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Experiment 4
Amplitude Modulation

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Aim.

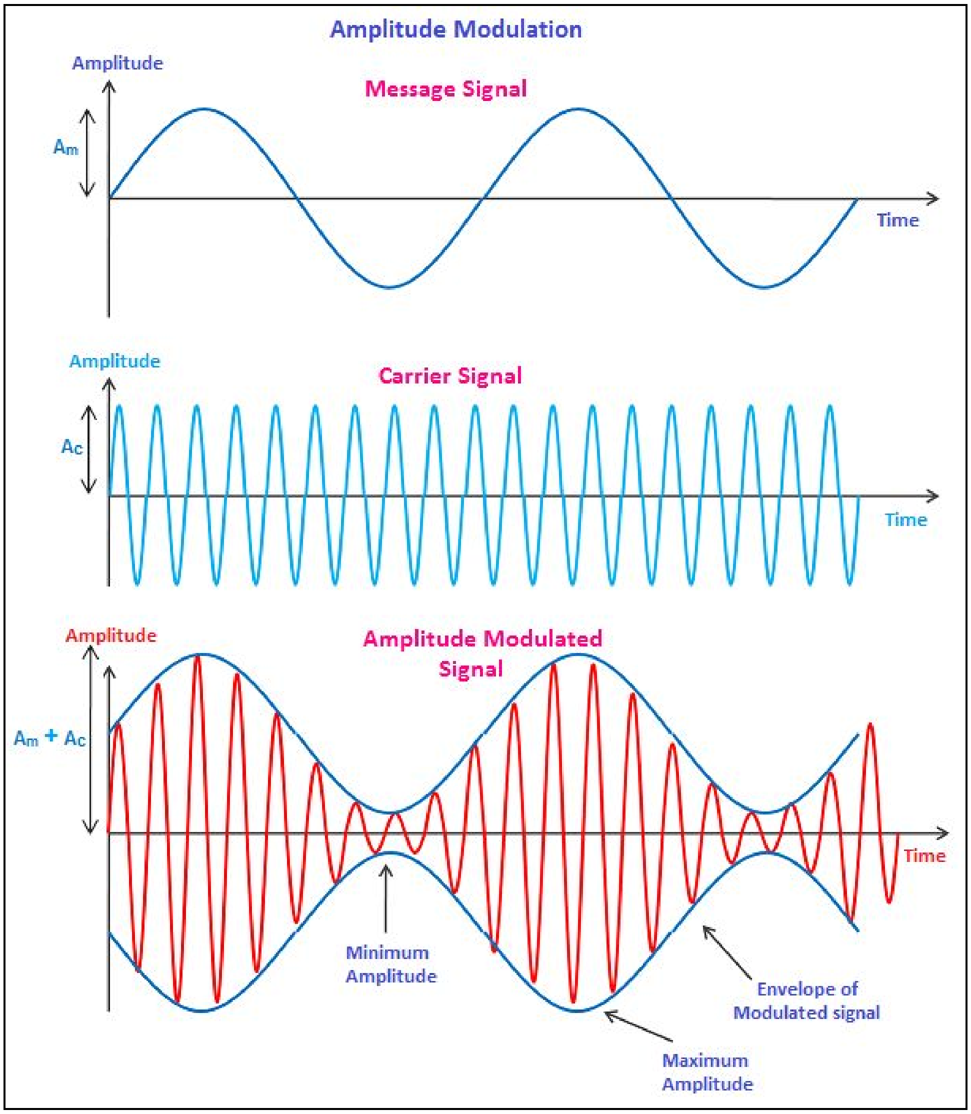
- To study amplitude modulation and observe the waveforms for three different modulation indices.

Apparatus.

- Trainer board ST 2201 & 2202
- Power supply
- Connecting Wires
- CRO
- Function Generator
- Carrier Generator.

Theory.

Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting information via a radio carrier wave. In amplitude modulation, the amplitude (signal strength) of the carrier wave is varied in proportion to that of the message signal being transmitted. The message signal is, for example, a function of the sound to be reproduced by a loudspeaker, or the light intensity of pixels of a television screen. This technique contrasts with frequency modulation, in which the frequency of the carrier signal is varied, and phase modulation, in which its phase is varied.



Amplitude Modulation

Description of different blocks of Amplitude Modulation Circuit:

(1) Input audio amplifier section:

This section is used to amplify low level audio signals coming from Mic/Loudspeaker and give it to A.M. Modulator section for live A.M. modulation. It consists of a pre-amplifier stage and output amplifier stage. Transistor BC148B is used for 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 signals. 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 signals. 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 a balanced modulator. The modulating audio signal is connected at pin 1 through buffer transistor Q1.This IC has two inputs as it works as a 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 sideband 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 the 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 the 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.

Procedure.

Modulation:

1. Fig. 1 shows the AM transmitter panel. Ensure that the following initial conditions exist on the board.
    1. Audio input select switch in INT position:
    2. Mode switch in DSB position.
    3. Output amplifier's gain pot in full clockwise position.
    4. Speakers switch in OFF position.

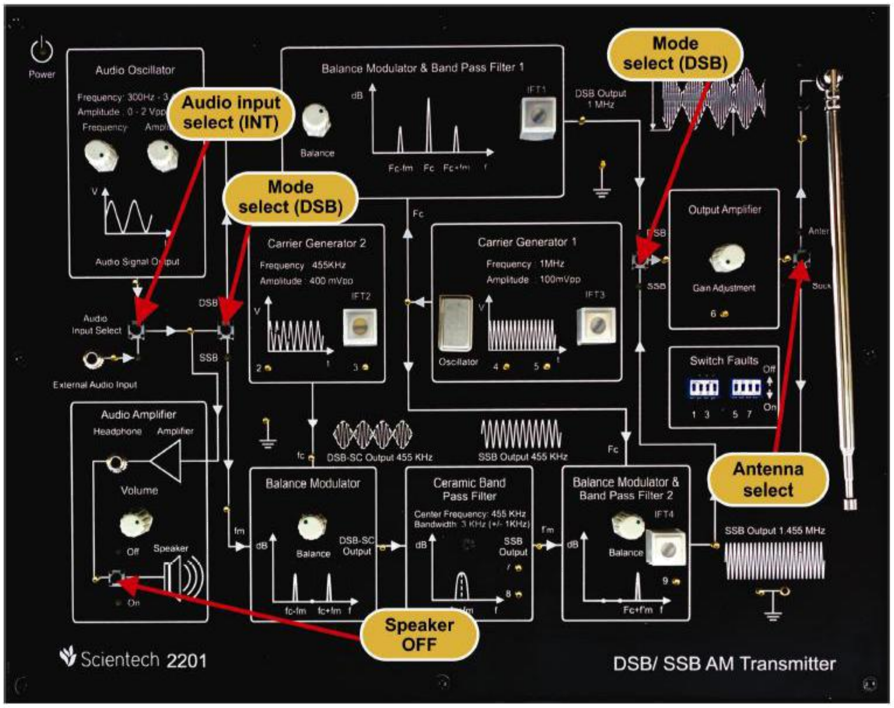


Fig. 1 AM Transmitter Panel

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.
6. 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:

$$Percentage\ Modulation = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

Where Vmax and Vmin are the maximum and minimum amplitudes.

