Amplitude modulation and demodulation

Aim :- 1) To superimpose the audio signal on to the carrier wave to get modulated wave.

2) To calculate the modulation index from the in put wave and out put wave and comparing them.

3) To extract (demodulate) the audio signal from the modulated wave to compare the frequencies and amplitudes of in put audio signal and demodulated wave.

Apparatus :- Two signal generators, two CROs, two NPN transistors, transformer, two capacitors, five resistors, power supply and connecting terminals.

Formulae :- 1. Modulation index $M_1 = \frac{b}{a}$

Where b = Amplitude of the signal or audio wave

a = Amplitude of the carrier wave

2. Modulation index $M_2 = \frac{E_{cmax} - E_{cmin}}{E_{cmax} + E_{cmin}}$

Where E_{cmax} =Maximum peak to peak amplitude of the modulated wave

E_{cmin} = Minimum peak to peak amplitude of the modulated wave

Description :- In the circuit(Fig-1) of amplitude modulation two NPN transistors (T1 and T2) are connected in series such that the collector of T2 is connected to the emitter of T1. The two transistors are provided voltage divider bias with help of resistors and $+V_{cc}$. The carrier wave is fed to the base of the transistor T1 through a capacitor. The capacitor can filter dc, if any, in the ac carrier wave. So pure ac carrier wave reaches to the base of T1. Similarly an audio wave from a signal generator is given to the base of T2 through a resistor in series with a capacitor. Here to measure the in put signal CRO Y1- plates are connected in parallel to the audio signal generator. The emitter current of T1 is the collector current of T2. This collector current Of T2 is as per the audio signal strength. The collector current of T1 is the sum of the currents of emitter and base of T1. So the collector current is the combination of carrier wave and audio signal which is nothing but modulated signal. This modulated wave is given to the Y2 – plates of the CRO through an audio transformer which is connected in parallel to a capacitor.

The other part of the experiment is demodulation. To demodulate the modulated wave the circuit is connected as shown in the Fig-2. In this circuit a parallel combination of a resistor and a capacitor is in series with a diode. The modulated signal is given to the P of the diode and the out put or demodulated audio signal is drawn from the parallel combination of the capacitor and resistance by connecting it to the Y- plates of a CRO.

