<u>EXPERIMENT 7:</u> AMPLITUDE MODULATION

Date: 17/02/2020

<u>Aim:</u> To study amplitude modulation and observe the waveforms for three different modulation indices.

<u>Apparatus:</u> Trainer board ST 2201 & 2202, power supply, connecting wires, CRO, function generator, carrier generator

<u>Theory/Equations:</u>

In communications, modulation means to vary some parameter of the high frequency carrier wave in proportion to the amplitude of the baseband or the modulating signal. A parameter of the carrier wave means, either of the following:

- amplitude
- frequency
- phase

Now when amplitude of the carrier wave is varied with respect to the amplitude of the baseband signal, the modulation incorporated is termed as amplitude modulation. The Fig 1.1 shows an AM wave

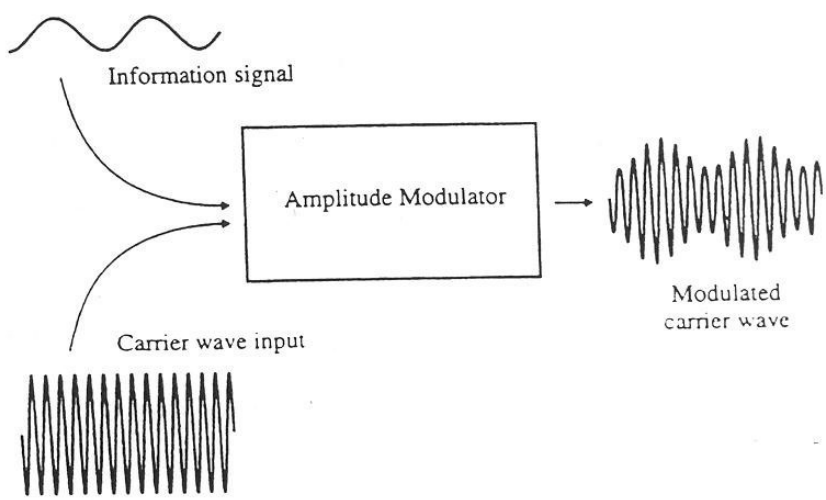


Fig. 1.1 Concept of AM wave

We go in for modulation of the carrier signal because if we want to transmit the baseband low frequency signal without any modulation the size of the antenna required will be too large.

Depth of Modulation:
The amount by which the amplitude of the carrier wave increases and decreases depends on the amplitude of the information signal and is called the 'depth of modulation'. The depth of modulation can be quoted as a fraction or as a percentage.

$$\text{Percentage Modulation} = \frac{Vmax - Vmin}{Vmax + Vmin}\ X\ 100\%$$

Description of different blocks of the circuit:

(1) Input audio amplifier section:
This section is used to amplify low level audio signal coming from Mic/Loudspeaker and give it to A.M. Modulator section for live A.M. modulation. It consist pre-amplifier stage and output amplifier stage. Transistor BC148B is used for the pre-amplification. Input signal from the Mica is given to BC148B through coupling capacitor. Output of BC148B is given to pin 10 of IC 810 which contains audio amplifier, driver & output stage. The amplified output is obtained at pin 16 which can be used as modulating signal.

(2) Modulating audio signal generator section:
IC 8038 is used to generate sine wave signal. Pot P2 is used to vary its frequency .The range is 20 Hz to20KHz.Two 100k pots are used to adjust the peaks of the sine wave and 1K preset is used for duty cycle adjustment. The sine wave signal is available at pin 2 of IC8038. This signal is amplified by IC LM356.Pot P2 is used to vary the amplitude of sine wave signal.

(3) RF Carrier oscillator section:
Transistor BC107B is used to generate RF sine wave signal. Pot P1 is used to vary its frequency from 200 kHz to1MHz.Here transistor Q2, Q3, Q4 and Q5 is used to amplify the RF signal of Q1. Pot P2 is used to vary the amplitude of sine wave from 0 to 10 Vpp.

