EEP3010

Communication Systems Lab

To study amplitude modulation (AM) and demodulation

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By:

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Abstract:

Amplitude modulation(AM) and demodulation are essential components in communication systems, enabling the transmission and reception of information signals. They are used in various applications such as radio broadcasting, television transmission, and long-distance communication. In AM the message information is transmitted by varying the amplitude of a carrier wave.

Amplitude Modulation is a method of transmitting data using radio waves. The amplitude of a carrier wave is adjusted in this approach based on the magnitude of the message signal.
The carrier signal has a higher frequency than the message signal.

$$s(t) = [1 + k_a m(t)]c(t)$$

Here m(t) is the message signal, ka is the sensitivity factor, c(t) is the carrier signal which is sinusoidal and s(t) is the modulated signal

At the receiver side, demodulation is the recovery of the message signal from the modulated signal. Demodulation is accomplished using a variety of techniques, one of which is envelope detection. The message signal is present in the form of an envelope after modulation and may be retrieved via envelope detection.

This experiment delves into the principles and practical aspects of amplitude modulation (AM) and demodulation within the context of communication systems. Utilizing an AM along with essential test equipment such as signal analyzers, function generators, and oscilloscopes, the experiment aims to comprehensively explore the process of AM modulation and its subsequent demodulation. Through a series of structured procedures, including time and frequency domain analyses, the experiment investigates the effects of varying modulation parameters on signal quality and fidelity. By analyzing experimental results and comparing them with theoretical expectations, this study provides valuable insights into the behavior of AM signals, aiding in a deeper understanding of modulation techniques in communication systems.

Objective:

To study amplitude modulation (AM) and demodulation and carry out time and frequency domain analysis.

Using the AM training kit, produce a message signal (sinusoidal) and a carrier signal, and then conduct amplitude modulation. Examine the modulated output on the DSO.

Examine various modulation instances, such as under modulation, critical modulation, and overmodulation.

Determine the modulation index for the case.

Demodulate the modulated signal and compare it to the original message signal.

Examine the modified signal's frequency spectrum.

Experimental Procedure:

Amplitude Modulation (AM) is a modulation technique used in communication systems to transmit information by varying the amplitude of a carrier wave in accordance with the message signal. In AM, the amplitude of the carrier wave is modified based on the instantaneous amplitude of the message signal.

In AM, the modulated signal $s(t)$ is expressed as:

$$s(t) = A_c[1 + m(t)]cos(2\pi f_c t)$$

where:

A_c = amplitude of the carrier signal

$m(t)$ = message signal

f_c = carrier frequency

t = time

The parameter m(t) represents the message signal, which typically carries the information to be transmitted. When this message signal is multiplied with the carrier signal, it causes the amplitude of the carrier to vary in accordance with the variations in the message signal.

Conditions of Amplitude Modulation:

- **Critical Modulation:**
  In critical modulation, the modulation index (μ) is exactly 1.
  This occurs when the maximum amplitude of the message signal equals the amplitude of the carrier signal.

  Mathematically,

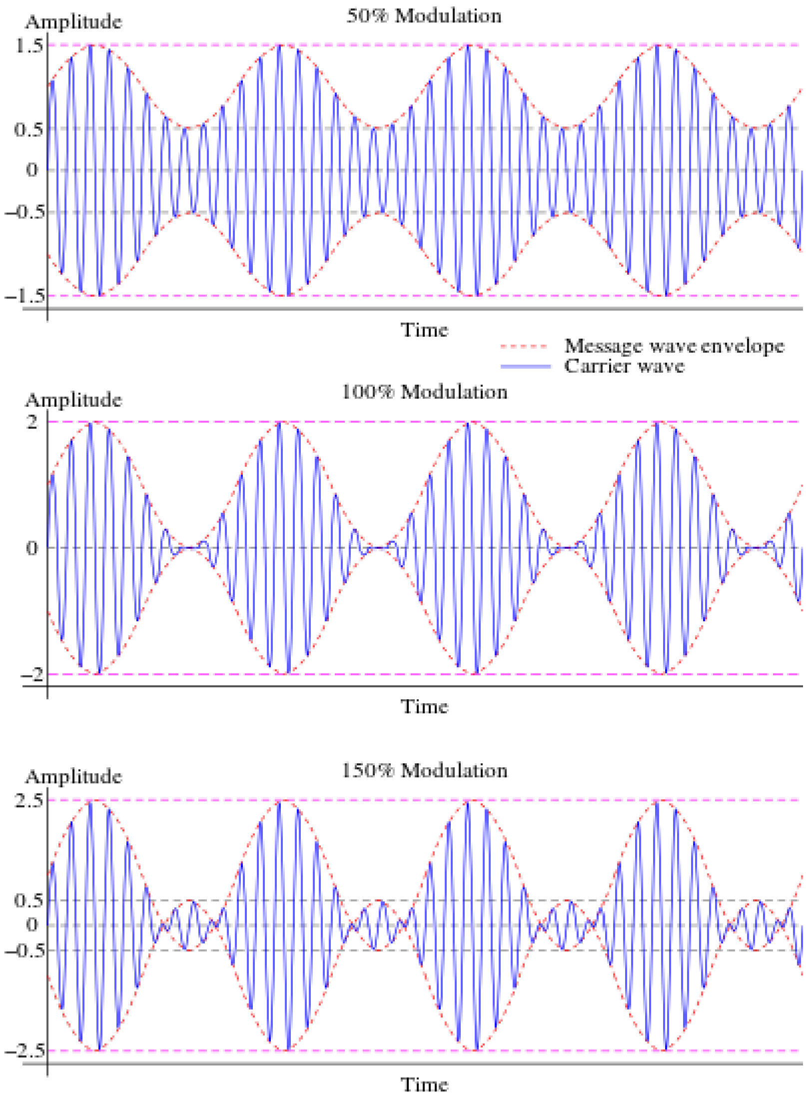
  $$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

