ICE-2212
ANALOG COMMUNICATION LAB

Laboratory Manual

RAJSHAHI UNIVERSITY

EPARTMENT OF INFORMATION AND ECOMMUNICATION ENGINEERING
RAJSHAHI UNIVERSITY

PREPARED BY,
MD. Firoz Ahmed
Lecturer
Department of Information and Communication Engineering
Rajshahi University, Rajshahi, Bangladesh.
ICE-2212: ANALOG COMMUNICATION LAB

ICE-2212: ANALOG COMMUNICATION LAB

List of Experiments

1. To Study Double Side Band (DSB) AM Generation.
2. To Study Single Side Band (SSB) Modulation.
3. To Study Single Side Band (SSB) AM Reception.
4. To Study Double Side Band (DSB) AM Reception
5. To Study of voice Transmission with DSB AM Transmission/ Reception.

EXPERIMENT NO: 1

Experiment Name: To Study Double Side Band (DSB) AM Generation.

Objective:

A. To study the operation of a DSB AM modulator.
B. To calculate the modulation index of an AM modulated wave.

Equipment:-

i. Modules ACL-01
ii. Power Supply
iii. 20MHZ Oscilloscope
iv. Connecting Links
v. Frequency Counter

Note: Keep all the switch faults in OFF position.

Theory:

Modulation: The modulation is simply a method of combining two different signals and is used in the transmitter section of a communication system. The two signals that are used are the information signal and the carrier signal. The information signal is the signal that is to be transmitted and received and is sometimes referred to as the intelligence .The carrier signal allows the information signal to be transmitted efficiently through the transmission media.
The carrier signal is normally generated by an oscillator and has a constant frequency and amplitude. The information signal that is fed into the transmitter modifies the carrier signal.

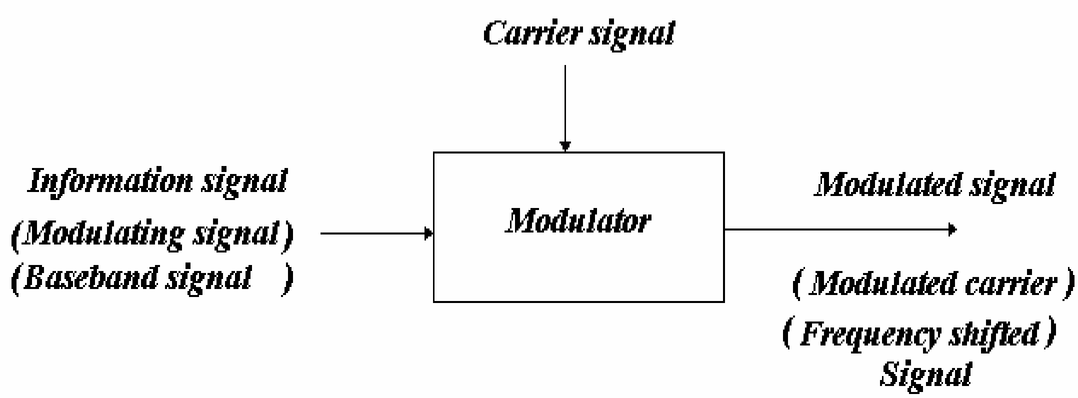


Fig. Process of Modulation

Amplitude Modulation:

It is the simplest form of signal processing in which the carrier amplitude is simply changed according to the amplitude of the information signal hence the name amplitude modulation. When the information signals amplitude is increased the carrier signals amplitude is increased and when the information signals amplitude is decreased the carrier signals amplitude is decreased .In other words the ENVELOPE of the carrier signals amplitude contains the information signal.

The relationship between the amplitude of the modulating signal and the amplitude of the carrier signal is important. This relationship, known as the modulation index m(also called the modulating factor or coefficient, or the degree of modulation), is the ratio

$$m = \frac{V_m}{V_c}$$

$$\text{Modulation index “m”} = \frac{\text{Vmax} - \text{Vmin}}{\text{Vmax} + \text{Vmin}}$$

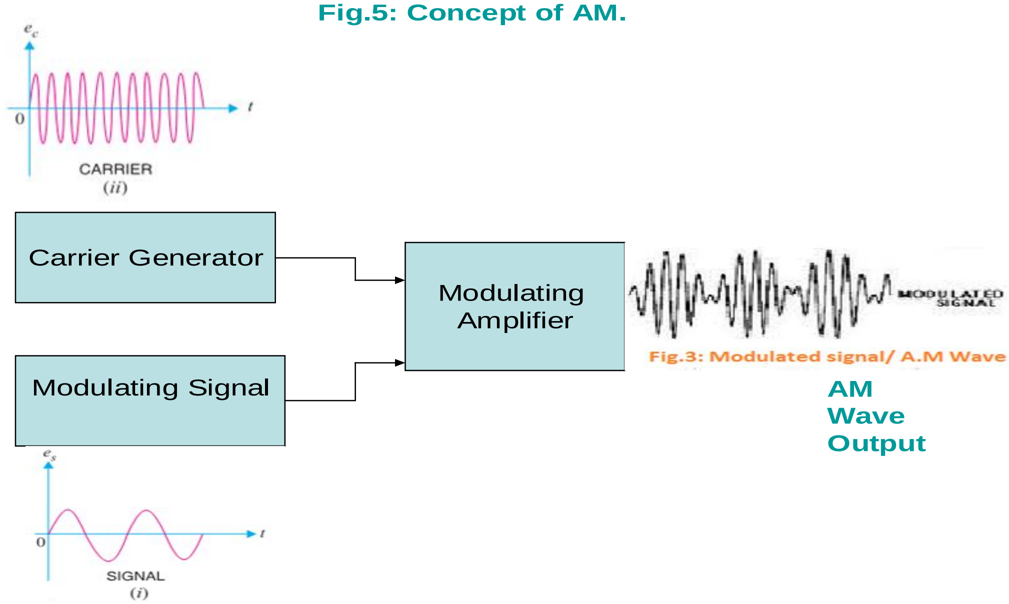
Depending on the modulation index, three conditions occur:

i. **Under 100% modulation:** When $V_m \langle V_c$, As a result no distortion will occur.

ii. **100% Modulation:** When $V_m = V_c$, As a result the proper modulated wave.

iii. **Over Modulation:** When $V_m \rangle V_c$, m will be greater than 1, As a result severe distortion will occur.

Fig.5: Concept of AM.



Modulation Mathematics:

The equation of a sinusoidal voltage waveform is given by: $v = V_{max}.\sin(\omega t+Ø)$ where:

- v is the instantaneous voltage
- V_{max} is the maximum voltage amplitude
- ω is the angular frequency
- Ø is the phase

Amplitude modulation uses variations in amplitude (V_{max}) to convey information. The wave whose amplitude is being varied is called the **carrier wave**. The signal doing the variation is called the **modulating signal.** For simplicity, suppose both carrier wave and modulating signal are sinusoidal; i.e.,

$v_c = V_c \sin \omega_c t$ (*c* denotes carrier)

and $v_m = V_m \sin \omega_m t$ (*m* denotes modulation)

We want the modulating signal to vary the carrier amplitude, V_c, so that:

$v_c = (V_c + V_m \sin \omega_m t).\sin \omega_c t$

where $(V_c + V_m \sin \omega_m t)$ is the new, varying carrier amplitude.

Expanding this equation gives:

$v_c = V_c \sin \omega_c t + V_m \sin \omega_c t.\ \sin \omega_m t$ which may be rewritten as:

$v_c = V_c\,[\sin \omega_c t + m \sin \omega_c t.\ \sin \omega_m t]$ where $m = V_m/V_c$ and is called the **modulation index**.

Now:

$\sin \omega_c t.\sin \omega_m t = (1/2)\,[\cos(\omega_c - \omega_m)\,t - \cos(\omega_c + \omega_m)\,t]$

so, from the previous equation:

$v_c = V_c\,[\sin \omega_c t + m \sin \omega_c t.\ \sin \omega_m t]$

we can express vc as:

$v_c = V_c \sin \omega_c t + (mV_c/2)\,[\cos(\omega_c - \omega_m)\,t] - (mV_c/2)\,[\cos(\omega_c + \omega_m)\,t]$

This expression for v_c has three terms:

1. The original carrier waveform, at frequency ωc, containing no variations and thus carrying no information.

2. A component at frequency $(\omega_c - \omega_m)$ whose amplitude is proportional to the modulation index. This is called the **Lower Side Frequency**.

3. A component at frequency $(\omega_c + \omega_m)$ whose amplitude is proportional to the modulation index. This is called the **Upper Side Frequency**.

It is the upper and lower side frequencies which carry the information. This is shown by the fact that only their terms include the modulation index *m*. Because of this, the amplitudes of the side frequencies vary in proportion to that of the modulation signal.

Sidebands:

If the modulating signal is a more complex waveform, for instance an audio voltage from a speech amplifier, there will be many side frequencies present in the total waveform. This gives rise to components 2 and 3 in the last equation being bands of frequencies, known as sidebands. Hence we have the upper sideband and the lower sideband, together with the carrier. Clearly, for a given carrier amplitude there are limits for the size of the modulating signal; the minimum must give zero carrier, the maximum gives twice the unmodulated carrier amplitude. If these limits are exceeded, the modulated signal cannot be recovered without distortion and the carrier is said to be over-modulated.

