

Object :- To Study the amplitude modulation and demodulation.

Apparatus :- Transistor PNP/NPN registers, capacitors, Audio frequency oscillator, CRO, diode - OA79, multimeter, Regulator, power supply, bread board.

Theory :- Modulation is defined as a process by which some characteristics of a high frequency wave such as amplitude, frequency or phase is altered in accordance with instantaneous value of some other voltage. Modulating voltage is an information signal while the voltage undergoing alteration is a high frequency and is called carrier signal. Let the carrier voltage is expressed as

$$e_c = E_c \cos(\omega_c t + \phi)$$

where E_c is the amplitude of carrier (voltage) wave, ω_c is the angular frequency of the carrier wave, ϕ is phase angle.

The magnitude of carrier wave varies in accordance with the amplitude and frequency of the modulating voltage (as signal) i.e

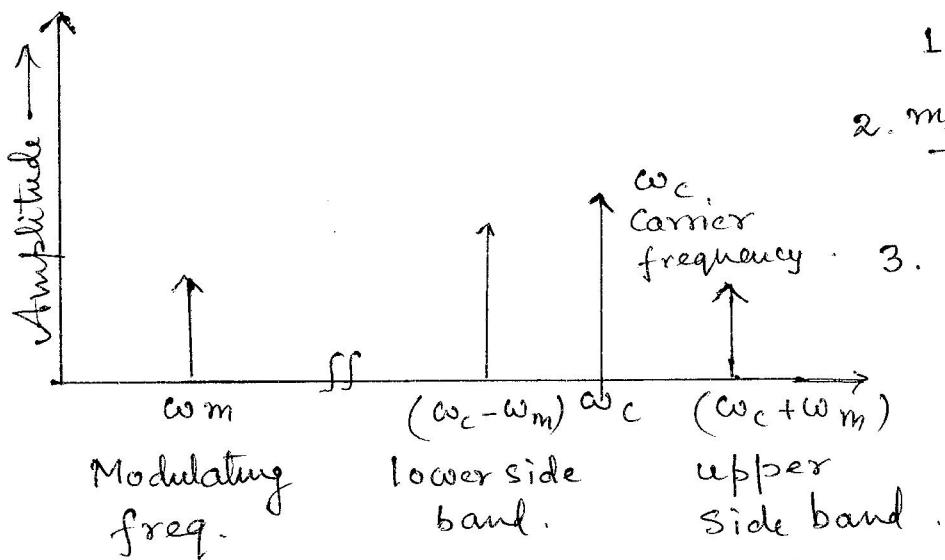
$$\text{Signal Voltage } e_m = E_m \cos \omega_m t \quad \dots \dots \dots (1)$$

$$\text{Carrier Voltage } e_c = E_c \cos(\omega_c t + \phi) \quad \dots \dots \dots (2)$$

The resultant modulated wave has the form

$$e = (E_c + K_x E_m \cos \omega_m t) \cos(\omega_c t + \phi) \quad \dots \dots \dots (3)$$