  $$\mu = k_a A_m$$

  Where A_{max} and A_{min} are the maximum and minimum amplitudes of the modulated signal, respectively.
  In this condition, the modulated signal faithfully preserves the information of the message signal without distortion.
- **Under Modulation:**
  Undermodulation occurs when the modulation index (μ) is less than 1.
  This happens when the amplitude of the message signal is insufficient to fully modulate the carrier wave.
  As a result, the modulated signal's envelope does not reach the full extent of the carrier's amplitude, leading to incomplete representation of the message signal.
  Undermodulation can result in poor signal quality and reduced transmission efficiency.
- **Overmodulation:**
  Overmodulation occurs when the modulation index (μ) exceeds 1.

Overmodulation leads to distortion in the modulated signal, as the carrier wave's amplitude is exceeded, causing signal clipping.

Overmodulation can result in signal distortion and interference, making it difficult to recover the original message signal at the receiver.



Material Required:

- N9010A Signal Analyzer/89601
- AFG3021B Function Generator (2 sets)
- DPO2024 Oscilloscope, 200 MHz
- AM trainer kit (Vinytics CT AM)
- BNC(m)-to-BNC(m) coaxial cable
- SMA(m)-to-BNC(m) coaxial cable
- SMA(m)-to-SMA(m) coaxial cable
- Connecting Chords

Amplitude Modulation:

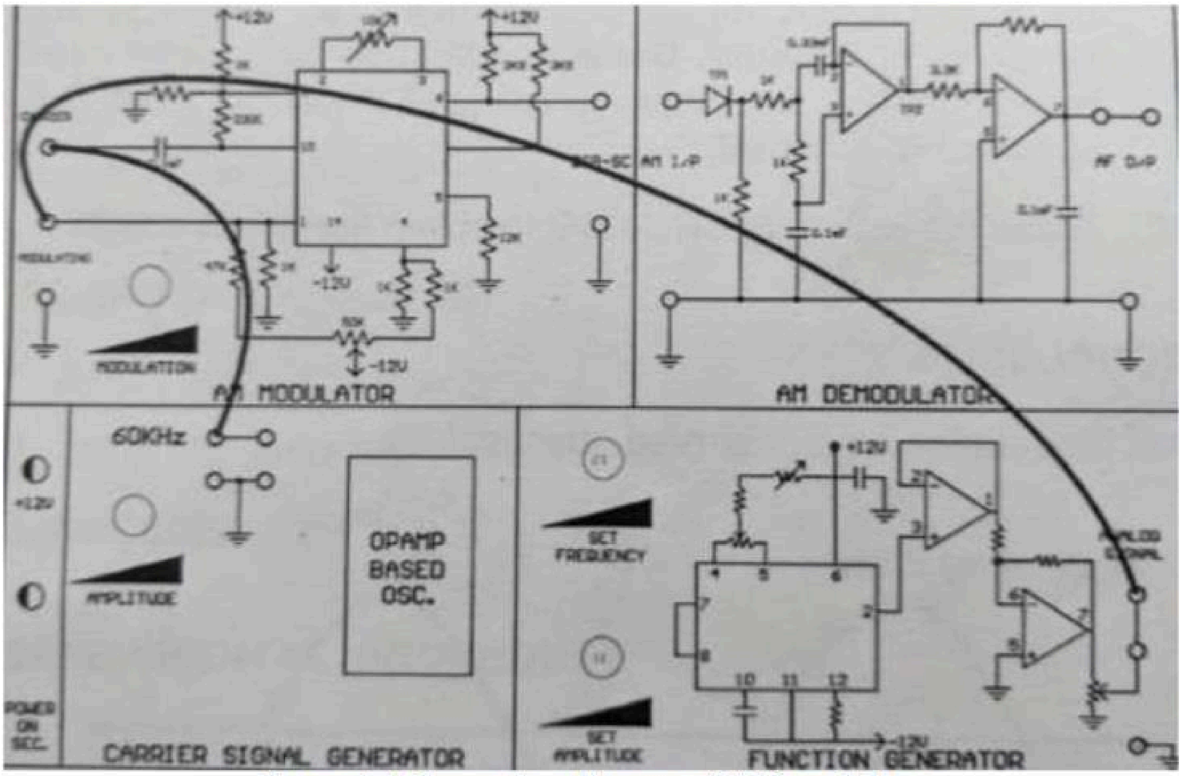


Figure 1.1 Connection diagram of AM modulator

- Initially, we adhere to the provided schematic and establish connections accordingly.
- The experiment commences with amplitude modulation. We generate a message signal (A sin(2mt)) with a frequency of 3.5 kHz.
- Subsequently, we observe the message signal m(t) using the oscilloscope.
- Adjustments to the modulating signal's frequency and amplitude are facilitated by manipulating the potentiometers labeled "Amplitude" and "Frequency" within the Function Generator Section, as depicted in the accompanying figure.
- A carrier signal is then produced from the Carrier Signal Generator section.
- The frequency of the carrier output remains constant at 60 kHz, as stipulated by the apparatus.
- Retrieval of the Amplitude Modulated signal occurs via the DSB-SC O/P port of the AM Modulator Section. This resultant AM signal is then visualized utilizing an oscilloscope.
- Alterations to the amplitude of the message signal ensue, and we observe the resultant effect on the modulated wave via the oscilloscope.
- Proceeding, we adjust the potentiometer labeled as "modulation" to augment the depth of modulation.
- Task 1 involves determining the sensitivity factor of the AM kit. This entails modifying parameters until the output achieves critical modulation (p1), thereby allowing for the straightforward calculation of Ka.

Demodulation:

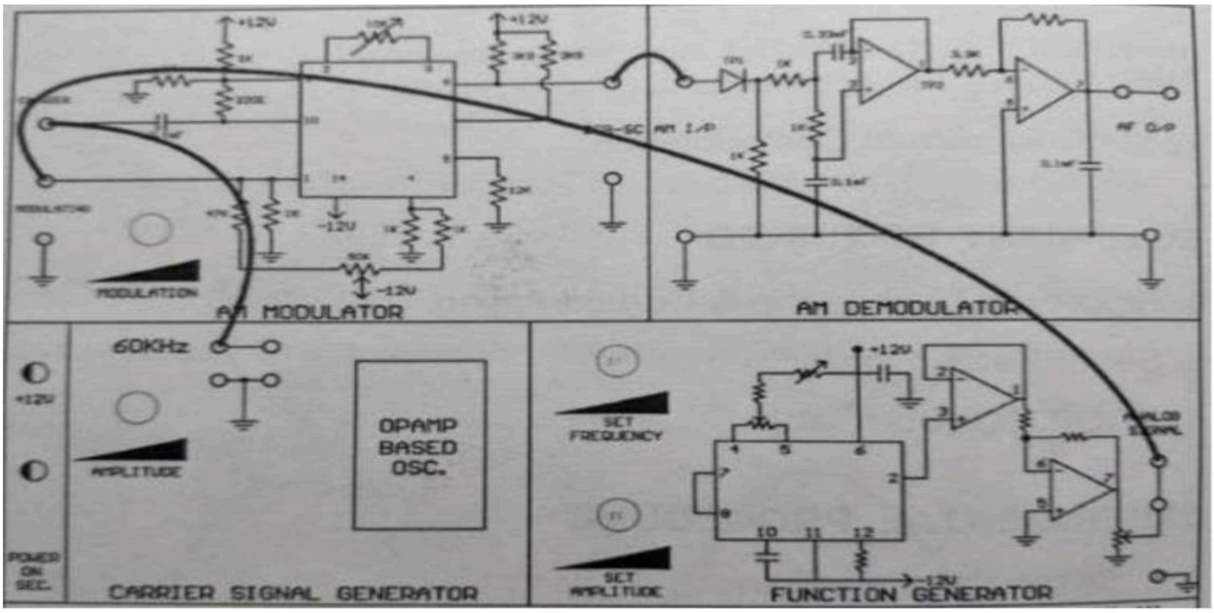


Figure 1.2 Connection diagram for amplitude demodulation

- The connections are established following the provided schematic diagram.
- The demodulated wave is acquired from the AM output (AM O/P) of the Demodulator Section. Subsequently, we observe this demodulated wave concurrently with the modulating signal at the Function Generator section.
- We proceed by adjusting the amplitude of the sine wave within the Function Generator Section, noting the resultant effect on the oscilloscope (DSO).