(4) Double balanced amplitude modulator section:
IC 1496 is used as balanced modulator. The modulating audio signal is connected at pin 1 through buffer transistor Q1.This IC has two inputs as it works as balanced modulator. The Second input can be connected at pin 4 through buffer transistor Q2.The RF carrier signal is connected at pin 8 through coupling capacitor from RF carrier oscillator section. The modulated outputs are available at pin 12 and 6 of this IC which are then balanced amplified by Q3, Q4, Q5 and Q6.The final balanced modulated output is available at output terminals. Bal-A preset is used to balance carrier signal while Bal-B preset is used to balance input audio signal. 1K preset is used to adjust output zero DC level.

(5) DC voltage generating section:
To observe the effect of dc voltages on AM modulating signal +1V dc and -8V to +8V dc voltage is required which is generated using IC741 and presets.

(6) Filter section:

Here notch filter of 455 KHz is designed using crystal. This filter is used to obtain suppressed carrier double side band modulated signal from DSB signal.

(7) AM demodulators:

(a) Diode detector circuit:

This circuit consists detector diode OA79 and capacitor C1, C2,C3 and load resistor R1. It works as an envelope detector circuit.R1 and C forms a low pass filter meant to reduce the carrier frequency ripple in the output.

(b) Product detector:

This section is similar to AM balance modulator section. the difference is only that input pin 8 is given RF carrier oscillator signal from RF carrier oscillator and pin 1 is given AM modulated signal from balanced modulator section. The output is product of these two signals which contains basic audio modulating signal which can be filtered by low pass filter.

(8) Output audio amplifier section:

This section is same as input audio amplifier section except pre-amplifier section.

(9) Power supply section:

The regulated power supply is used for different supply voltages. Using step down transformer, diode bridge and IC7805, 7815, 7915 we can obtain different DC supply voltages required for the operation of different blocks.

<u>Procedure</u>:

Modulation:

1. Fig. 1.2 shows the AM transmitter panel. Ensure that the following initial conditions exist on the board.
   - **a.** Audio input select switch in INT position:
   - **b.** Mode switch in DSB position.
   - **c.** Output amplifier's gain pot in full clockwise position.
   - **d.** Speakers switch in OFF position.

2. Turn on power to the **ST2201** board.

3. Turn the audio oscillator block's amplitude pot to its full clockwise (MAX) position, and examine the block's output (t.p.14) on an oscilloscope

4. Monitor, in turn, the two inputs to the balanced modulator & band pass filter circuits 1 block, at t.p.1 and t.p.9

5. Next, examine the output of the balanced modulator & band pass filter circuit 1 block (at t.p.3), together with the modulating signal at t.p.1 Trigger the oscilloscope on the t.p. 1 signal.

To determine the depth of modulation, measure the maximum amplitude (Vmax) and the minimum amplitude (V min) of the AM waveform at t.p.3, and use the following formula:

$$\text{Percentage Modulation}=\frac{Vmax-Vmin}{Vmax+Vmin}\ X\ 100\%$$

where V_{max} and V_{min} are the maximum and minimum amplitudes.

7. Now vary the amplitude and frequency of the audio-frequency sinewave, by adjusting the amplitude and frequency present in the audio oscillator block. Note the effect that varying each pot has on the amplitude modulated waveform. The amplitude and frequency amplitudes of the two sidebands can be reduced to zero by reducing the amplitude of the modulating audio signal to zero. Do this by turning the amplitude pot to its MIN position, and note that the signal at t.p. 3 becomes an un-modulated sine wave of frequency 1 MHz, indicating that only the carrier component now remains.