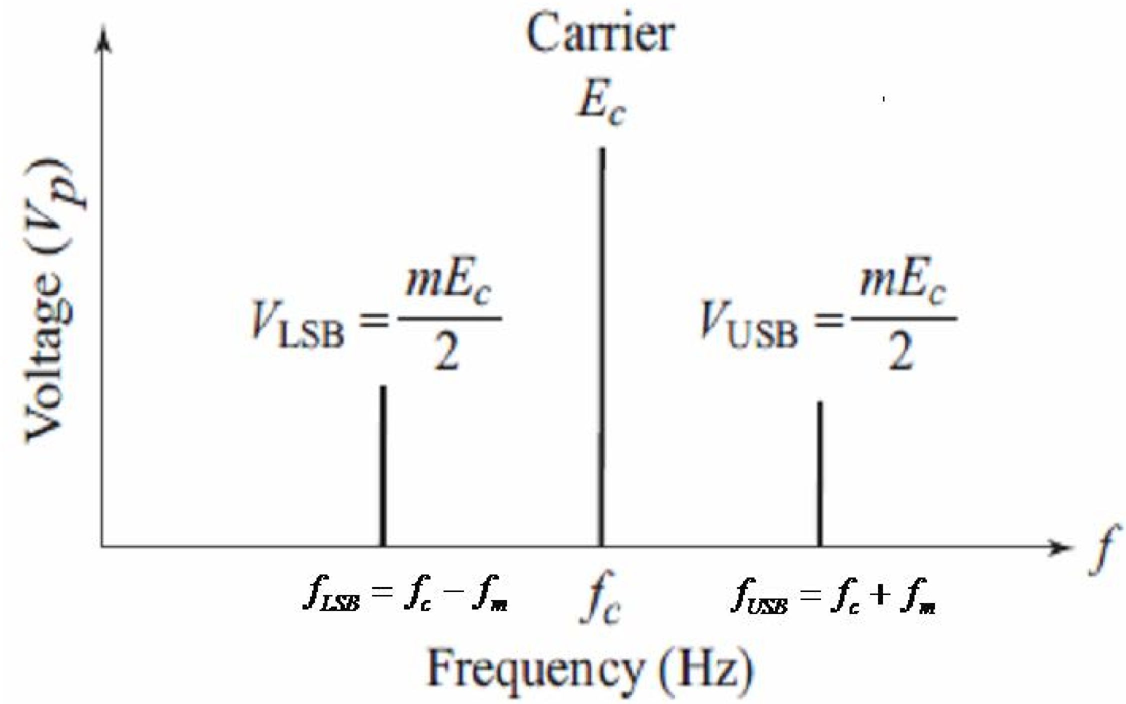


Figure: Frequency Spectrum of AM Wave

Power of the Modulated Signal: The total power of an AM signal is the sum of the contributes related to the carrier and to the upper and lower sidebands. Considering a sine modulating signal and a load resistance R, the different components supply the following powers:

$$\mathrm{PC} = \frac{A^2}{2 \bullet R} \quad \text{Power associated to the Carrier}$$

$$\mathrm{PL} = \frac{(\mathrm{m} \bullet \mathrm{A})^2}{8 \bullet \mathrm{R}} = \frac{\mathrm{m}^2 \bullet \mathrm{A}^2}{4 \bullet 2\mathrm{R}} = \frac{\mathrm{m}^2 P_C}{4} \quad \text{Power associated to the lower sideband}$$

$$\mathrm{PU} = \frac{(\mathrm{m} \bullet \mathrm{A})^2}{8 \bullet \mathrm{R}} = \frac{\mathrm{m}^2 \bullet \mathrm{A}^2}{4 \bullet 2\mathrm{R}} = \frac{\mathrm{m}^2 P_C}{4} \quad \text{Power associated to the upper sideband}$$

It is important to note that:

The power associated to the carrier is fixed and does not depend on the modulation. The power associated to each side band depends on the index of modulation and reaches at maximum 25% of the power of the carrier (50% of the two side bands together)

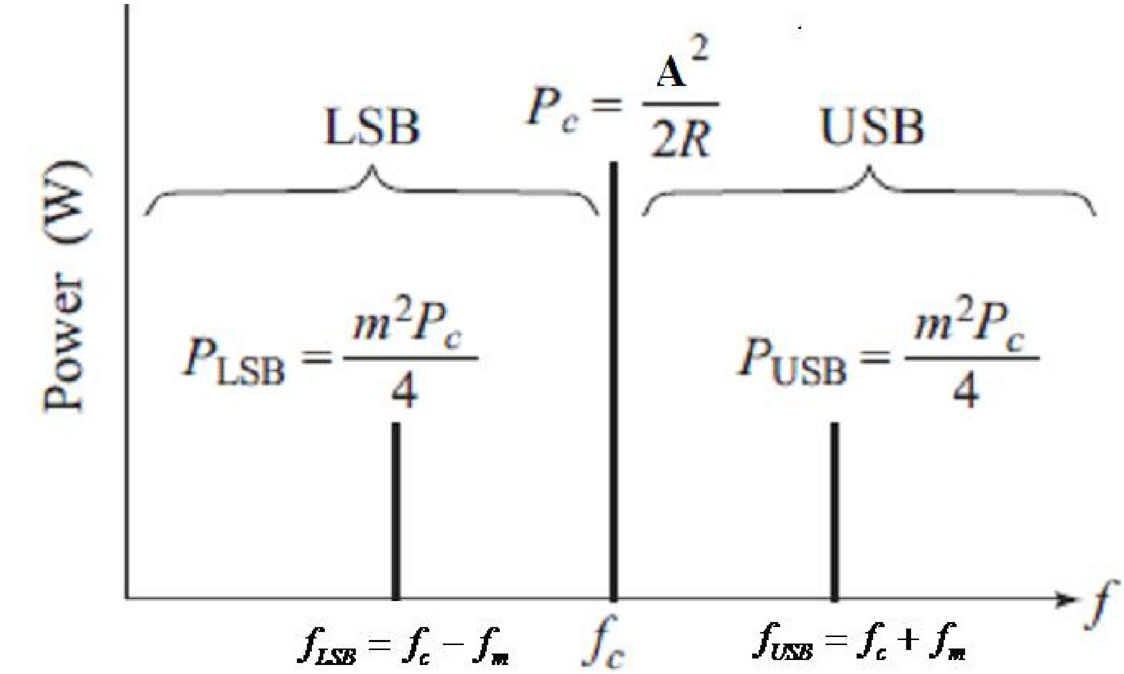


Figure: Power Spectrum of AM

Double sideband suppressed carrier modulation: -

In AM modulation two -thirds of the transmitted power appears in the carrier which itself conveys no information. The real information is contained within the sidebands. One way to overcome this problem is simply to suppress the carrier since the carrier does not provide any useful information there is no reason why it has to be transmitted. By suppressing the carrier the resulting signal is simply the upper and lower sidebands. Such a signal **is referred to as a double-sideband suppressed carrier (DSSC or DSB) signal.** Double sideband suppressed carrier modulation is simply a special case of AM with no carrier. **A circuit called a balanced modulator generates double sideband suppressed carrier signals**.

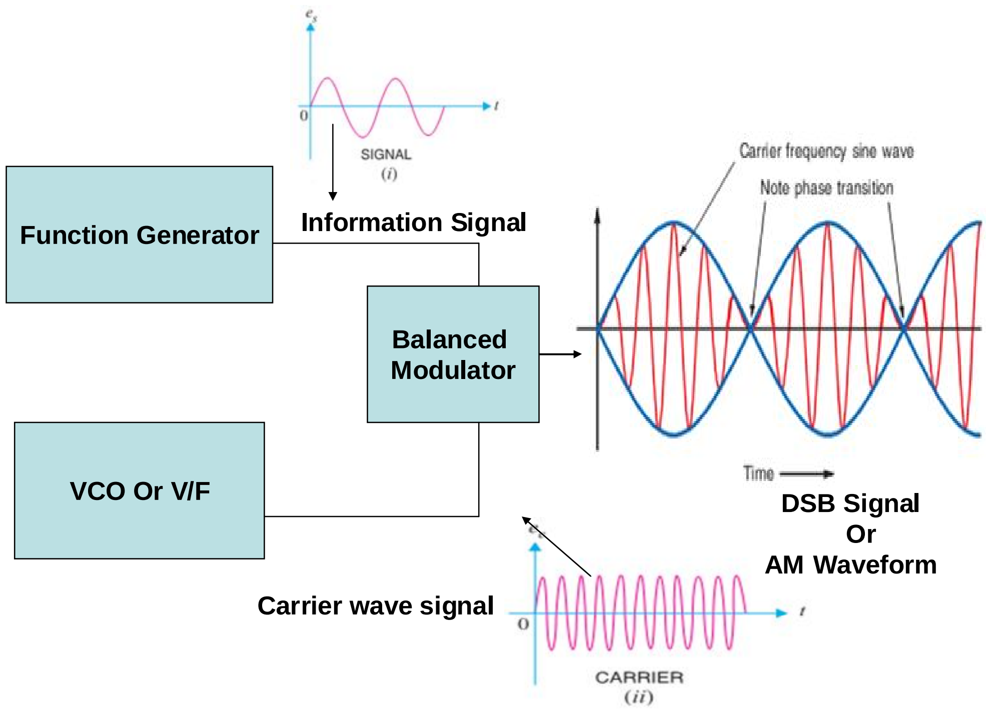
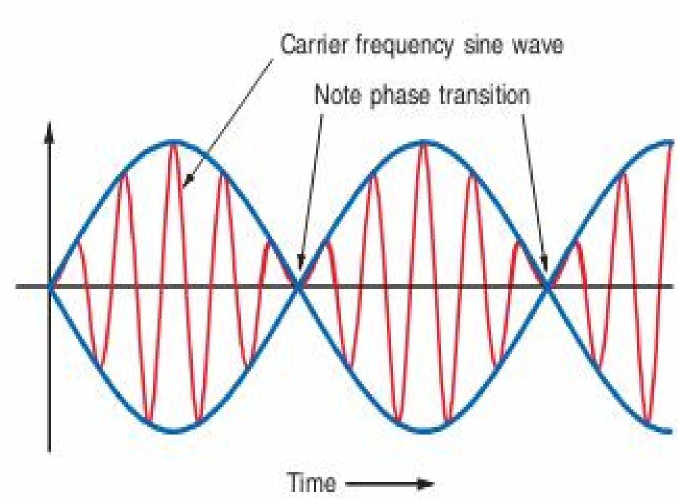
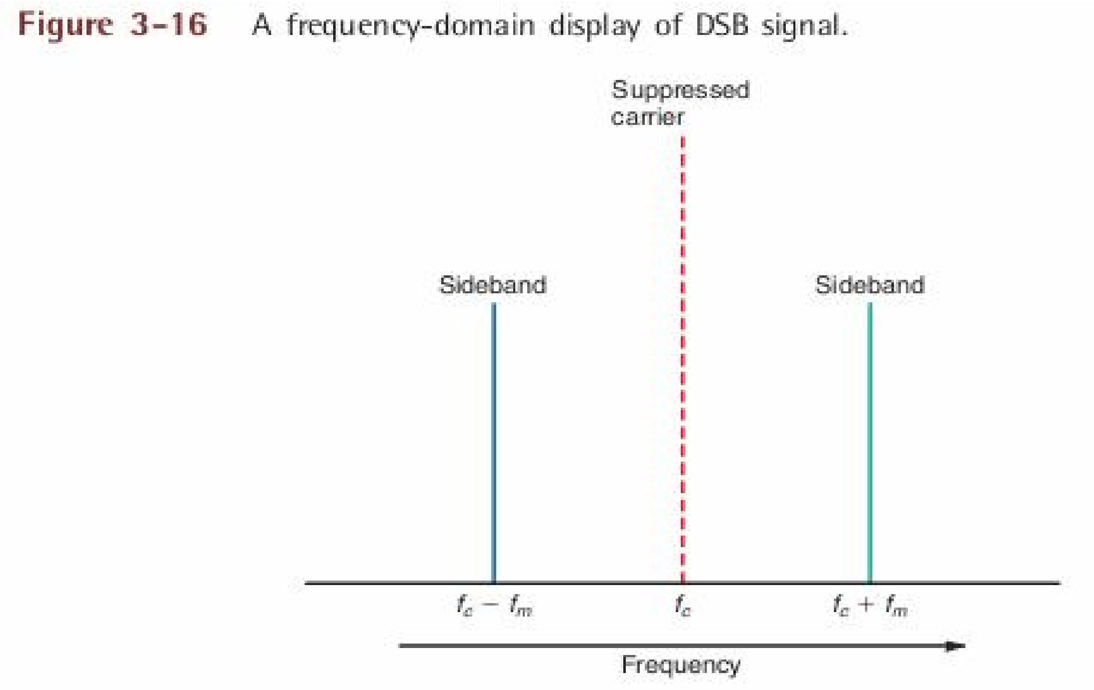