Frequency Domain Analysis:

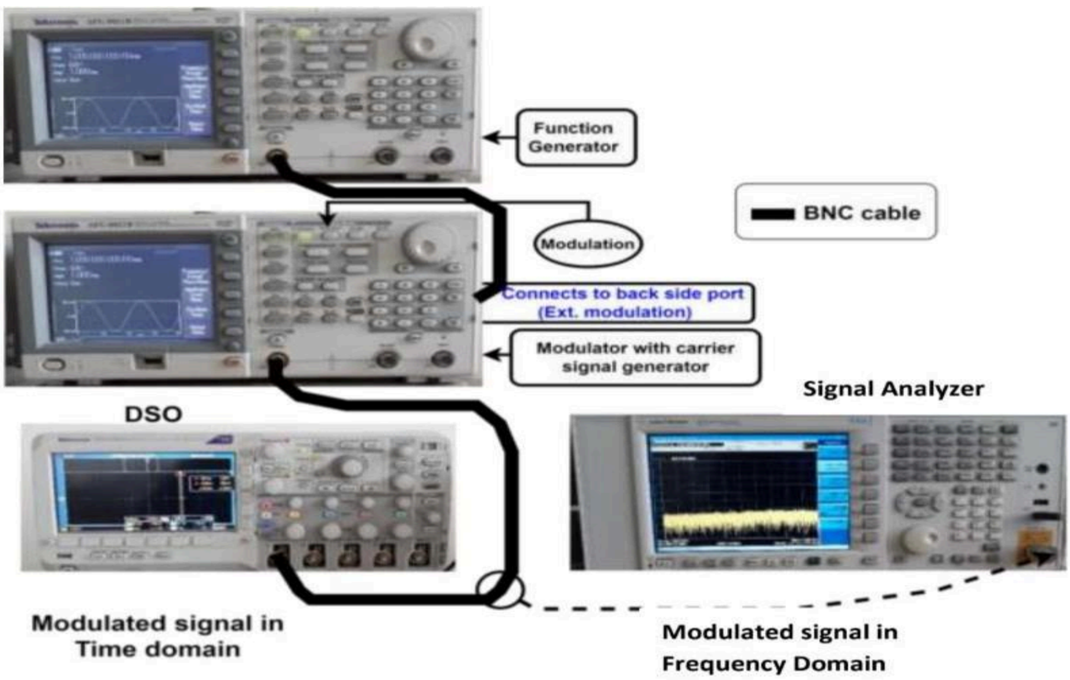


Figure 1.3 Connection diagram of AM for frequency domain analysis.

- Create a message signal and a carrier signal using two function generators.

● As the message signal, use a sinusoid with an amplitude of 1 Vpp and a frequency of 30 kHz. The output of the message signal function generator is passed to the other function generator.

● A 1 MHz sinusoid is used as the carrier signal. Set the carrier signal function generator to modulation mode with an external AM source and a depth of 50%.

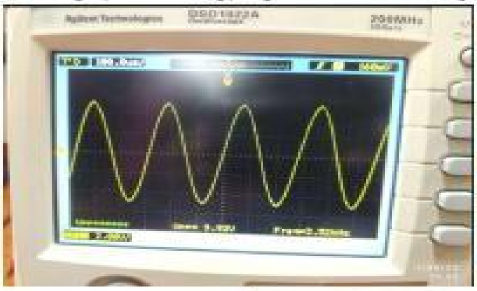
● Examine the output of the signal analyzer. Set the center frequency to 1 MHz and choose a reasonable span until three peaks are observed.

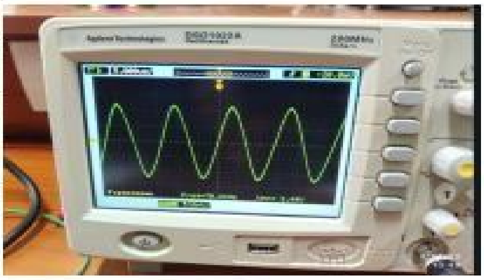
● To eliminate noise, lower the video bandwidth. Identify the peaks and record the frequency.