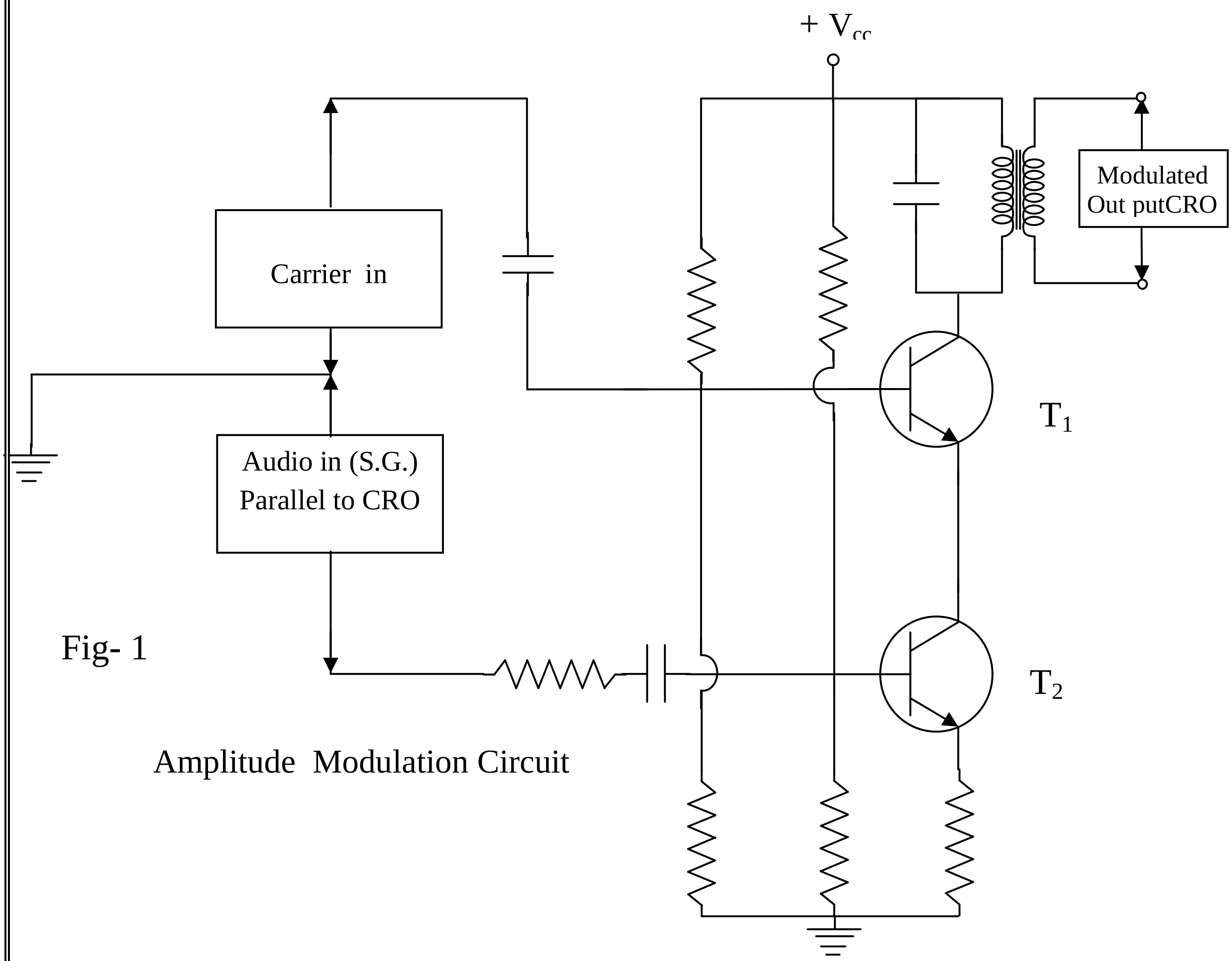
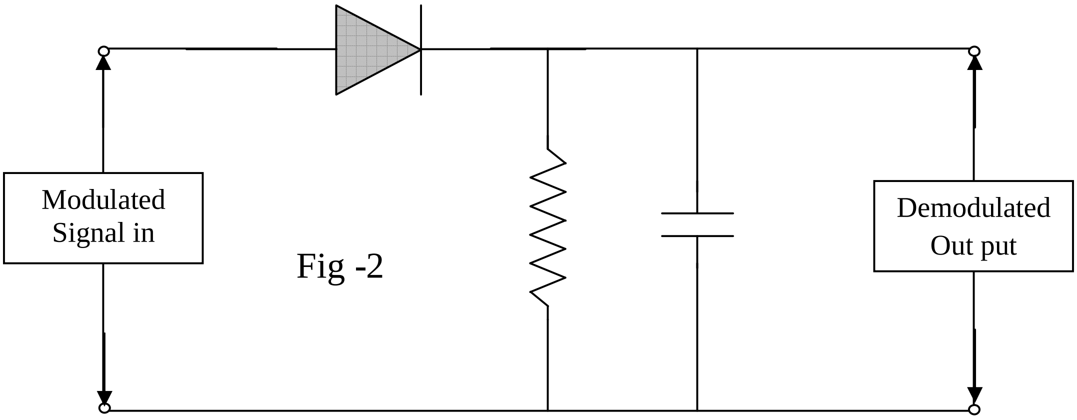


Fig- 1

Amplitude Modulation Circuit



Amplitude demodulation circuit

Theory :- Amplitude modulation (AM) is a technique used in electronic communication, most commonly for transmitting information via a radio carrier wave. AM works by varying the strength of the transmitted signal in relation to the information being sent.

As originally developed for the electric telephone, amplitude modulation was used to add audio information to the low-powered direct current flowing from a telephone transmitter to a receiver. As a simplified explanation, at the transmitting end, a telephone microphone was used to vary the strength of the transmitted current, according to the frequency and loudness of the sounds received. Then, at the receiving end of the telephone line, the transmitted electrical current affected an electromagnet, which strengthened and weakened in response to the strength of the current. In turn, the electromagnet produced vibrations in the receiver diaphragm, thus closely reproducing the frequency and loudness of the sounds originally heard at the transmitter.

In contrast to the telephone, in radio communication what is modulated is a continuous wave radio signal (carrier wave) produced by a radio transmitter. In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent side bands. This process is known as heterodyning. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Amplitude modulation that results in two side bands and a carrier is often called *double sideband amplitude modulation* (DSB-AM). This is the process taking place at the transmitting end.

At the receiving end the modulated signal is taken as the in put in to the receiver and the receiver extracts the original wave from the modulated wave and gives it as out put. This is the process of demodulation.

Modulation index

It is the measure of extent of amplitude variation about an demodulated maximum carrier. This quantity is also called as *modulation depth* and it indicates by how much the modulated variable varies around its 'original' level. For AM, it relates to the variations in the carrier amplitude. We compare the modulation indices both at the in put level and out put level as shown in the above equations.