Figure: DSB Signal Generation

Figure 3-15 A time-domain display of a DSB AM signal.





(A) To study the operation of a DSB AM modulator

PROCEDURE & OBSERVATIONS: -

1) Carryout the connections modules ACL-01 as shown in fig-1.14 (See refer book)
2) Power the modules with the supply and carryout the following presetting**:**

FOR Under 100% Modulation (3-4):

3) **Function generator sine wave:** **Freq. about** $f_m = \frac{1}{T} = 1 \times \frac{5ms}{5} = 1KHz$ **1KHz, amplitude/Level about 0.5Vp-p**.

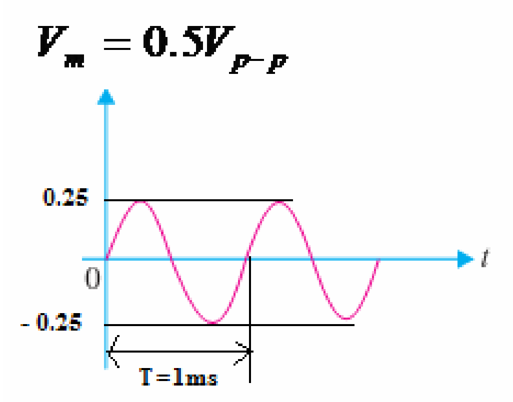


FIG.1.1: Modulating Signal

4) **<u>VCO</u>: Level about,** $V_c = 1V_{p-p}$ **,Freq. about,**

$$f_c = 454\,KHz\,, T = \frac{1}{5}\times 11\mu s = 2.2\mu s,$$

$$\therefore\ f_c = \frac{1}{T} = \frac{1}{2.2\times 10^{-6}} = 454\,KHz$$

$V_c = 1V_{p-p}$

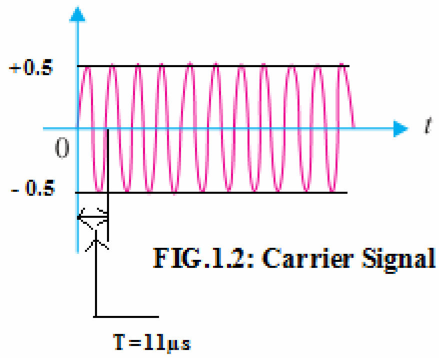
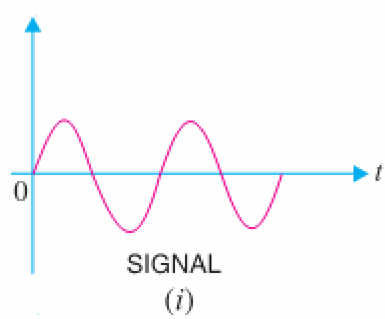
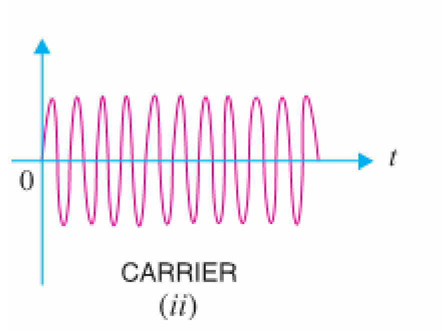


FIG.1.2: Carrier Signal

5) Balanced modulator carrier nulls completely **<u>clock wise out level</u>** in intermediate position.
6) Connect the oscilloscope to the inputs of the modulator (SIG and CAR) and detect the modulating signal and carrier signal, draw their waveforms.(**OR See Lab book figure-1.16A/B**)





7) Move the probe from point SIG to Post OUT (output of the modulator) where a signal modulated in amplitude is detected, draw the waveform**.(OR See Lab book fig.1.16C)**

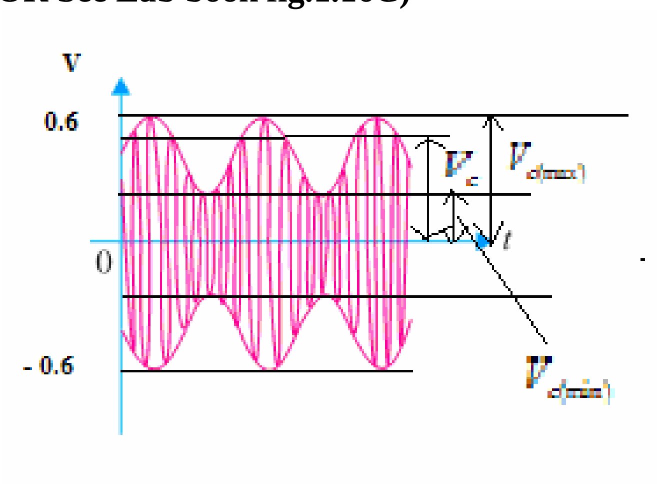


FIG.1.3: Under Modulated Signal

8) Vary the amplitude of the modulating signal and check the 3 following conditions: Modulation percentages lower than the 100 **%(See Lab Fig.1.16C)**, Equal to the 100% **(See Lab Fig.1.16D)**, Superior to 100% over modulation **(See Lab Fig.1.16E)**. Draw the respective waveforms

<u>Modulation percentages lower than the 100 %(Under 100% Modulation):</u> **<u>OUTPUT WAVEFORMS:-</u>**

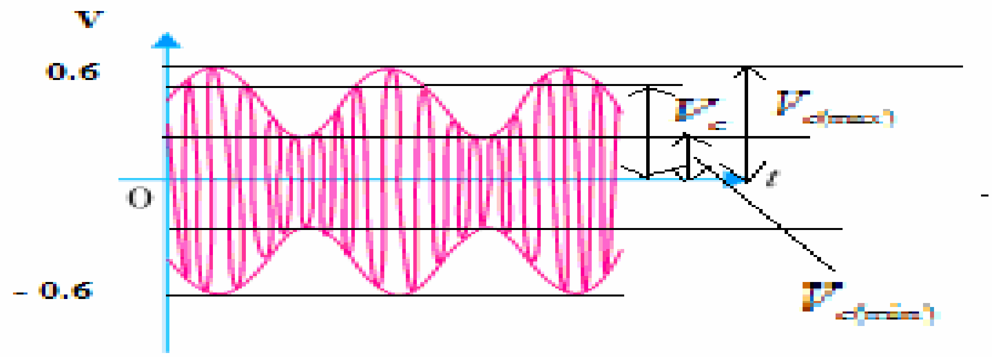


FIG.1.3: Under Modulated Signal

9) Vary the frequency and waveform of the modulating signal and check the corresponding variations of the **modulated signal**.