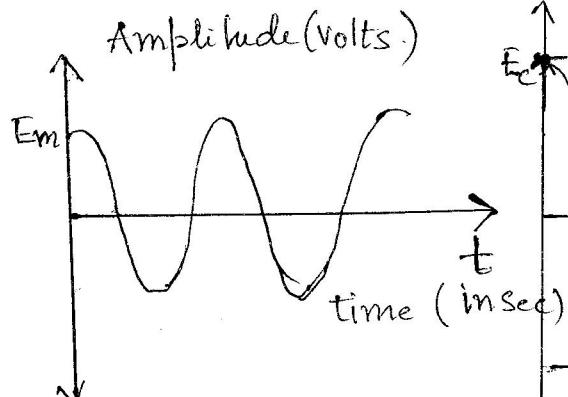
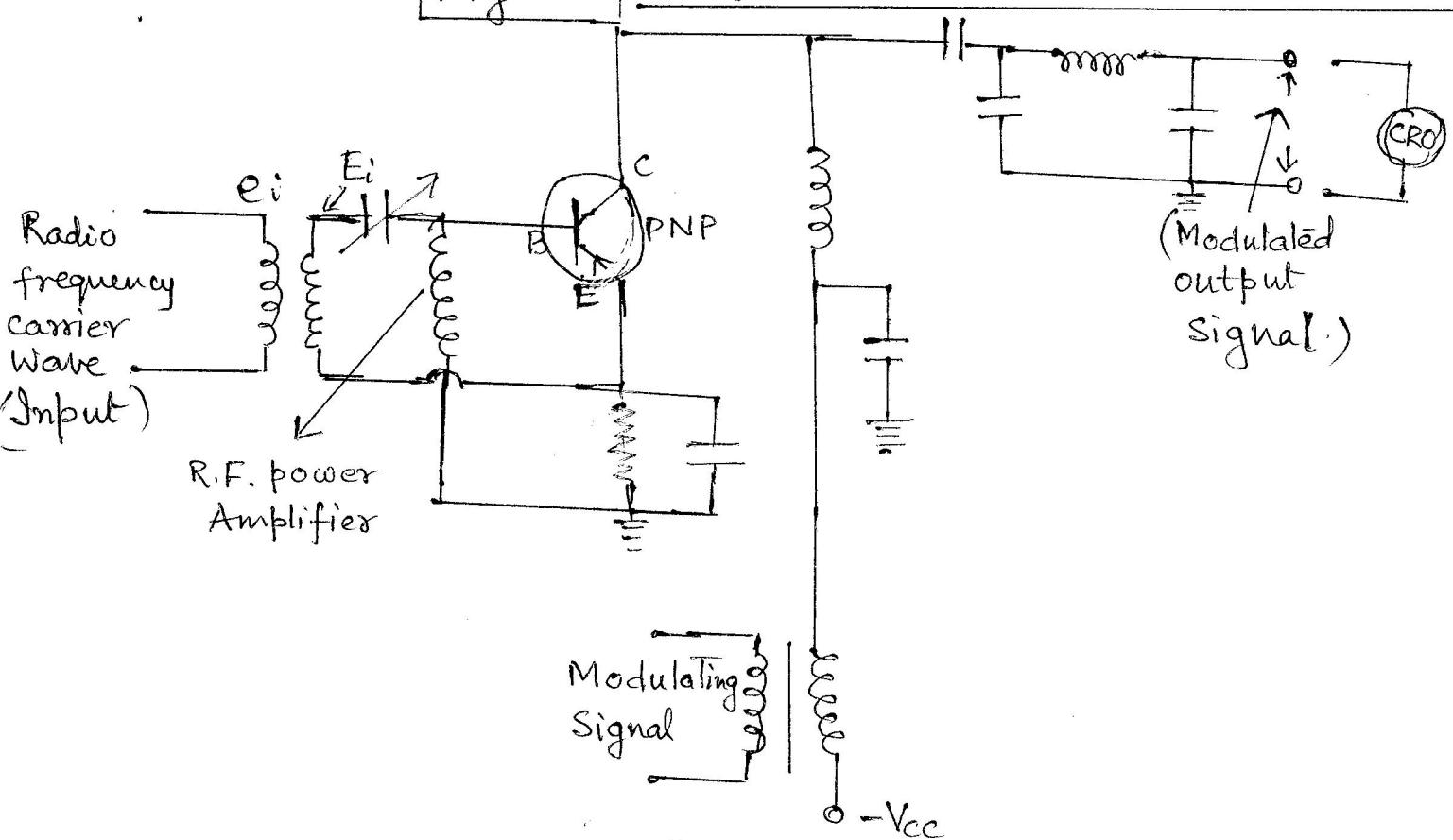
The amplitude factor ($E_c + K_x E_m \cos \omega_m t$) represents the sinusoidal variation of amplitude of the wave. K_x is proportionality factor which determines the maximum variation in amplitude for a given signal voltage E_m .