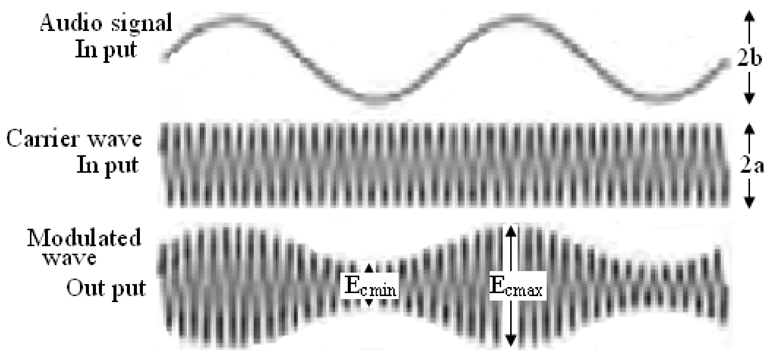


Fig - 3

Procedure :- The circuit is connected as shown in the Fig-1 for producing amplitude modulated wave. The frequency of the carrier wave is in MHz. First measure the peak to peak (2a) vertical voltage of the carrier wave of the Y2- plates on CRO screen, find the peak voltage (a). Note this value in the table-1.(This can be measured by connecting the CRO Y2-plates to the transformer secondary coil or directly to the carrier in.) Set the frequency of the audio signal to nearly 1 KHz and apply it to the base of T2 and adjust the time base of the CRO to observe at least two audio waves on the screen of the CRO. Also adjust the amplitude of the audio signal such that the audio wave in the modulated wave is completely observed on Y2-plates. Now the audio signal peak to peak voltage (2b) and the peak voltage (a) are measured from the Y1-plates and noted in table-1.

Now measure the maximum voltage (E_{cmax}) and minimum voltage (E_{cmin}) of the modulated signal from Y2-plates of CRO as shown in the Fig-3. Note them in the table-1. Repeat the experiment by changing the amplitude of the audio signal and note the values a, b, E_{cmax} and E_{cmin} in the table-1.

For demodulation, Y2-plates are disconnected from the secondary of the transformer. Now the secondary of the transformer is connected to demodulation circuit as in put. The out put of the demodulation circuit is connected to Y2-plates of CRO.

Now set the frequency (f_1) of in put audio signal to a convenient value and measure the time period and frequency (f_2) of the out put signal i.e. demodulated wave. These values are noted in the table-2. The experiment is repeated by changing the in put frequency. These frequency values ($f_1$and f_2) are found to be equal.

Similarly the amplitudes of the in put audio signal (b_1) and demodulated signals (b_2) can be compared as in the table-3. This part of the experiment is repeated by changing the amplitude of the in put audio signal (b_1). The ratio (b1/ b_2) is found to be constant.

Precautions :- 1) Before going to the experiment the amplitude of the carrier wave measured.

2) The amplitude of the in put audio signal should not exceed the amplitude of the carrier signal.

Results :- 1) The modulation index at in put terminal and at the out put terminal are found to be equal in modulation.

2) The frequency of the in put audio signal and frequency of the demodulated wave are found to be equal.

3) The ratio of the amplitude of the in put audio signal and amplitude of the demodulated wave is found to be constant.

Table -1

Measurement of peak voltage of in put signal (a)

Peak to peak (Vertical length). (l) = Divisions

Voltage Sensitivity. (n) = Volt/Div

Peak Voltage a = (nxl)/2 = Volts

S.No.	Measurement of b			$M_1 = \frac{b}{a}$	Measurement of E_{cmax}			Measurement of E_{cmin}			$M_2 = \frac{E_{cmax} - E_{cmin}}{E_{cmax} + E_{cmin}}$
	Peak to peak (Vertical) length. (Divisions) (l)	Voltage Sensitivity. (Volt/Div) (n)	Peak Voltage b = (nxl)/2 (volts)		Peak to peak (Vertical) length. (Divisions) (l)	Voltage Sensitivity. (Volt/Div) (n)	E_{cmax} = (nxl) (volts)	Peak to peak (Vertical length). (Divisions) (l)	Voltage Sensitivity. (Volt/Div) (n)	E_{cmin} = (nxl) (volts)	

Tables for demodulation or detection

Table – 2

Comparison of in put and out put frequencies

S.No.	In put applied frequency (f_1) (Hz)	Measurement of out put frequency			
		Peak to peak Horizontal length (l) (Divisions)	Time base (t) Sec/div	Period T=(l x t) Sec	Frequency $f_2 = \frac{1}{T}$ Hz

Table – 3

Comparison of in put and out put amplitudes

S.No.	In put amplitude b_1			Out put amplitude b_2			$\frac{b_1}{b_2}$
	Peak to peak (Vertical length) (Divisions) (l)	Voltage Sensitivity. (Volt/Div) (n)	Peak Voltage b_1=(nxl)/2 (volts)	Peak to peak (Vertical length) (Divisions) (l)	Voltage Sensitivit y (Volt/Div) (n)	Peak Voltage b_1=(nxl)/2 (volts)	

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