For 100% Modulation:

Function generator sine wave: **Freq. about** $f_m = \frac{1}{T} = 1 \times \frac{5ms}{5} = 1KHz$ **1KHz, amplitude/Level about 1Vp-p**.

$$V_m = 1V_{p-p}$$

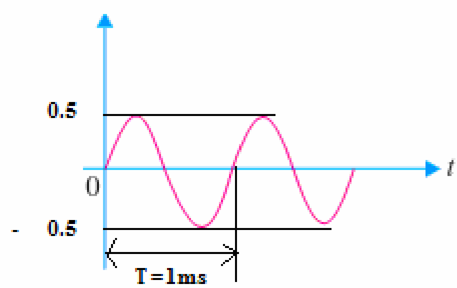


FIG.. : Modulating Signal

VCO: **Level about,** $V_c = 1V_{p-p}$, **Freq. about,**

$$f_c = 454\,KHz\,, T = \frac{1}{5} \times 11\mu s = 2.2\mu s,$$

$$\therefore\ f_c = \frac{1}{T} = \frac{1}{2.2 \times 10^{-6}} = 454\,KHz$$

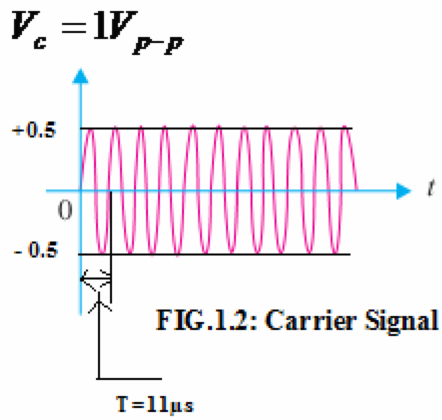


FIG.1.2: Carrier Signal

OUTPUT WAVEFORMS:-

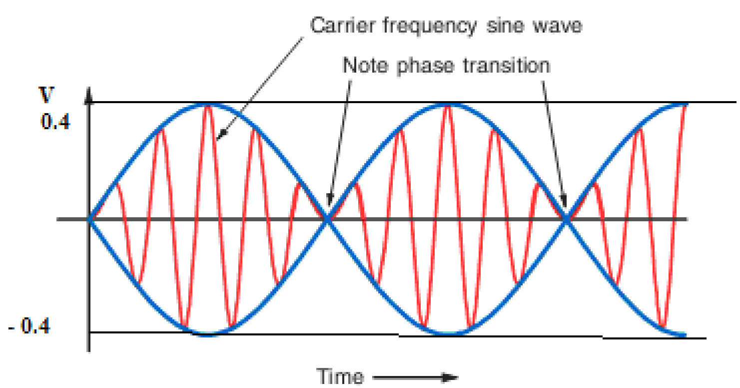


FIG.1.5: Modulated Signal

10) Vary the amplitude of the modulating signal and note that the modulated signal can result saturated or **over modulated**.

For Over Modulation:

Function generator sine wave: **Freq. about** $f_m = \frac{1}{T} = 1 \times \frac{5ms}{5} = 1KHz$ **1KHz, amplitude/Level about 1.5Vp-p**.

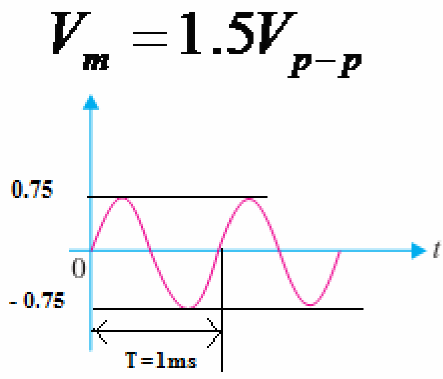


FIG.1.6: Modulating Signal

VCO: **Level about,** $V_c = 1V_{p-p}$, **Freq. about,**

$$f_c = 454\,KHz, T = \frac{1}{5} \times 11\mu s = 2.2\mu s,$$

$$\therefore f_c = \frac{1}{T} = \frac{1}{2.2 \times 10^{-6}} = 454\,KHz$$

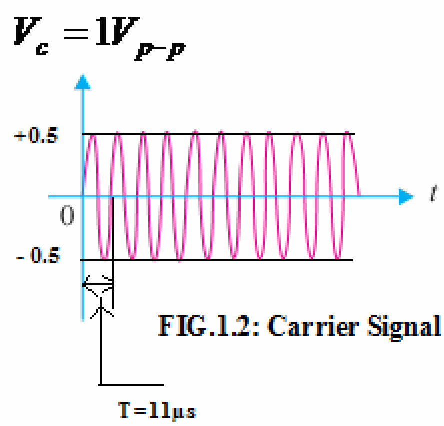


FIG.1.2: Carrier Signal

OUTPUT WAVEFORMS:-

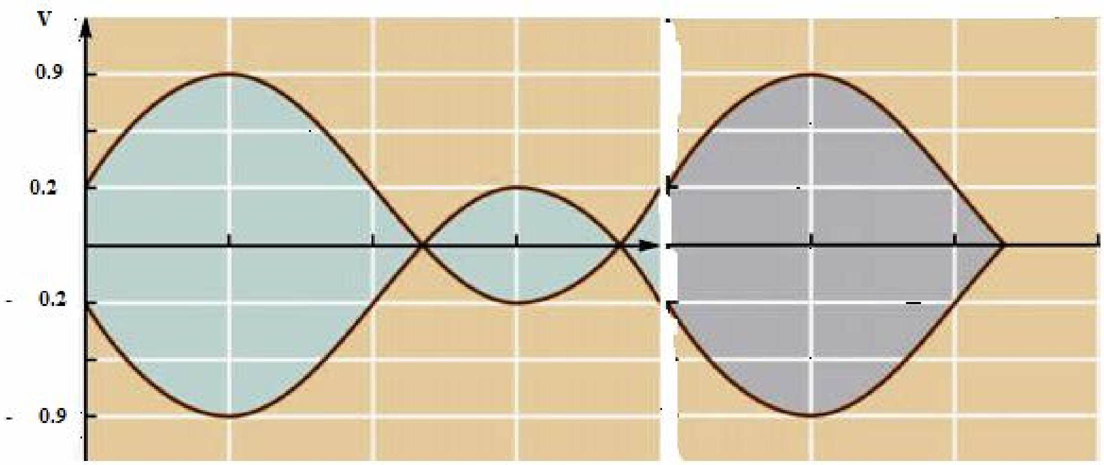


FIG.1.7: Modulating Signal

(B) To calculate the modulation index of an AM modulated.

PROCEDURE & OBSERVATIONS: -Same as (A)

Observation Table: calculated the modulation index of an AM modulated wave

Name of the Modulated Signal	Modulation Index, $m = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} \times 100\%$	Carrier Power $P_c = \frac{V_C{}^2}{2R}(w)$	LSB Power $P_{LSB} = \frac{m^2 P_C}{4}(w)$	USB Power $P_{USB} = \frac{m^2 P_C}{4}(w)$	Total Power $P_T = P_C + P_{LSB} + P_{USB}(w)$
(i) Under 100% Modulation	$m = \frac{0.6-0.2}{0.6+0.2} \times 100\%$ $= 0.5 \times 100\% = 50\%$	$P_c = \frac{V_C{}^2}{2R}(w)$ $= \frac{1^2}{2 \times 1\Omega}$ $= 0.5w$	$P_{LSB} = \frac{m^2 P_C}{4}(w)$ $= \frac{0.5^2 \times 0.5}{4}$ $= 0.032w$	$P_{USB} = \frac{m^2 P_C}{4}(w)$ $= \frac{0.5^2 \times 0.5}{4}$ $= 0.032w$	$P_T = 0.5 + 0.032 + 0.032(w$ $= 0.141$
(ii) 100% Modulation	$m = \frac{0.8-0}{0.8+0} \times 100\%$ $= 100\%$	$P_c = \frac{V_C{}^2}{2R}(w)$ $= \frac{1^2}{2 \times 1\Omega}$ $= 0.5w$	$P_{LSB} = \frac{m^2 P_C}{4}(w)$ $= \frac{1^2 \times 0.5}{4}$ $= 0.125w$	$P_{USB} = \frac{m^2 P_C}{4}(w)$ $= \frac{1^2 \times 0.5}{4}$ $= 0.125w$	$P_T = 0.5 + 0.125 + 0.125(w$ $= 0.187$
(iii) Over 100% Modulation	$m = \frac{0.9-(-0.2)}{0.9+(-0.2)} \times 100\%$ $= 157\%$	$P_c = \frac{V_C{}^2}{2R}(w)$ $= \frac{1^2}{2 \times 1\Omega}$ $= 0.5w$	$P_{LSB} = \frac{m^2 P_C}{4}(w)$ $= \frac{1.57^2 \times 0.5}{4}$ $= 0.308w$	$P_{LSB} = \frac{m^2 P_C}{4}(w)$ $= \frac{1.57^2 \times 0.5}{4}$ $= 0.308w$	$P_T = 0.5 + 0.308 + 0.308(w$ $= 0.279$

Results:

Discussion:

Precaution:

EXPERIMENT NO: 2

Experiment Name: To Study Single Side Band (SSB) Modulation.

Objective:

A. To study the operation of AM modulator with Suppressed Carrier.
B. To Study Single Side Band (SSB) Generation.

Equipment:-

vi. Modules ACL-01
vii. Power Supply
viii. 20MHZ Oscilloscope
ix. Connecting Links
x. Frequency Counter

Note: Keep all the switch faults in OFF position

PRE-LAB TASK:-

Study types of SSB filter particularly Ceramic filter, SSB generation methods. Implement a low pass filter/ tunable filter/ Ceramic Filter. Test the circuit on any software of your choice before final implementation. Your task report must contain Circuit Diagram, description, analysis result produced by the software**.**

THEORY:-

Signal Side Band Transmission (SSB) :

Single sideband (SSB) AM is a radio communication technique in which the transmitter suppresses one sideband and therefore transmits only a single sideband. Or We can say that it is a refinement of the technique of amplitude modulation designed to be more efficient in its use of electrical power and bandwidth.