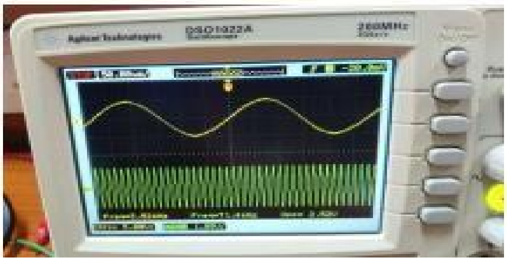
● Determine the signal's occupied bandwidth.

Test Results:

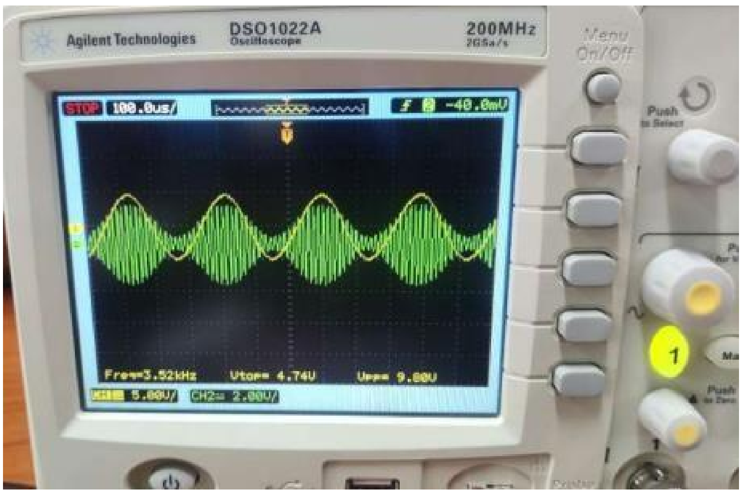
1. For the first part of performing Amplitude modulation we generate message signal and carrier signal.







2. Next by using the AM generator kit we were able to produce amplitude modulated waves.



The green coloured waves are the amplitude modulated signal and the yellow show modulated signal.

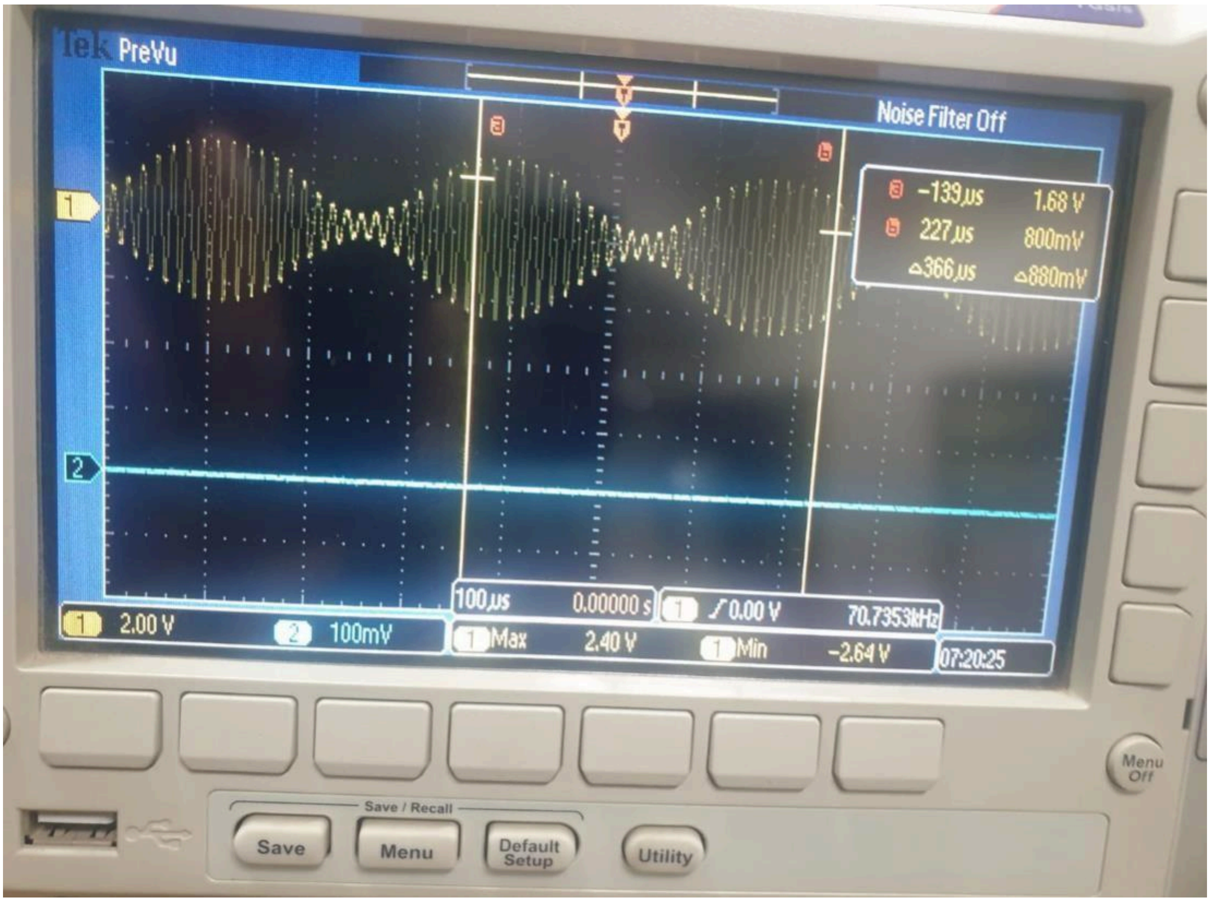
3. We observed while changing the value of Ka ,how the modulation signal becomes critical modulated, under-modulated and over modulated.