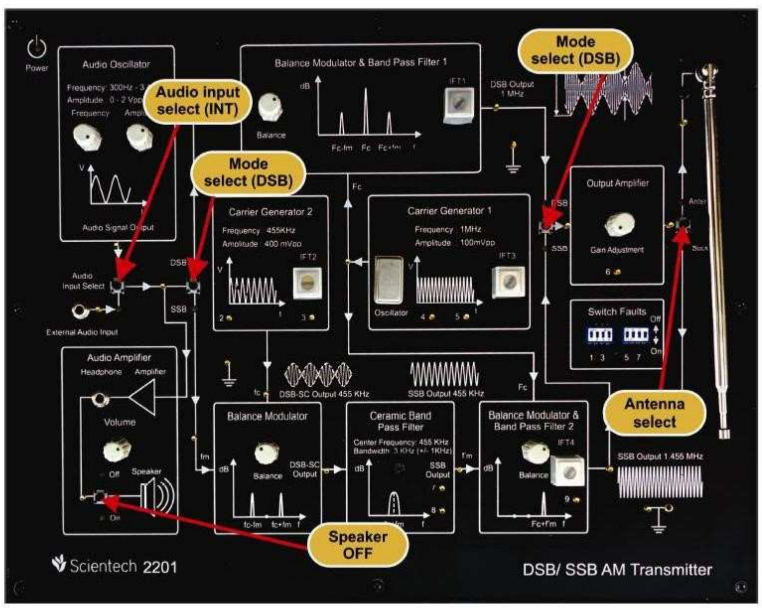


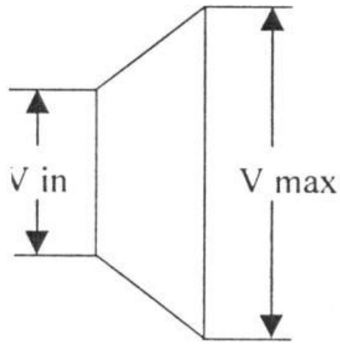
Fig. 1.2 AM transmitter

To calculate modulation index of DSB wave by trapezoidal pattern.

1. Repeat from step no. 1 to step no. 6

2. Now apply the modulated waveform to the Y input of the oscilloscope and the modulating signal to the X input.

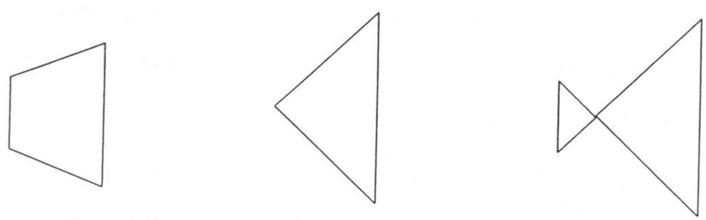
3. Press the XY switch, you will observe the waveform similar to the one given below:



Calculate the modulation index by substituting in the formula:

$$\text{Percentage Modulation}=\frac{Vmax-Vmi}{Vmax+Vmin}\ X\ 100\%$$

4. Some common trapezoidal patterns for different modulation indices are as shown



m<1 m=1 m>1

Demodulation:

1. Fig. 1.3 shows the AM receiver panel. Position the **ST2201** & **ST2202** modules, with the **ST2201** board the left, and a gap of about three inches between them.

2. Ensure that proper initial conditions exist on the **ST2201 & ST2202** board

3. Turn on power to the modules. We will now transmit the SSB waveform to the **ST2202** receiver. The mode of transmission can be selected by a selection switch (i.e. by an antenna or by a link).

4. On the **ST2202** module, monitor the output of the IF amplifier 2 block (t.p. 28) and turn the tuning dial until the amplitude of the monitored signal is at its greatest. Check that you have tuned into the SSB signal, by turning **ST2201**'s amplitude pot (in the audio oscillator block) to its MIN position, and checking that the monitored signal amplitude drops to zero. Return the amplitude pot to its MAX position