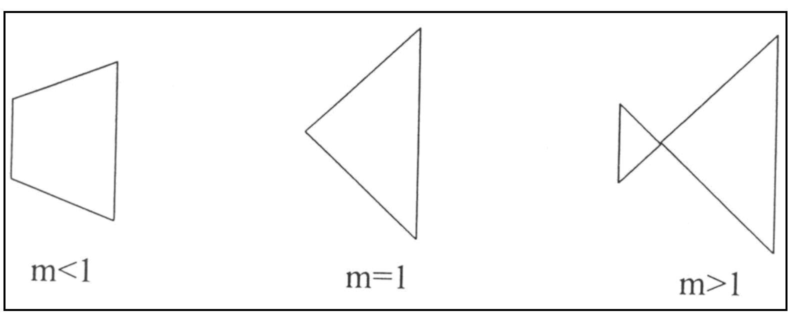
7. Now vary the amplitude and frequency of the audio-frequency sine wave, by adjusting the amplitude and frequency present in the audio oscillator block. Note the effect that varying each pot has on the amplitude modulated waveform. The amplitude and frequency amplitudes of the two sidebands can be reduced 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.

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:
4. Calculate the modulation index by substituting in the formula

$$Percentage\ Modulation = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

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



Demodulation:

1. Fig. 2 shows the AM receiver panel. Position the **ST2201** & **ST2202** modules, with the **ST2201** board on the left, and a gap of about three inches between them.