Under Modulated Case:

Amax = 2.4 V

Amin = 0.4V

u = 0.714

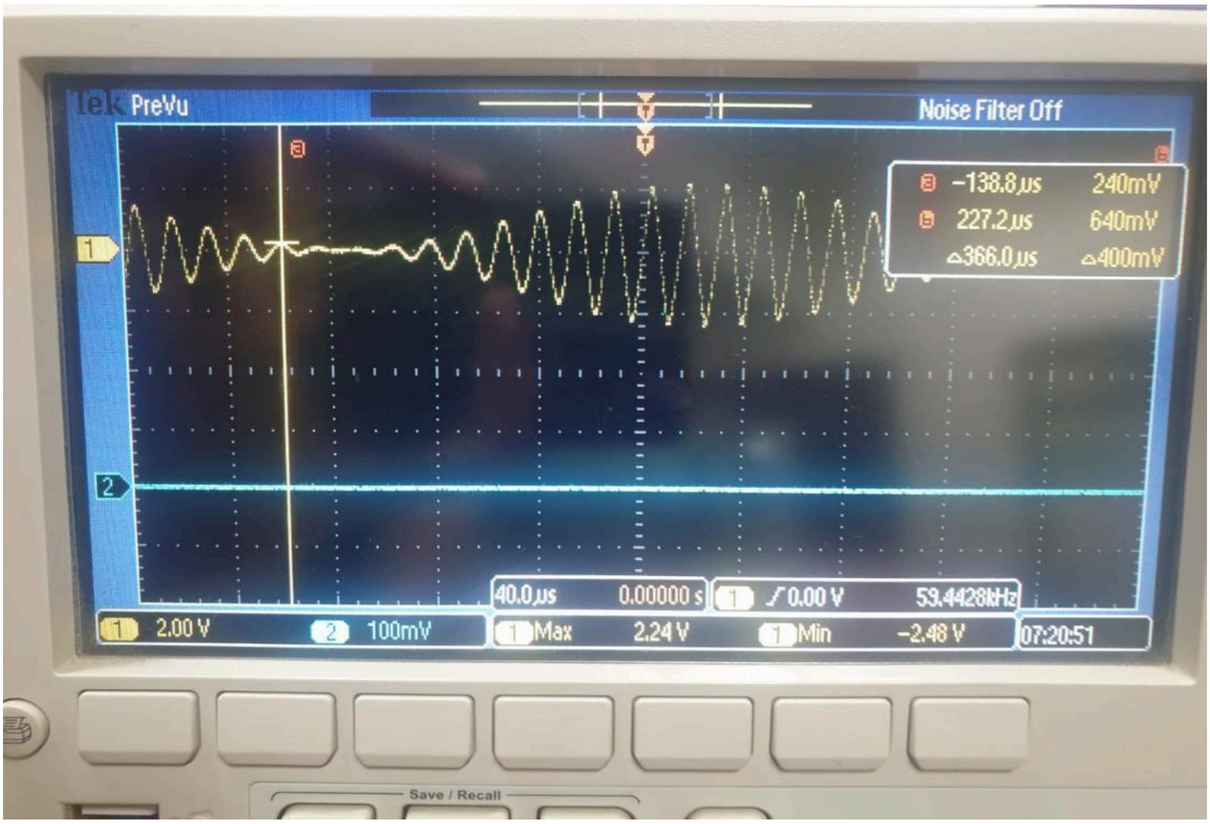


Critical Modulated Case:

