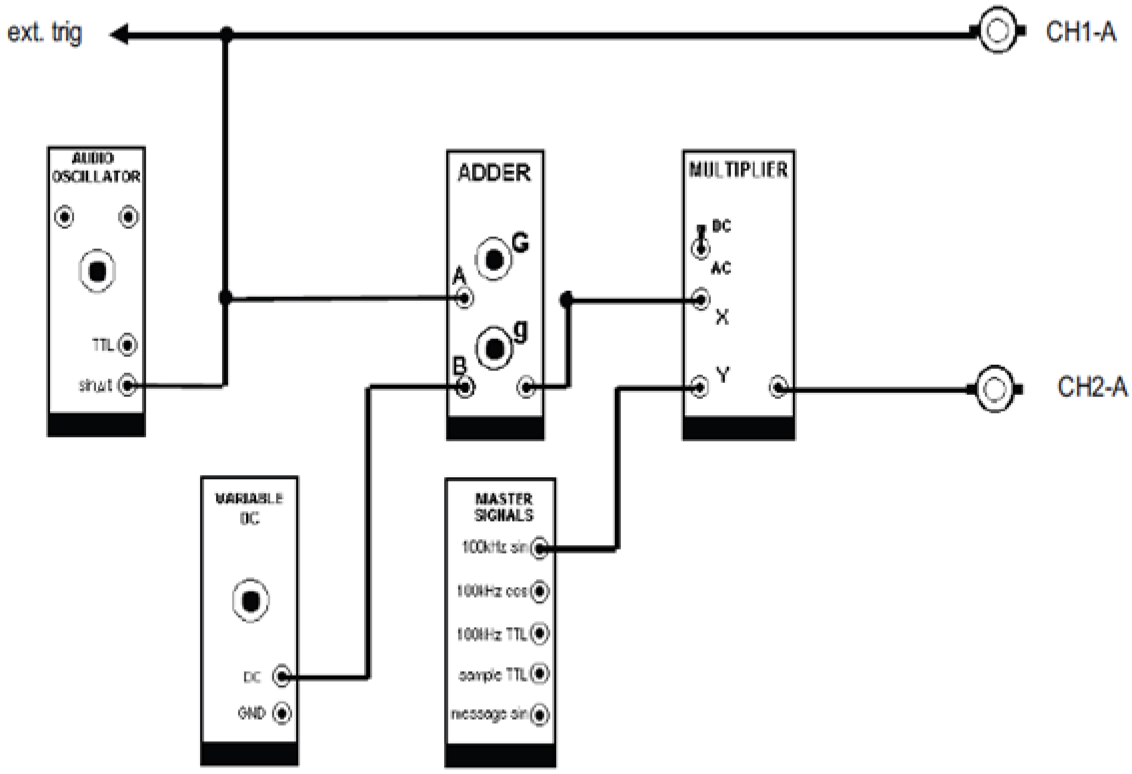

Figure .7 The TIMS Model of The Block Diagram of Figure 2

4. Turn both **g** and **G** fully anti-clockwise. This removes both the DC and the AC parts of the message from the output of the Adder.

5. Turn the front panel control on the Variable DC module almost fully anticlockwise This will provide an output voltage of about minus 2 volts. The Adder will reverse its polarity, and adjust its amplitude using the '**g**' gain control.

6. Whilst noting the oscilloscope reading on CH1-A, rotate the gain '**g'** of the Adder clockwise to adjust the DC term at the output of the Adder to 1 V which indicate the DC value .

7. Vary the Adder gain **G**, and thus '**μ**', and confirm that the envelope of the AM behaves as expected, including for values of **μ < 1** then measure **μ** using Eq. 2 and save the displayed signal in your lab sheets**.**

8. Using PicoScope plot the **spectral components** of AM signal for **μ**<1 in your lab sheets.

9. Repeat points 7 and 8 for **μ = 1** and **μ >1.**

Part ll:

1. Construct TIMS Model of the AM generator connected Envelop Recovery as shown in below **Figure**

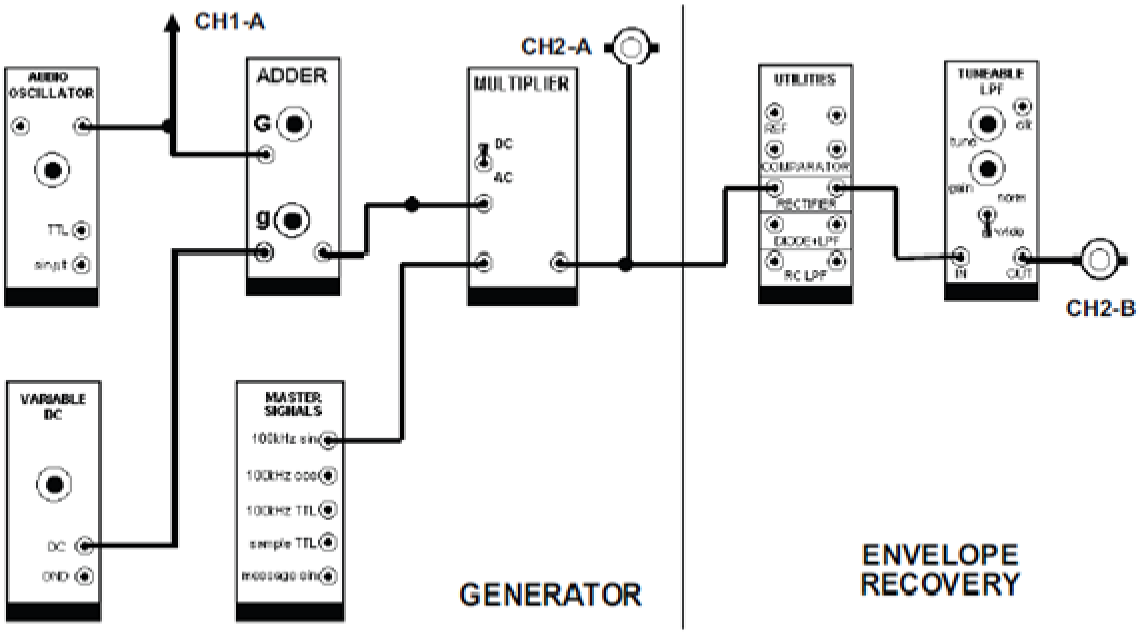

Figure .8 TIMS Model of the AM generator connected Envelop Recovery

1. Vary Adder gain G , thus μ , for any value less than one, in other words let **μ**<1.
2. Vary the cutoff frequency of the LPF, and find the range of acceptable values for best recovery of the message and write the result in your lab sheet.
3. Plot, in time, the best recovered signal you can obtain in lab sheets.