Amplitude modulation typically produces a modulated output signal that has twice the bandwidth of the modulating signal, with a significant power component at the center carrier frequency. Single sideband modulation improves this.

In single sideband; carrier is not transmitted so there is a reduction by 50% of the transmitted power i.e. - 3dBm. Because of SSB, only one sideband is transmitted, so there is a further reduction by 50% in transmitted power i.e. -3dBm (+) -3dBm = -6dBm.

Finally, because only one sideband is received, the receiver’s bandwidth is reduced by one half. Thus effectively reducing the required power by the Modulator is- 50% (-3dBm (+) -3dBm (+) -3dBm = -9dBm).

If a demodulator bandwidth can be reduced by 50%: the needed transmitter power is also reduced by 50%, i.e., the demodulator Signal to Noise Ratio (SNR) is improved as the demodulator bandwidth is reduced.

In SSB we transmit only one sideband as shown in figure 1.

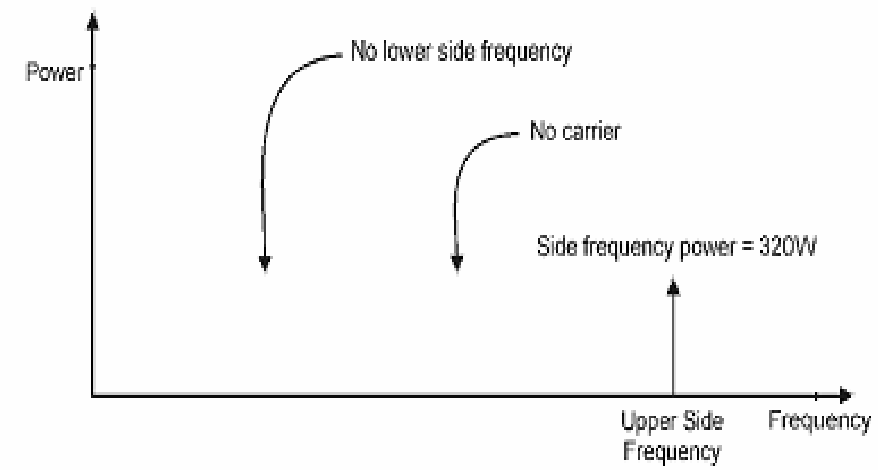


Figure 1

The bandwidth of an SSB system is equal to the range of frequencies present in the information waveform where as a DSB signal has a bandwidth twice as wide as the highest frequency component in the information signal. This also means a greatly reduced bandwidth for the system. In figures 1 we are transmitting just a single frequency.

The SSB Modulator:

The design of the SSB modulator is accomplished in two stages. First we generate a DSBSC signal and then remove the lower sideband to achieve the final SSB result.

Generating the DSBSC Signal:

To do this, we use a balanced modulator. The principle of this circuit is shown in figure 2.

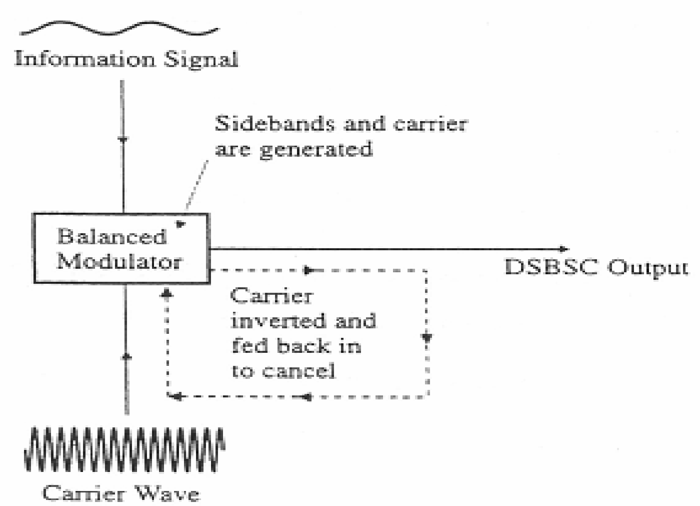


Figure 2

Internally, the balanced modulator generates the AM waveform, which includes the carrier and both sidebands. It then offers the facility to feed a variable amount of the carrier back into the modulator in anti-phase to cancel the carrier output.
In this way we can balance out the carrier to suppress it completely leaving just the required DSBSC waveform same as shown in fig 3.

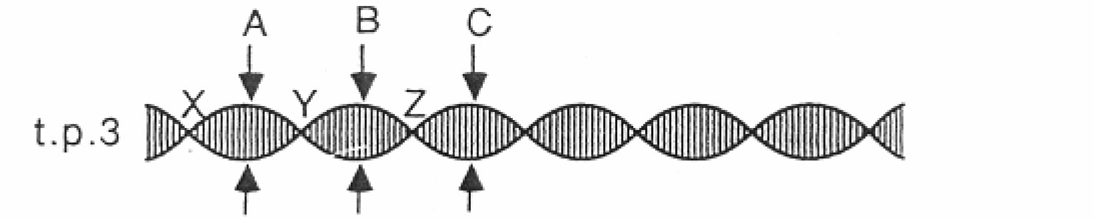


Figure 3

From DSBSC to SSB:

The DSBSC signal consists of the two sidebands, one of which can be removed by passing them through a band pass filter. On the modulator this is achieved as shown in figure 4.

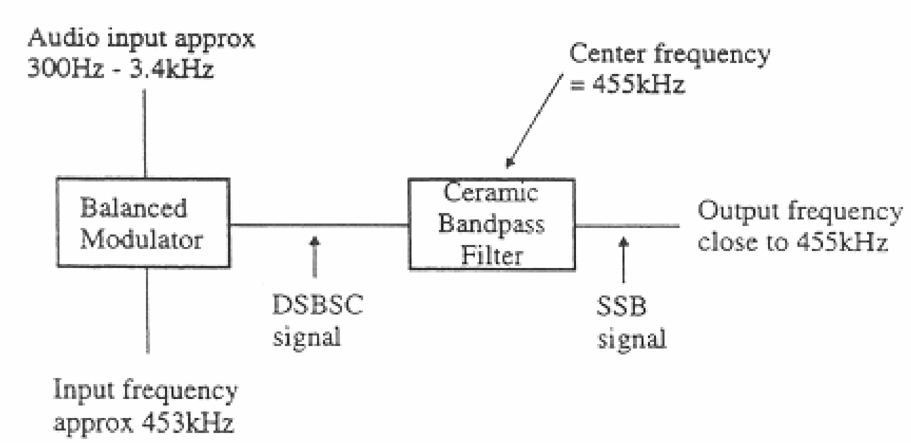


Figure 4

The inputs to the balanced modulator comprise the modulating signal, which extend from 300Hz to 3.4 KHz and the carrier signal of frequency 450KHZ.

A ceramic band pass filter (455KHZ) passes only a narrow range of frequencies with a sharp cut-off outside of its pass band.

A. To study the operation of AM modulator with Suppressed Carrier.

PROCEDURE & OBSERVATIONS:-

1) Carryout the connections modules ACL-01 as shown in fig-4.11 (See refer book)
2) Power the modules with the supply and carryout the following presetting**:**
3) **Function generator sine wave:** **Freq. about** $f_m = \frac{1}{T} = 1 \times \frac{5ms}{5} = 1KHz$ **1KHz, amplitude/Level about 1Vp-p**.

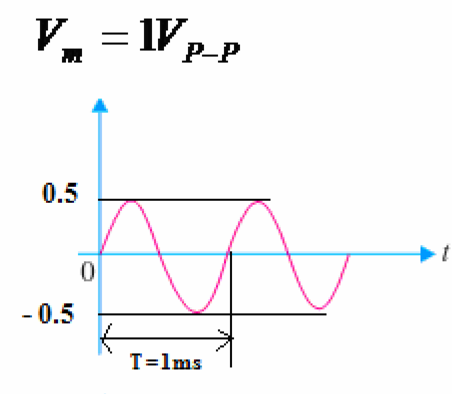


FIG.1.1: Modulating Signal

4) **VCO**: **Level about,** $V_c = 2V_{p-p}$ **,Freq. about 457 KHz. Switch ON 500KHz**

$$f_c = 454\,KHz\,, T = \frac{1}{5} \times 11\mu s = 2.2\mu s,$$

$$\therefore\ f_c = \frac{1}{T} = \frac{1}{2.2 \times 10^{-6}} = 454\,KHz$$

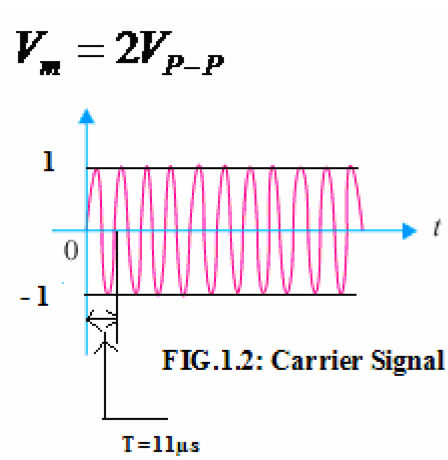
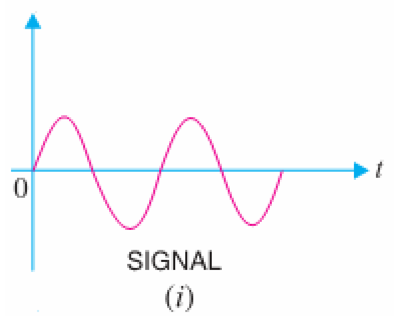
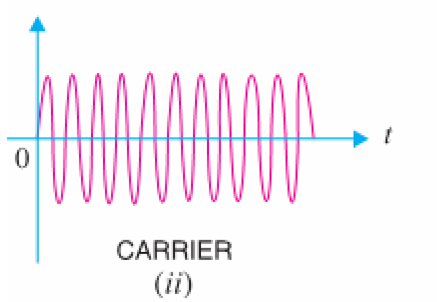