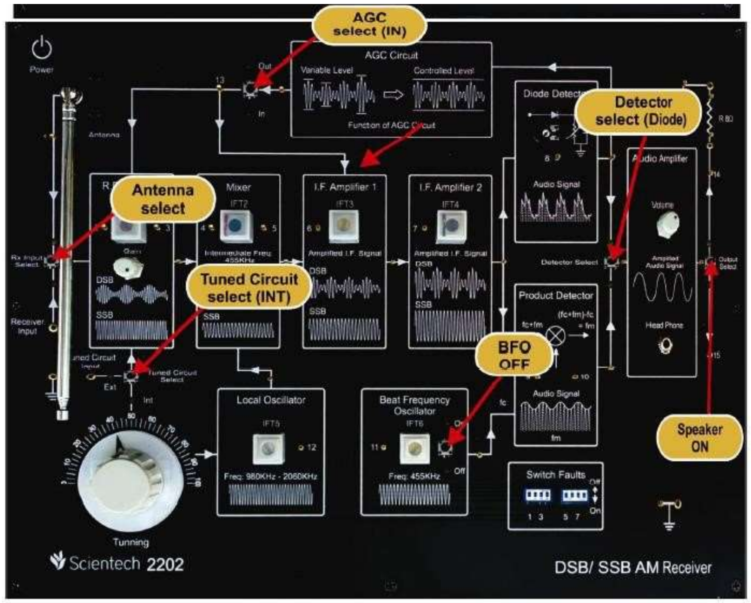


Fig. 1.3. AM Receiver

Observation Table:

V_{max} (in V)	V_{min} (in V)	Modulation Index(in %)	Remarks
3.0	1.4	31.81	Under-modulation
2.2	0	100.00	Perfect Modulation
1.6	-0.8	300.00	Over-modulation

In the above table,

Vmax = Maximum voltage of upper side band of AM modulated signal

Vmin = Minimum voltage of upper sideband AM modulated signal

Modulation Index = $\frac{Vmax-Vmin}{Vmax+Vmin}\ X\ 100\%$

Result/Output Waveforms:

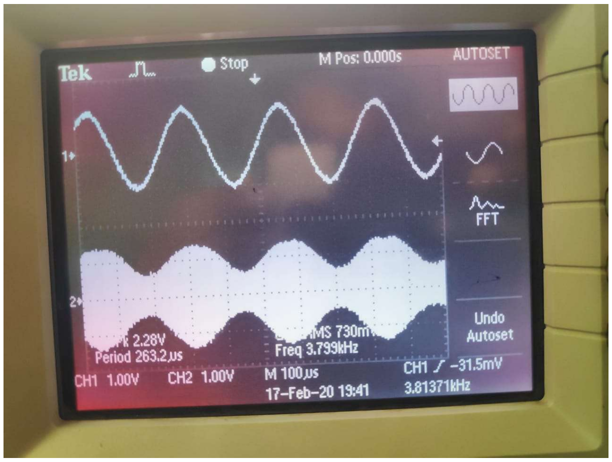


Fig 1. Under modulated AM Wave

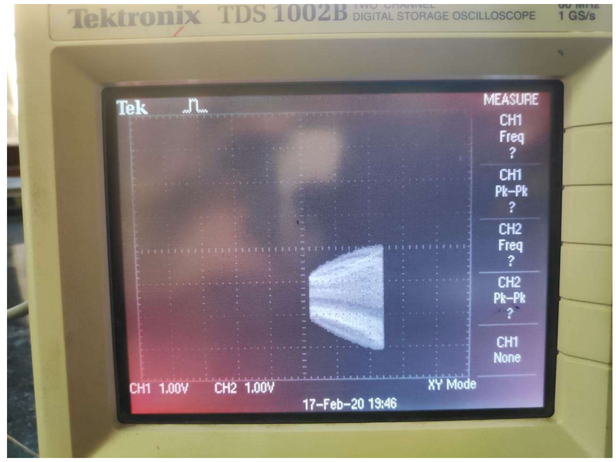


Fig 2. Under modulated AM Wave
XY Format

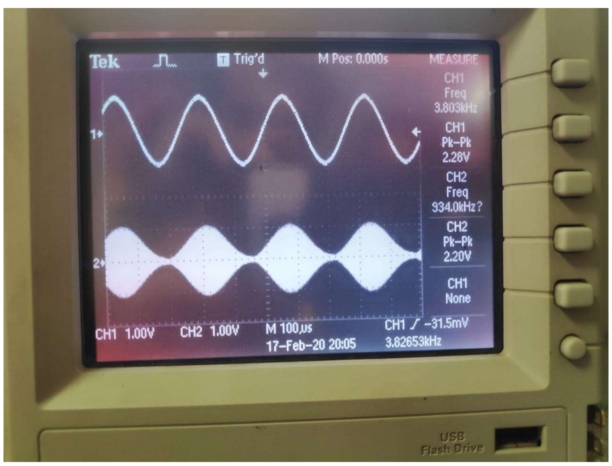


Fig 3. Perfectly modulated AM
Wave

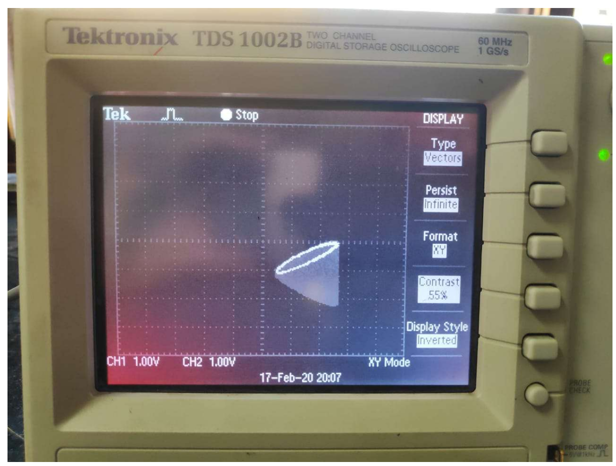
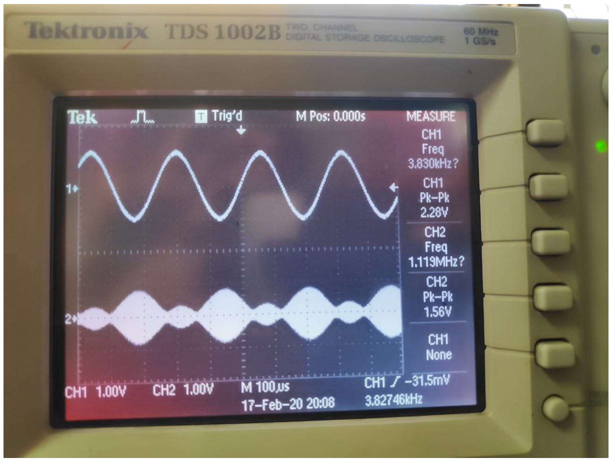


Fig 4. Perfectly modulated AM
Wave XY Format



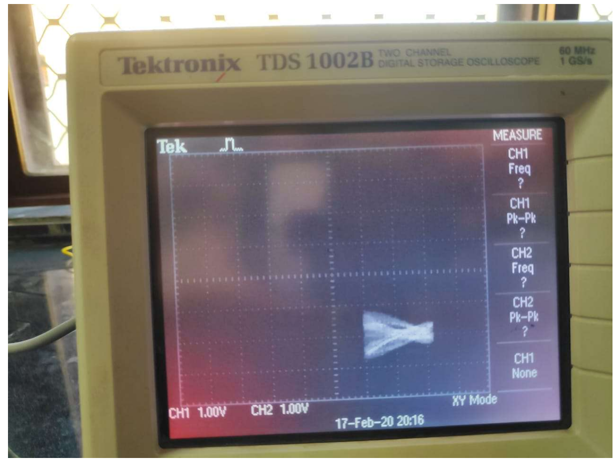
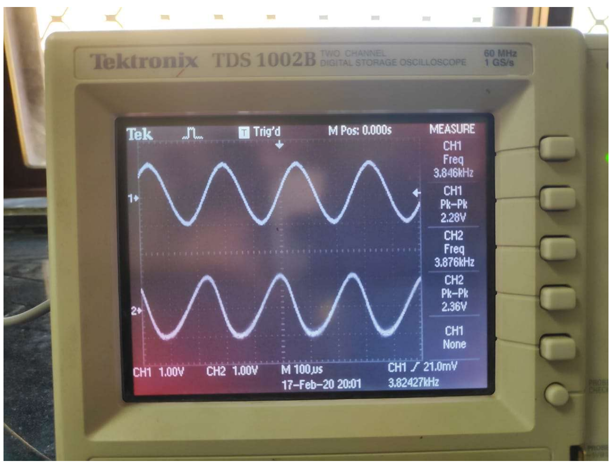