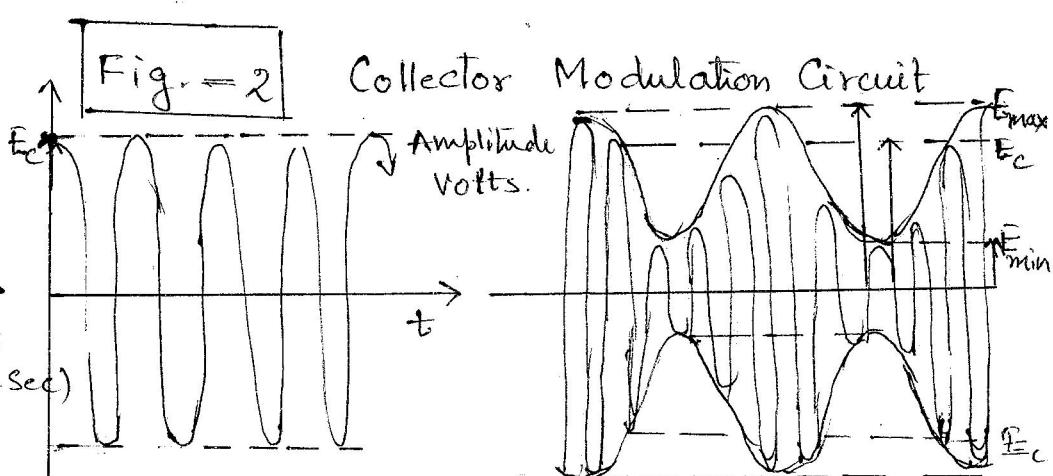
1. $E_c \cos \omega_c t$ = Original Carrier Voltage

2. $\frac{m_a E_c}{2} \cos(\omega_c + \omega_m)t$ Upper Side Band (USB)

3. $\frac{m_a E_c}{2} \cos(\omega_c - \omega_m)t$ Lower Side Band (LSB)



(a) Modulating Wave, ω_m
(Low frequency)



(b) Carrier wave, ω_c
(High frequency)

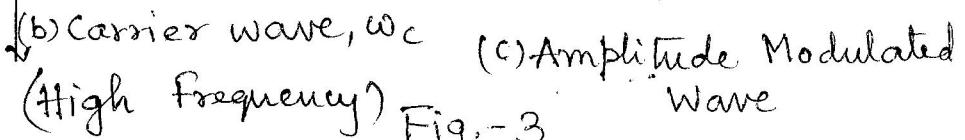


Fig. - 3

Phase Θ is taken to be zero because it plays no part in this process. Hence eq(3) can be written as

$$e = E_c \left(1 + \frac{k_\alpha E_m}{E_c} \cos \omega_m t \right) \cos \omega_c t$$

$$\text{or } e = E_c \left(1 + m_\alpha \cos \omega_m t \right) \cos \omega_c t \quad [\text{where } m_\alpha = \frac{k_\alpha E_m}{E_c}]$$

where m_α is a modulating factor (index)

$$\text{or } e = E_c \cos \omega_c t + \frac{E_c m_\alpha}{2} \cos (\omega_c + \omega_m) t + \frac{E_c m_\alpha}{2} \cos (\omega_c - \omega_m) t \quad \dots (4)$$

On the basis of the three terms in eq(4) which has different frequency terms, these frequencies are arranged in bands as shown in fig. 1

The magnitude of amplitude of both the upper and lower side bands is $\frac{m_\alpha}{2} E_c$. If m_α be unity, then each side band term is half the carrier voltage in amplitude.

The value of m_α is given by $m_\alpha = \frac{E_{\max} - E_{\min}}{E_{\max} + E_{\min}}$
 m_α ranges from zero to one.

The circuit diagram for modulation is shown in figure - 2.

Modulating signal has been applied to the collector in series with d.c. collector supply voltage, Transformer T, matches the output stage of modulating amplifier with the collector load of class C amplifier. Capacitor C often has low reactance to radio frequencies but high reactance to modulating signal frequencies. Thus it grounds the carriers and serves to keep radio frequencies out of modulating circuit and out of power supply, rectifying etc.

To obtain 100% modulating, maximum value of modulating voltage E must have equal power supply voltage V_{cc} . Under these conditions the r.f. output of the modulator amplifier is zero at the negative peak of the modulating signal. Then we have

$$E_{mm} = V_{cc}, I_{mm} = I_c$$

$$P_o = \frac{E_{mm} \times I_{mm}}{2} = \frac{V_{cc} I_c}{2}$$

The effective load in the modulation is given by

$$R_L = \frac{E_{mm}}{I_{mm}} = \frac{V_{cc}}{I_c}$$

Figure-3, shows the (a) Modulating wave (b) Carrier wave (c) Amplitude Modulated Wave.

Amplitude Demodulation

Demodulation is the process in which the original modulating voltage is recovered from the modulated wave. Demodulation is the reverse process of modulation.

In amplitude modulation envelope, the carrier amplitude has symmetrical variation of its positive and negative half cycles that correspond to modulating voltage. As this envelope is symmetrical, the mean value of detected or rectified r.f. current is zero. Therefore, unidirectional devices are used which make the modulated wave unsymmetrical either by wiping out the negative half r.f. cycles or by making positive and negative half

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cycles unequal. Consequently, d.c. or mean value of detection radio frequency current then rises and falls at modulating signal rate and may be separated by employing suitable filters.