FIG.1.2: Carrier Signal

5) Balanced modulator carrier nulls completely **clock wise out level** in intermediate position.
6) Connect the oscilloscope to the inputs of the modulator (**SIGNAL IN** and **CARRIER IN**) and detect the modulating signal and carrier signal, draw their waveforms.(**OR See Lab book figure-4.12A/B**)





7) Move the probe from point **SIGNAL IN** to Post **RF OUT** (output of the modulator) where a signal modulated in amplitude is detected, draw the waveform.**(OR See Lab book fig.4.12 C)**

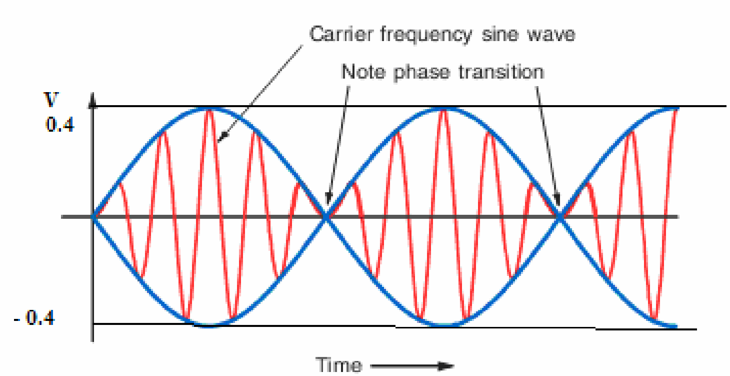


FIG.1.5: Modulated Signal

Prepared By: Md. Firoz Ahmed, Lecturer, Dept. of ICE, R.U.Bangladesh.

8) Vary the amplitude of the modulating signal and check the corresponding variation of the modulated signal. Draw the respective waveforms.
9) Vary frequency and waveform of the modulating signal and check the corresponding variations of the modulated signal. Draw the respective waveforms.

(B) To Study Single Side Band (SSB) Generation.

PROCEDURE & OBSERVATIONS:-

SSB generation:

1) Carryout the connections modules ACL-01 as shown in fig-4.14 (See refer book)
2) Power the modules with the supply and carryout the following presetting**:**
3) **Function generator sine wave: Freq. about 3KHz**

   $f_m = \frac{1}{T} = 1 \times \frac{0.5ms}{5} = 3KHz$ **, amplitude/Level about 1Vp-p**.

$$V_m = 1V_{P-P}$$

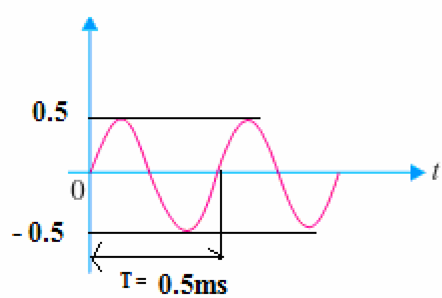


FIG.1.1: Modulating Signal

4) **VCO**: **Level about,** $V_c = 2V_{p-p}$, **Freq. about 454/457 KHz.**

$$f_c = 454\,KHz\,, T = \frac{1}{5} \times 11\mu s = 2.2\mu s,$$

$$\therefore f_c = \frac{1}{T} = \frac{1}{2.2 \times 10^{-6}} = 454\,KHz$$

$$V_m = 2V_{P-P}$$

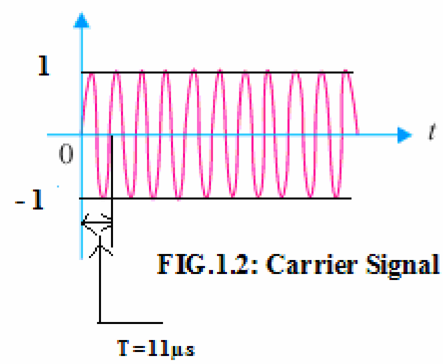


FIG.1.2: Carrier Signal

5) Balanced modulator carrier nulls completely **clock wise out level** in intermediate position.
6) Connect the output of the balanced modulator1 to the input of the 455 kHz ceramic filter.
7) With the oscilloscope examine the output signal of the filter and check that it is a sine wave. Why it's a pure sine wave?
8) Measure the frequency **fc** of the carrier (Post **CARRIER IN**), **fm** of the modulating signal (Post **SIGNAL IN**) and **Fssb** of the SSB signal across the output of the filter (Post **OUT**).
9) Check that: **Fssb = fc + fm** .This means that the band extracted by the filter corresponds to the upper sideband**.(See Lab book FIG. 4.13A).**
10) Repeat the last measurements setting the frequency of the carrier to 458 kHz you obtain **Fssb = fc – fm**, this means that the band extracted by the filter corresponds to the lower sideband.
11) Increase the frequency of the modulating signal and check that the SSB signal attenuates and tends to annul. Explain the reason.

OBSERVATION TABLE:

Side band Name	**Calculated SSB frequency,** F_{SSB} **(KHz)**	**Measured SSB frequency,** $F_{SSB} = \frac{1}{T}(KHz)$	**Error%**
Lower Side band frequency, $F_{SSB} = f_C - f_m$ **(KHz)**	$F_{SSB} = 454 - 3$ $= 451(KHz)$	$F_{SSB} = \frac{0.5\mu s}{5} \times 2.5$ $= 400(KHz)$	$\frac{(451-400)}{451} \times 100\%$ $= 11.30\%$
Upper Side band frequency, $F_{SSB} = f_C + f_m$ **(KHz)**	$F_{SSB} = 454 + 3$ $= 457(KHz)$		$\frac{(457-400)}{457} \times 100\%$ $= 12.4\%$

Results:

Discussion:

Precaution:

EXPERIMENT NO: 3

Experiment Name: To Study Single Side Band (SSB) AM Reception.

Objective:

A) To Study Single Side Band (SSB) AM Reception Using Product Detector.

Equipment:-

xi. Modules ACL-01
xii. Power Supply
xiii. 20MHZ Oscilloscope
xiv. Connecting Links
xv. Frequency Counter

Note: Keep all the switch faults in OFF position

THEORY:-

Signal Side Band Transmission (SSB) :

Single sideband (SSB) AM is a radio communication technique in which the transmitter suppresses one sideband and therefore transmits only a single sideband. Or We can say that it is a refinement of the technique of amplitude modulation designed to be more efficient in its use of electrical power and bandwidth.

Amplitude modulation typically produces a modulated output signal that has twice the bandwidth of the modulating signal, with a significant power component at the center carrier frequency. Single sideband modulation improves this.

In single sideband; carrier is not transmitted so there is a reduction by 50% of the transmitted power i.e. - 3dBm. Because of SSB, only one sideband is transmitted, so there is a further reduction by 50% in transmitted power i.e. -3dBm (+) -3dBm = -6dBm.

Finally, because only one sideband is received, the receiver's bandwidth is reduced by one half. Thus effectively reducing the required power by the Modulator is- 50% (-3dBm (+) -3dBm (+) -3dBm = -9dBm).

If a demodulator bandwidth can be reduced by 50%: the needed transmitter power is also reduced by 50%, i.e., the demodulator Signal to Noise Ratio (SNR) is improved as the demodulator bandwidth is reduced.

In SSB we transmit only one sideband as shown in figure 1.

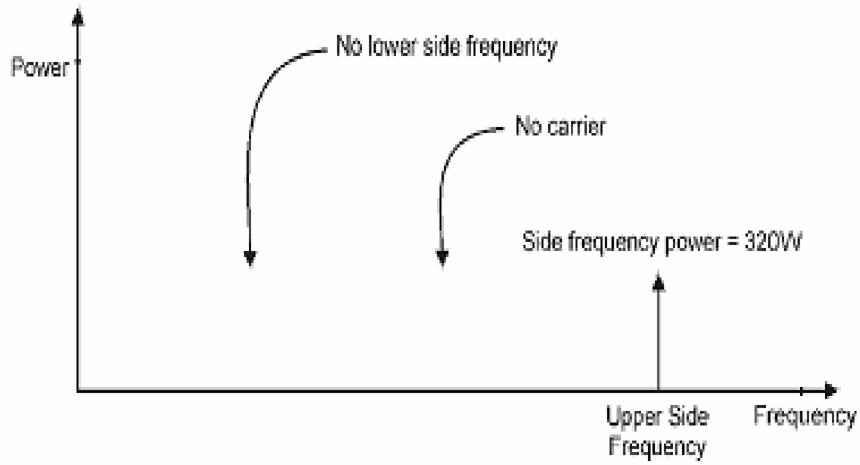


Figure 1

The bandwidth of an SSB system is equal to the range of frequencies present in the information waveform where as a DSB signal has a bandwidth twice as wide as the highest frequency component in the information signal. This also means a greatly reduced bandwidth for the system. In figures 1 we are transmitting just a single frequency.

The SSB Modulator:

The design of the SSB modulator is accomplished in two stages. First we generate a DSBSC signal and then remove the lower sideband to achieve the final SSB result.

Generating the DSBSC Signal:

To do this, we use a balanced modulator. The principle of this circuit is shown in figure 2.