Fig 5. Over modulated AM Wave

Fig 4. Over modulated AM Wave
XY Format



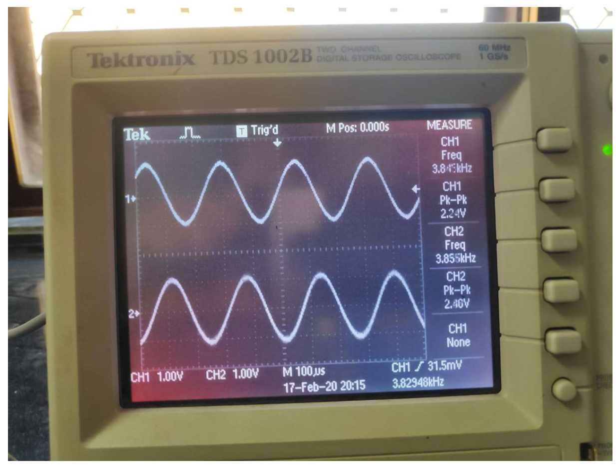


Fig 7. Perfectly modulated AM
Wave Reconstructed

Fig 8. Under modulated AM Wave
Reconstructed

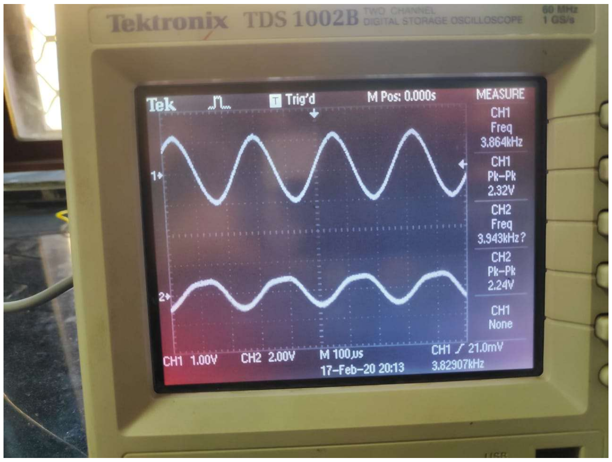


Fig 9. Over modulated AM Wave Reconstructed

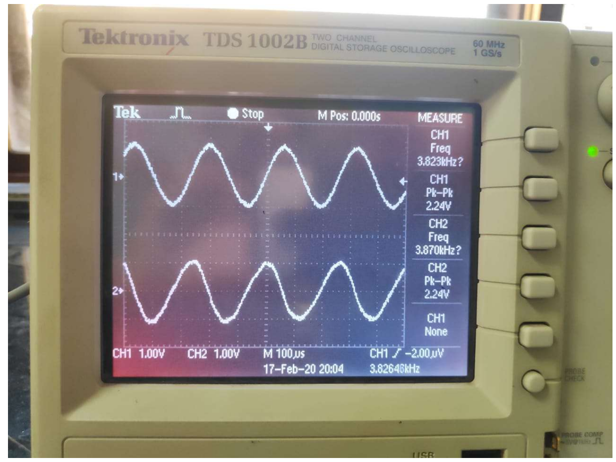


Fig 10. Perfectly modulated AM Wave Reconstructed transmitted via Antenna

Conclusion:

AM Modulation for given input signal was done using Trainer kit by varying the value of Carrier wave amplitude to change Modulation Index and setting appropriate values for filters.

AM Demodulation for the modulated signal was done by finely tuning the values of RF Oscillator and Intermediate Frequency to obtain the message signal at the output side.

The above was done for signals transmitted via wire and antenna.

Remarks: **Signature**