The circuit diagram is shown in the fig. - 4. Linear diode detection utilises the rectification characteristic of diode in half wave rectifier. The load and the ripple will be very small and can be removed by the filter circuit in the output circuit.

Result :- The amplitude modulation and demodulation waveform can be traced on tracing paper when CRO is connected in the output circuit.

The waveform for modulated wave is shown in fig-3C and that of demodulated wave is shown in fig-5

Precautions :-

- (1) The connections should be made as shown in fig- and fig.-4 for modulation and demodulation and connections should be tight.
- (2) The power should be switched off after completion of the experiment and the open end of the wire should not be touched when the power is on.
- (3) The waveform should be traced on tracing paper with precaution which is formed on the screen of CRO.

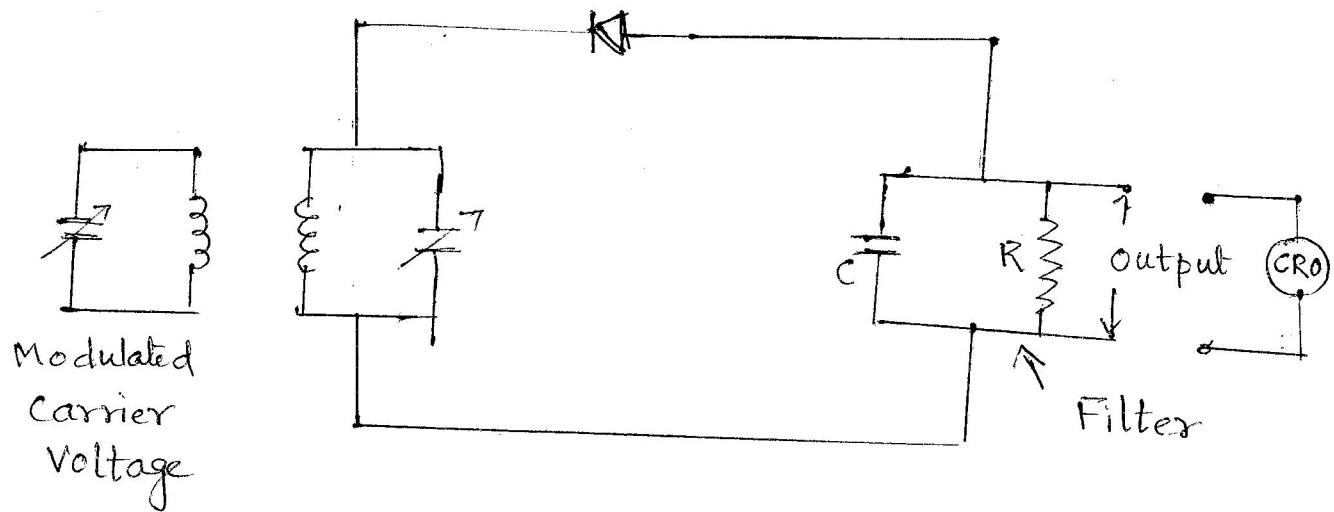


Fig. -4, Linear diode detector circuit

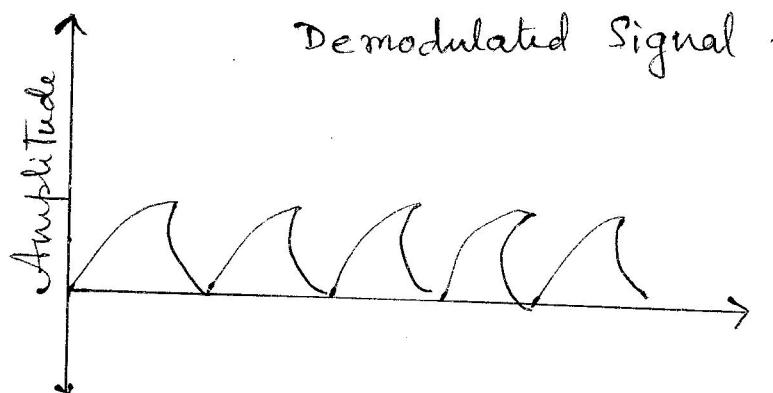


Fig. -5. Demodulated Signal.