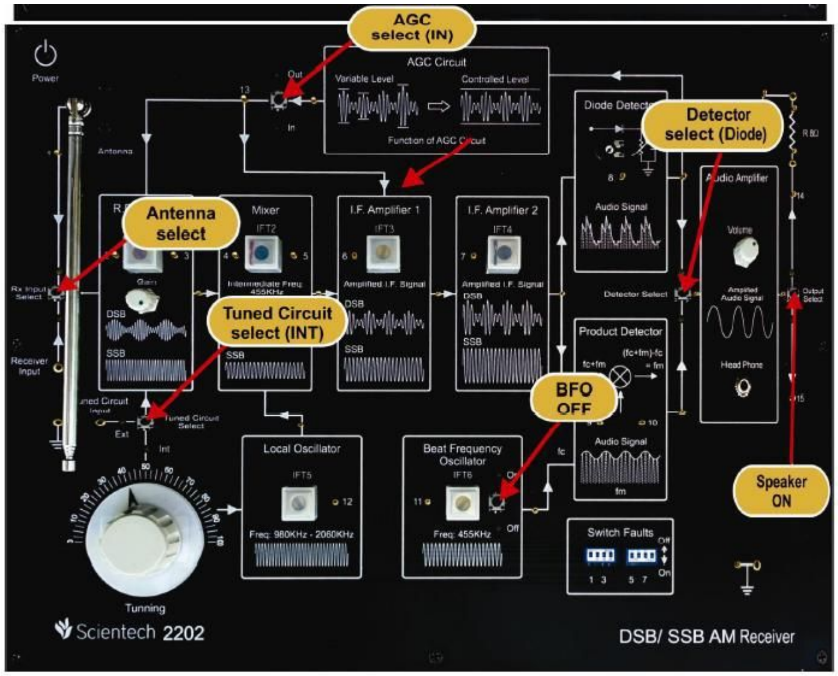


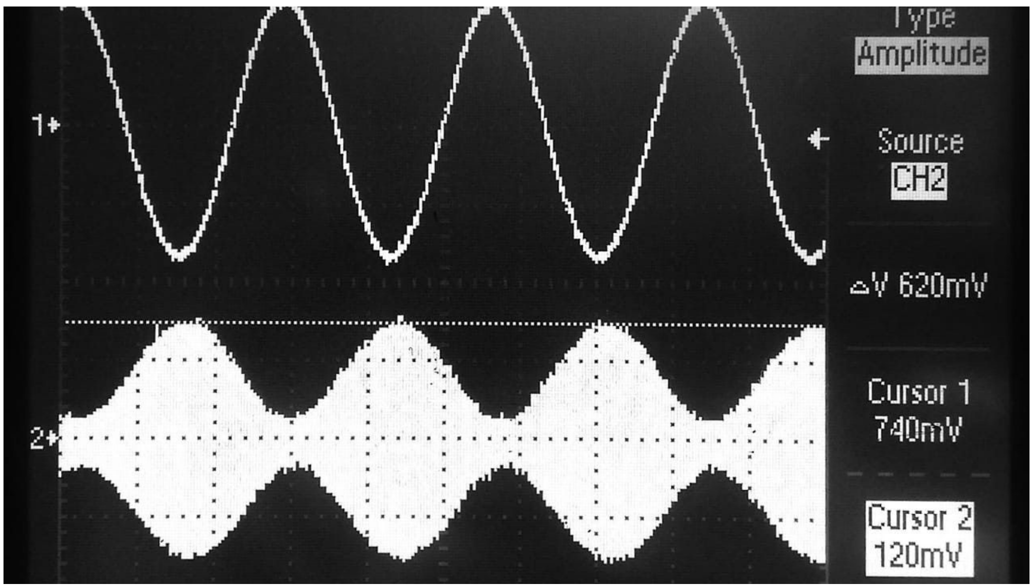
Fig. 2 AM RecieverPanel

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.

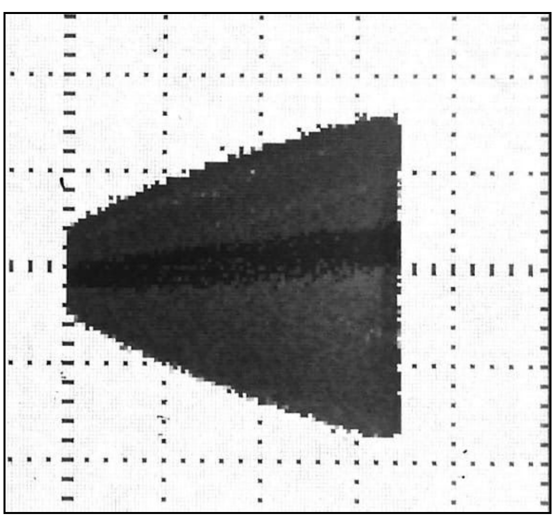
5. On the **ST2202** module, monitor the output of the product detector block (at t.p. 37), together with the output of the audio amplifier block (t.p. 39), triggering the scope with the later signal.

Observation.