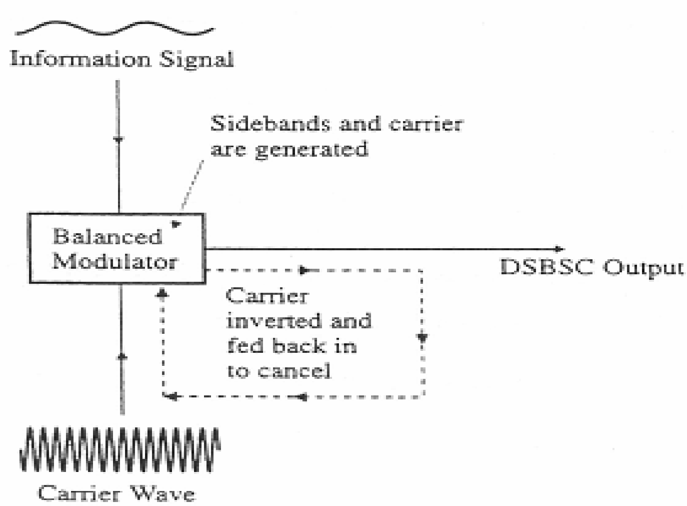


Figure 2

Internally, the balanced modulator generates the AM waveform, which includes the carrier and both sidebands. It then offers the facility to feed a variable amount of the carrier back into the modulator in anti-phase to cancel the carrier output.
In this way we can balance out the carrier to suppress it completely leaving just the required DSBSC waveform same as shown in fig 3.

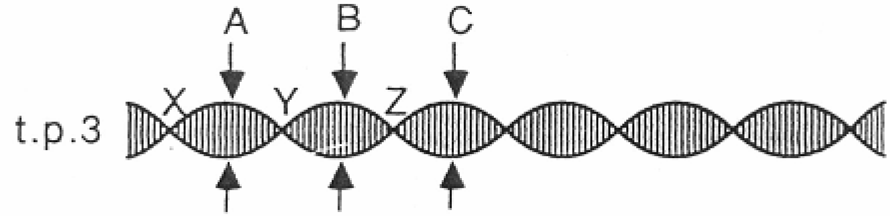


Figure 3

From DSBSC to SSB:

The DSBSC signal consists of the two sidebands, one of which can be removed by passing them through a band pass filter. On the modulator this is achieved as shown in figure 4.

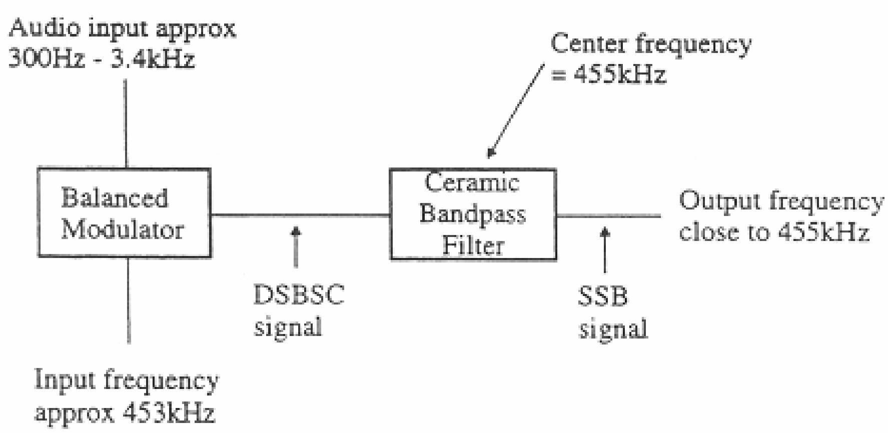


Figure 4

The inputs to the balanced modulator comprise the modulating signal, which extend from 300Hz to 3.4 KHz and the carrier signal of frequency 450KHZ.

A ceramic band pass filter (455KHZ) passes only a narrow range of frequencies with a sharp cut-off outside of its pass band.

SSB Demodulator:

We are using product detector to demodulate the single sideband modulated wave.

Product Detector :

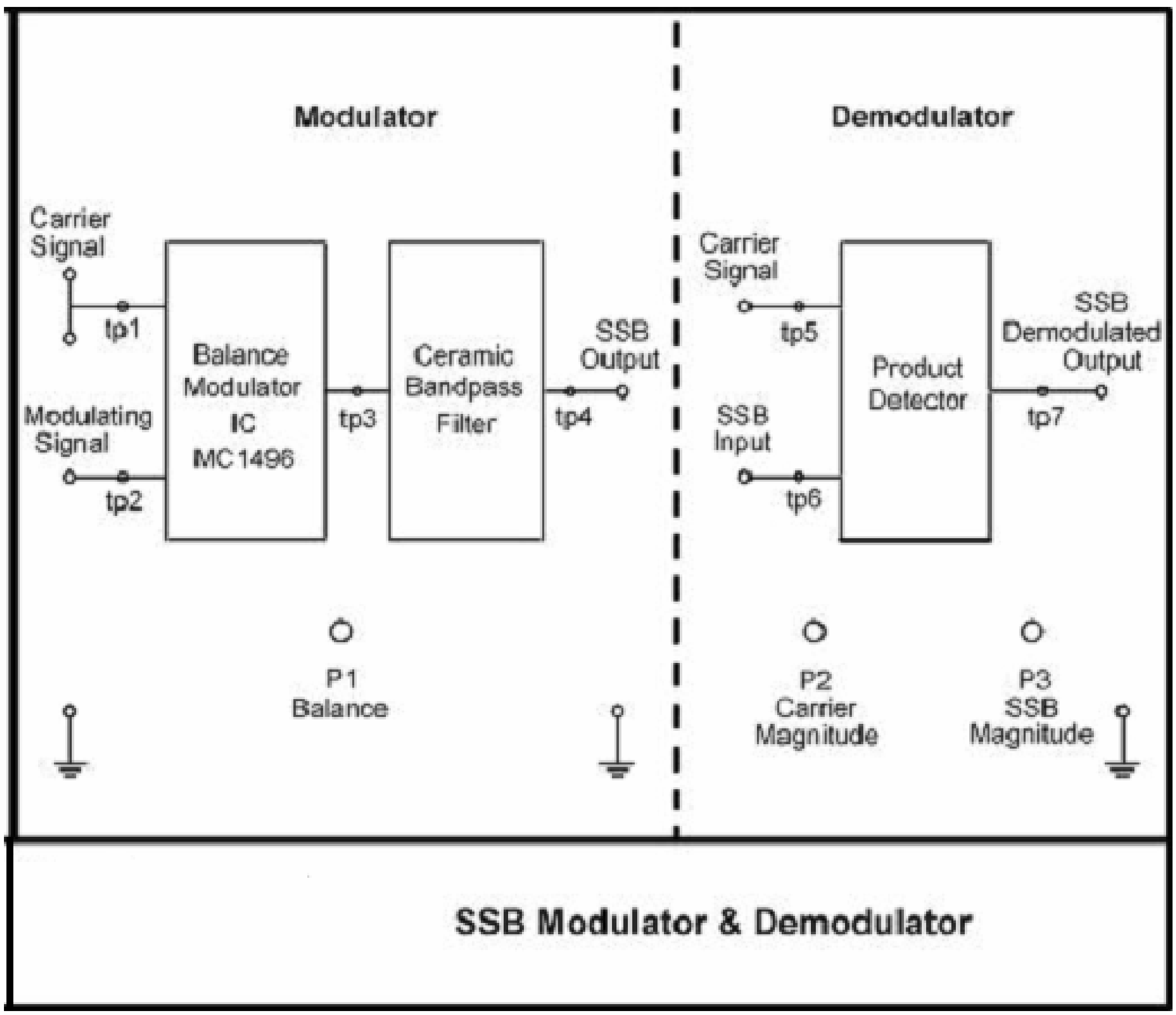
A product detector is a demodulator which accepts a modulated wave and a carrier wave. The simplest form of product detector multiplies an incoming signal by its carrier with the same frequency and phase as the carrier of the incoming signal. This mixing process results in the generation of two new frequency components.

1. A component whose frequency is the sum of the two input frequencies:
2. A component whose frequency is the difference between the two input frequencies.

A low-pass filter at the output of the product detector rejects all frequencies except the difference frequency. Consequently, any slight difference in frequency between the modulator output and carrier frequency will results audio frequency at the product detector's output.

Advantages of product detector:

1. The product detector can decode over modulated AM, AM with suppressed carrier, and SSB in addition to regular AM.
2. A signal demodulated with a product detector will have a higher signal to noise ratio than the same signal demodulated with an envelope detector.



PROCEDURE & OBSERVATIONS:-

1) Carryout the connections modules ACL-01 as shown in fig-4.14 (See refer book)
2) Power the modules with the supply and carryout the following presetting**:**
3) **<u>Function generator sine wave:</u> Freq. about 3 KHz**

   $f_m = \frac{1}{T} = 1 \times \frac{0.5ms}{5} = 3KHz$ **, amplitude/Level about 1Vp-p**.