m < 1



Signal and AM Wave



$V_{max} = 740\ mV$

$V_{min} = 120\ mV$

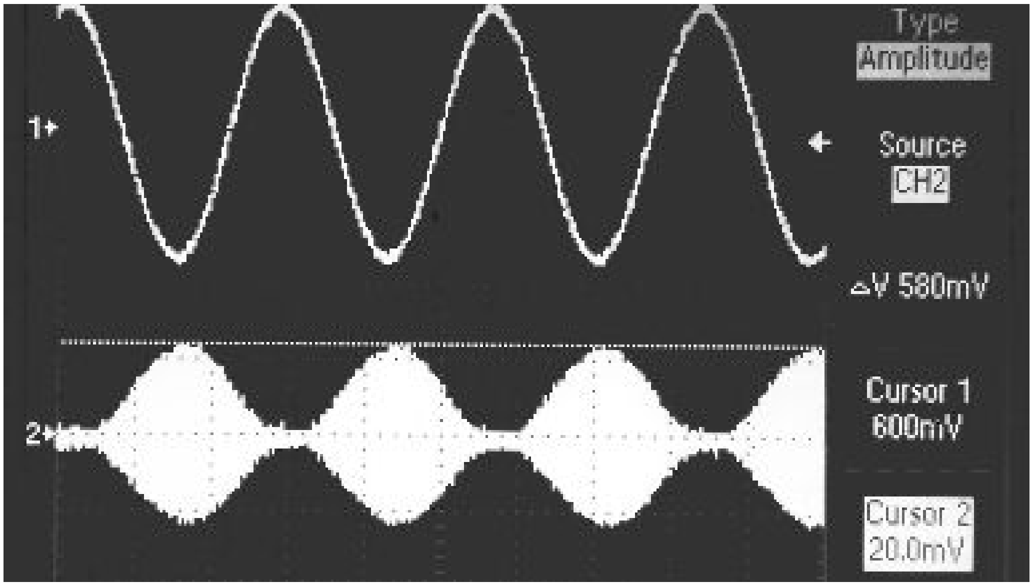
$m = 0.72$

$f_m = 3.6\ kHz$

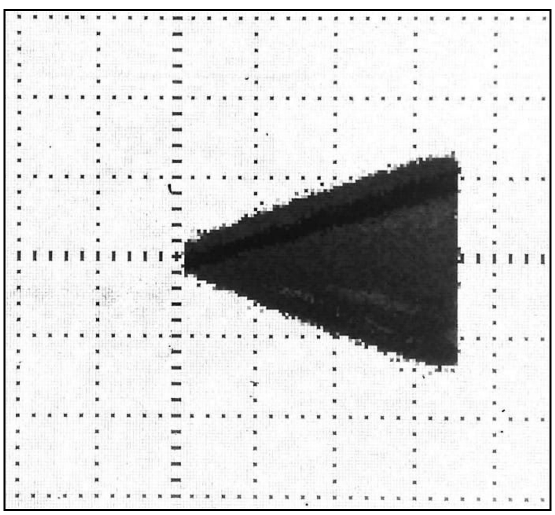
$f_c = 1\ MHz$

Trapezoid Pattern

m = 1



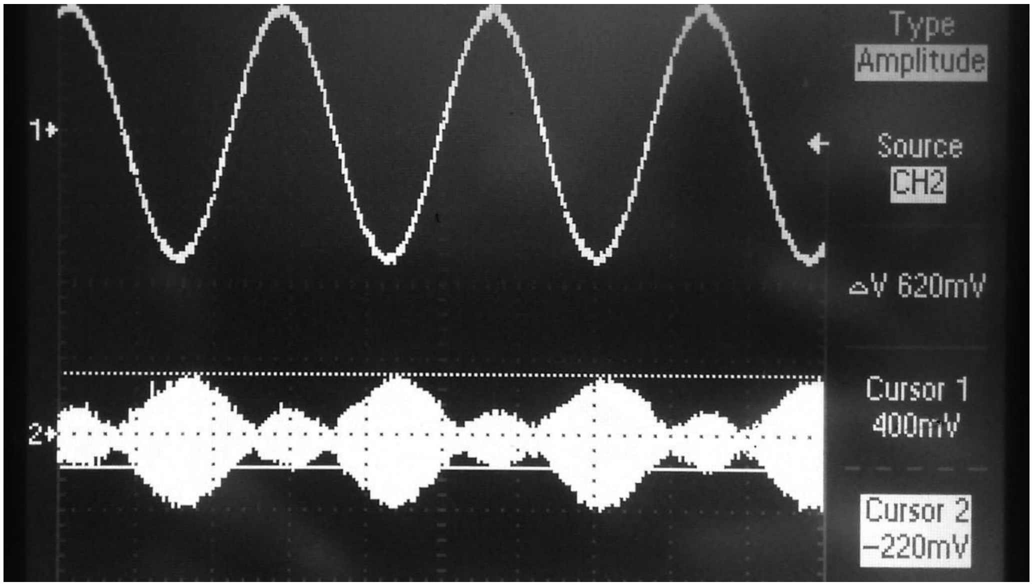
Signal and AM Wave



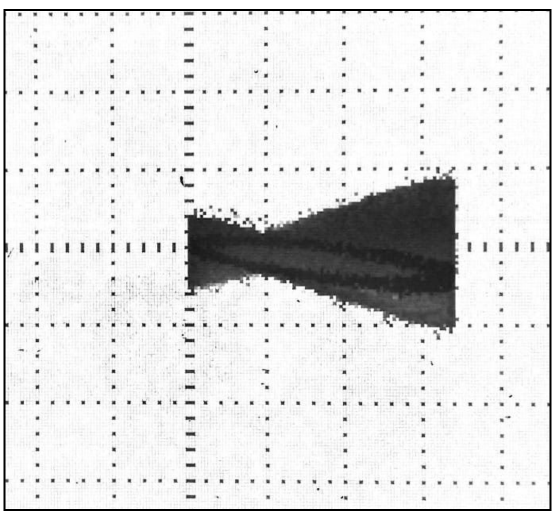
$$V_{max} = 600\ mV$$
$$V_{min} = 20\ mV$$
$$m = 0.93$$
$$f_m = 3.6\ kHz$$
$$f_c = 1\ MHz$$

Trapezoid Pattern

m > 1

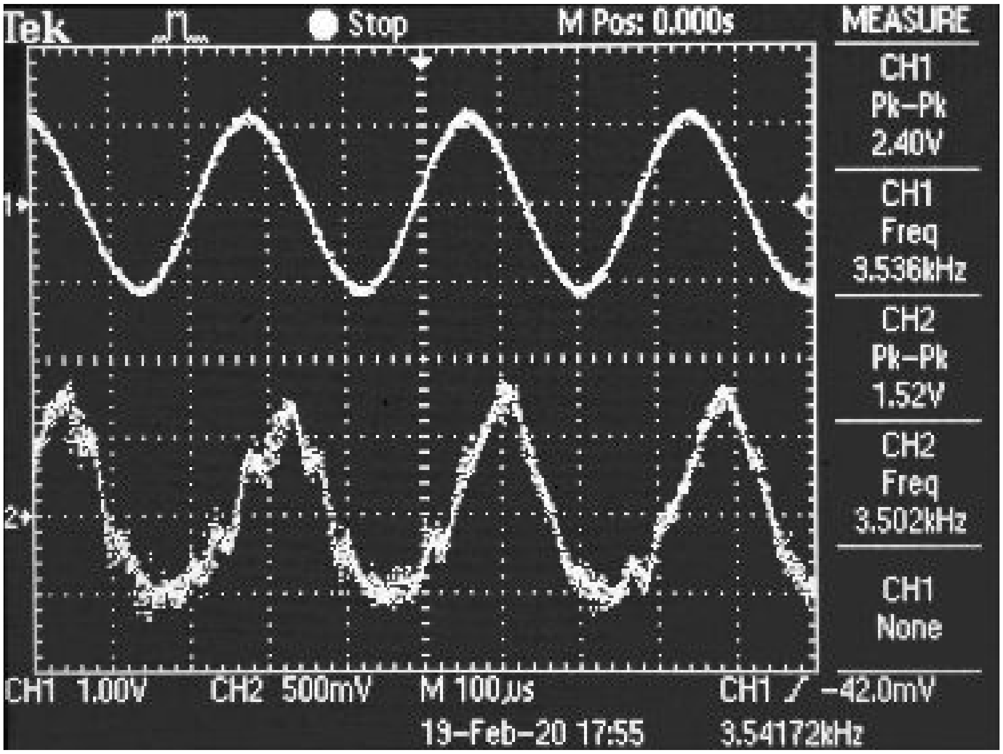


Signal and AM Wave



$$V_{max} = 400\ mV$$
$$V_{min} = -220\ mV$$
$$m = 3.44$$
$$f_m = 3.6\ kHz$$
$$f_c = 1.2\ MHz$$

Trapezoid Pattern



Reconstructed Signal

Conclusion.

In this experiment we studied Amplitude Modulation by transmitting a sine wave as a message signal by modulating it. We also analysed the waveforms produced for three different modulation indices namely ($m < 1$, $m = 1$, $m > 1$). Finally, we demodulated and reconstructed the original message signal.

Remarks.

Signature.