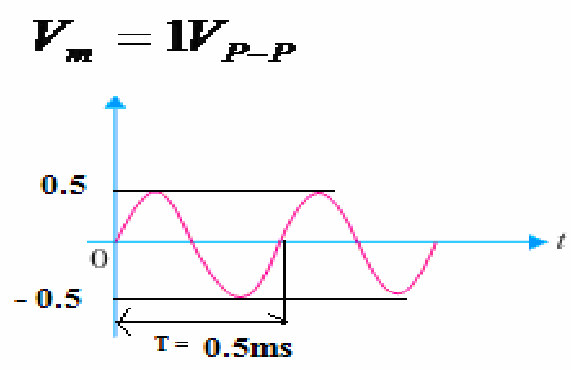


FIG.1.1: Modulating Signal

4) **<u>VCO</u>: Level about,** $V_c = 2V_{p-p}$ **, Freq. about 454/457 KHz.**

$$f_c = 454\,KHz, T = \frac{1}{5} \times 11\mu s = 2.2\mu s,$$

$$\therefore f_c = \frac{1}{T} = \frac{1}{2.2 \times 10^{-6}} = 454\,KHz$$

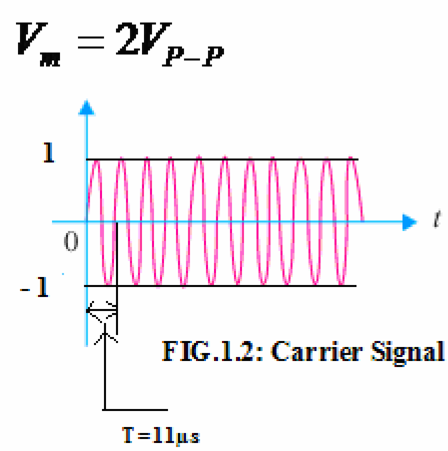


FIG.1.2: Carrier Signal

5) **Balanced modulator1:** **carrier null** pot **P7** in central position, so that the modulator is "balanced" and obtain an AM signal across the output with suppressed carrier, pot **P8** fully **clock wise.**

6) **Balanced modulator2:** **carrier null** pot **P9** in central position, so that the modulator is "balanced" and obtain an AM signal across the output with suppressed carrier, pot **P10** fully **clock wise.**

7) Connect the output of the balanced modulator1 to the input (**IN**) post of the 455 kHz ceramic filter.

8) With the oscilloscope examine the output signal of the filter and check that it is a sine wave. Why it's a pure sine wave?

9) Connect the output of ceramic filter to **SIGNAL IN** post of **balanced modulator2.**

10) Connect the output post of COLPITT'S OSCILLATOR to CARRIER IN post of **balanced modulator2.**

11) Connect the output post of balanced modulator2 to **IN** post of BAND PASS FILTER.

12) Connect the output post of BAND PASS FILTER to **IN** post of MIXER.

13) With the oscilloscope examine the output signal of the filter and check that it is a sine wave. Why it's a pure sine wave?

14) Connect the output post of BAND PASS FILTER to **RF IN** post of MIXER on ACL-02.

15) Connect the output post of LOCAL OSCILLATOR to **LO IN** post of MIXER. Keep pot P2 in fully clockwise position.

16) Connect **MIXER OUT** to **IN1** post of **Product Detector**

17) Connect **OUT** post of BFO [*BFO (Beat Frequency Oscillator) - an oscillator whose output frequency is approximately equal to the transmitter's carrier frequency and is input to product detector that recovers the message* signal.] to IN2 post of Product **Detector**. Keep pot P3 in fully clockwise position

18) Observe the final output at the OUT post of product detector by connecting this post to channel 2 of CRO. While doing this to observe the output clearly connect the input modulating signal to channel1 of CRO and tune local oscillator frequency about 1.02 MHz or in such a way that output frequency at PRODUCT DETECTOR should follow input frequency. If output frequency of VCO and BFO coincides you will get better result.

19) Increases the frequency of the modulating signal (SINE WAVE) and check that the detected signal attenuates and tends to null.

Observations:

Fc= fm= Vc= Vm=

Waveforms and Frequency Spectrum at different points:

Observation Point	Waveform	Frequency Spectrum
Modulated Signal		
BFO Output		
Product Detector Output		
Filter Output		

Results:

Discussion:

Precaution:

EXPERIMENT NO: 4

Experiment Name: To Study Double Side Band (DSB) AM Reception.

Objective:

A. To Study Double Side Band (DSB) AM Reception Using Envelop Detector via cable
B. To Study Double Side Band (DSB) AM Reception Using Envelop Detector via Antenna.

Equipment:-

xvi. Modules ACL-01
xvii. Power Supply
xviii. 20MHZ Oscilloscope
xix. Connecting Links
xx. Frequency Counter

Note: Keep all the switch faults in OFF position

THEORY:-

Demodulation of AM: -

The process of detection provides a means of recovering the modulating Signal from modulated signal. Demodulation is the reverse process of modulation.

The detector circuit is employed to separate the carrier wave and eliminate the side bands. Since the envelope of an AM wave has the same shape as the message, independent of the carrier frequency and phase, demodulation can be accomplished by extracting envelope.

An increased time constant RC results in a marginal output follows the modulation envelope. A further increase in time constant the discharge curve become horizontal if the rate of modulation envelope during negative half cycle of the modulation voltage is faster than the rate of voltage RC combination ,the output fails to follow the modulation resulting distorted output is called as " diagonal clipping : this will occur even high modulation index.

The depth of modulation at the detector output greater than unity and circuit impedance is less than circuit load (Rl > Zm) results in clipping of negative peaks of modulating signal. It is called "negative clipping "There are two methods.

1) Square law demodulator
2) Envelop detector

Envelop detector:

It is a simple and highly effective system. This method is used in most of the commercial AM radio receivers. An envelop detector is as shown below.

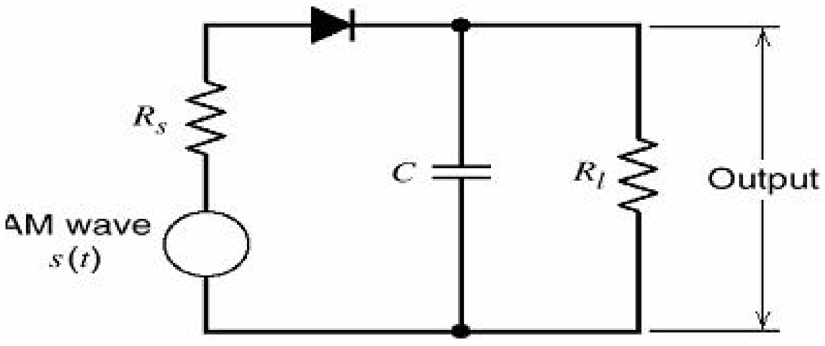


Figure: Envelope detector

During the positive half cycles of the input signals, the diode D is forward biased and the capacitor C charges up rapidly to the peak of the input signal. When the input signal falls below this value, the diode becomes reverse biased and the capacitor C discharges through the load resistor R_L.

The discharge process continues until the next positive half cycle. When the input signal becomes greater than the voltage across the capacitor, the diode conducts again and the process is repeated.

The charge time constant $(r_f + R_S)$C must be short compared with the carrier period, the capacitor charges rapidly and there by follows the applied voltage up to the positive peak when the diode is conducting.

That is the charging time constant shall satisfy the condition,

$$(r_f + R_s)C \ll \frac{1}{f_c}$$

On the other hand, the discharging time-constant R_L C must be long enough to ensure that the capacitor discharges slowly through the load resistor R_L between the positive peaks of the carrier wave, but not so long that the capacitor voltage will not discharge at the maximum rate of change of the modulating wave.

That is the discharge time constant shall satisfy the condition,

$$\frac{1}{f_c} \ll R_L C \ll \frac{1}{W}$$

Where 'W' is band width of the message signal.

The result is that the capacitor voltage or detector output is nearly the same as the envelope of AM wave.

PROCEDURE:-

11) Carryout the connections modules ACL-01 as shown in fig-1.14 (See refer book)

12) Power the modules with the supply and carryout the following presetting**:**

13) **<u>Function generator sine wave:</u> Freq. about** $f_m = \frac{1}{T} = 1 \times \frac{5ms}{5} = 1KHz$ **1KHz, amplitude/Level about 0.5Vp-p**.

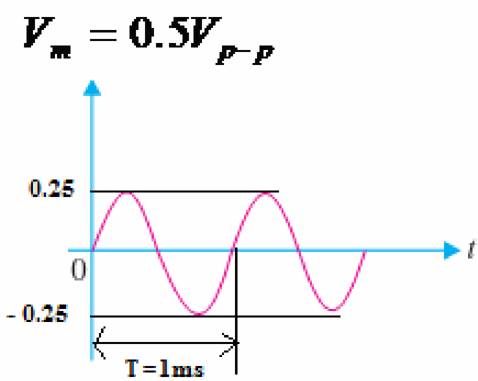


FIG.1.1: Modulating Signal

10) **<u>VCO</u>: Level about,** $V_c = 2V_{p-p}$ **,Freq. about 850 KHz. Switch ON 1500KHz**

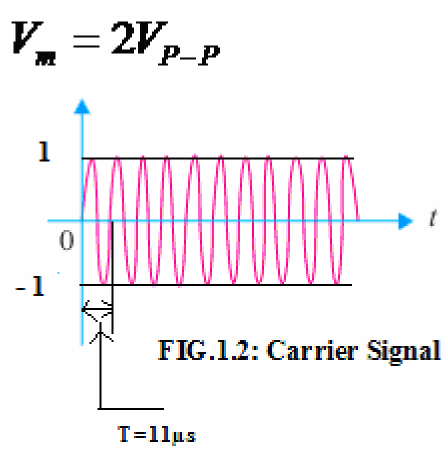


FIG.1.2: Carrier Signal

11) <u>Local Oscillator(ACL02):</u> 1300KHz, 2V

12) Then see lab book.

Envelope Detector:

1) Here the signal from the amplitude modulator from the previous practical is demodulated using an envelope detector. Confirm that the modulated signal is the same.
2) Use the oscilloscope to monitor the detector output and adjust the time constant. Note that a large carrier component is present if the time constant is too short.
3) Increase the time constant and note that the amplitude of the detected output decreases and becomes distorted as the filter cannot discharge in time to follow the required output.
4) Use the spectrum analyzer to observe the carrier component amplitude
5) Compare the original modulating signal with the detector output in both shape and phase at various time constants using the oscilloscope.

Observations:

Fc= fm= Vc= Vm=

Waveforms and Frequency Spectrum at different points and output of detector:

Observation Point	Waveform	Frequency Spectrum
Carrier		
Modulated Signal		
Detected Signal		

Results:

Discussion:

Precaution:

Prepared By: Md. Firoz Ahmed, Lecturer, Dept. of ICE, R.U.Bangladesh.