Amax = 2.24 V

Amin = 0 V

u = 1

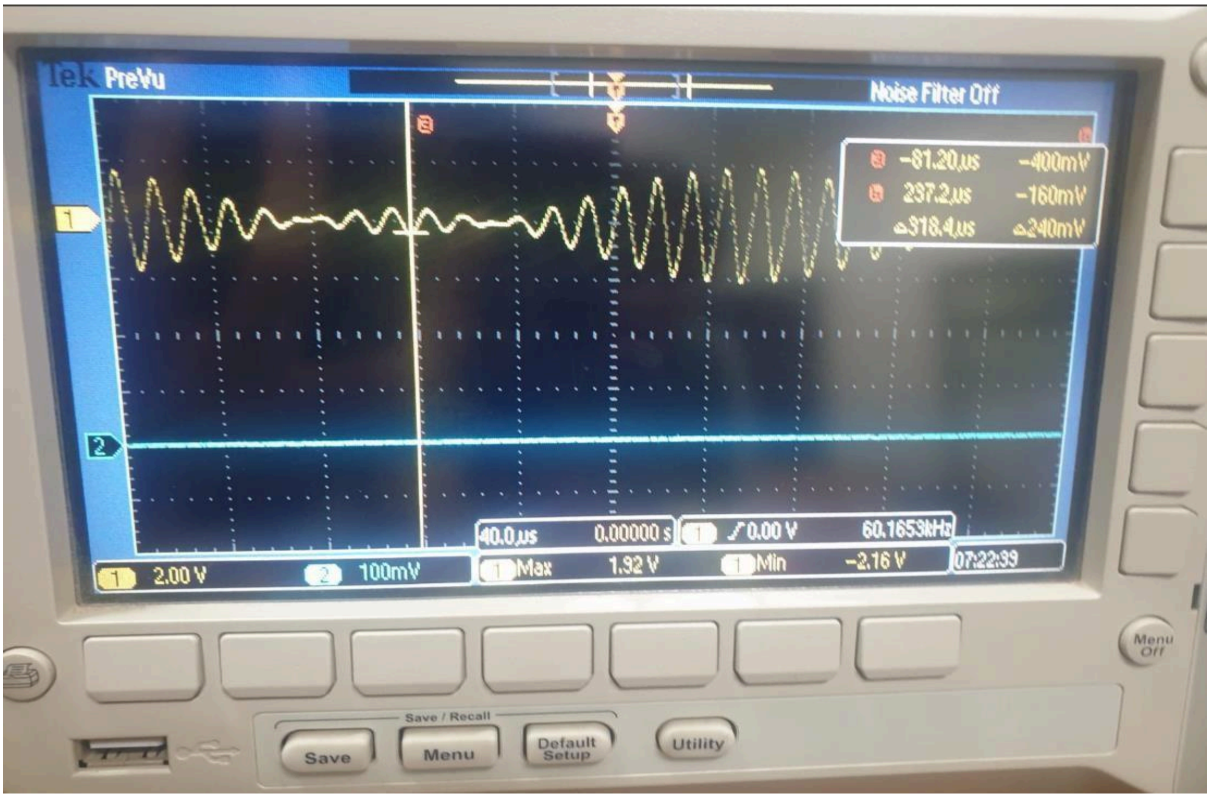


Overmodulated Case:

Amax = 1.82 V

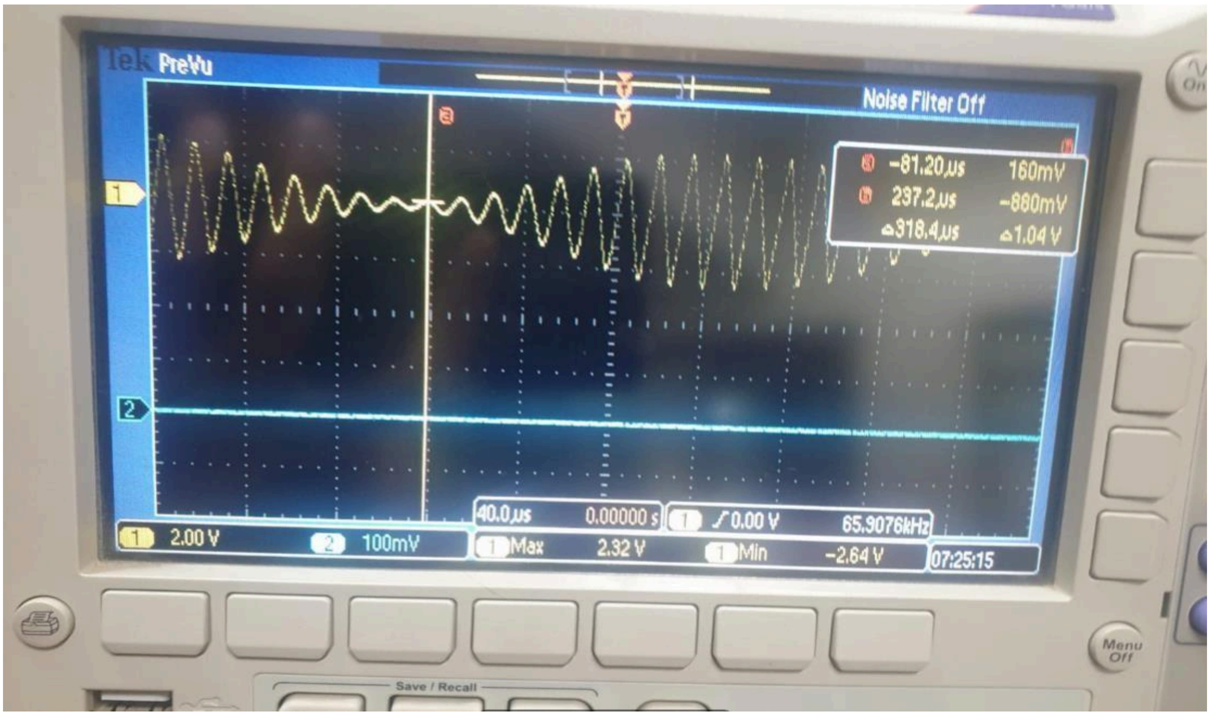
Amin = -0.4 V

u= 1.53

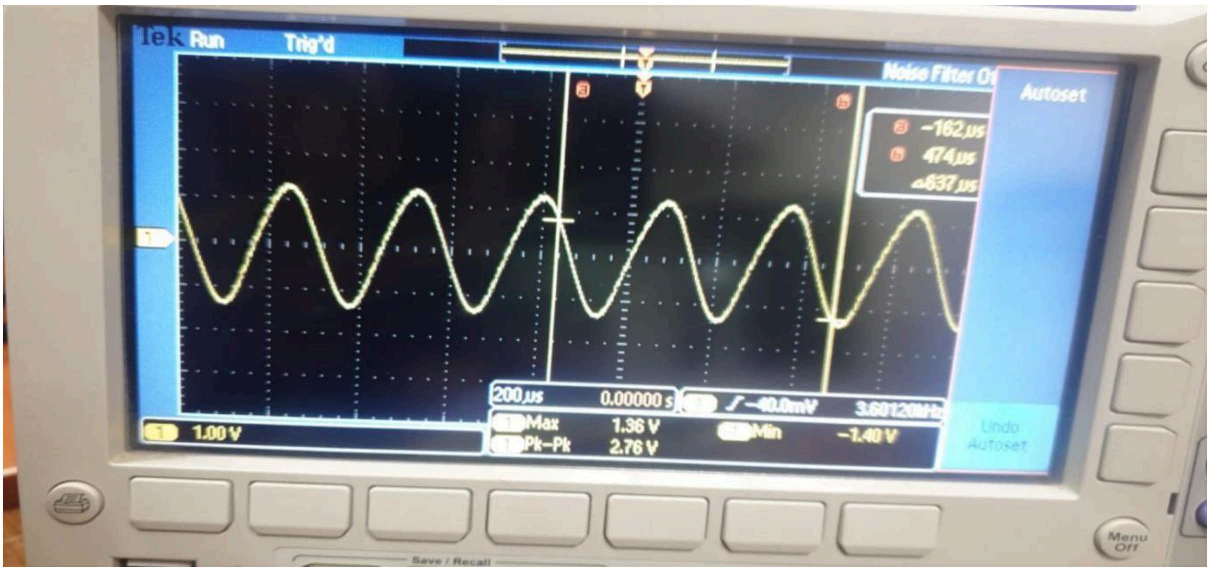


Modulation Type	Am	Ac	fm	fc	Amax	Amin	u
Under-Modulation	10 V	2.5V	3.5Khz	70 Khz	2.4 V	0.4 V	0.714
Critical Modulation	10 V	2.5V	3.5Khz	70 Khz	2.24 V	0 V	1
OverModulation	10 V	2.5 V	3.5Khz	70 Khz	1.92 V	-0.4 V	1.53

4. The wave we observed while changing the amplitude of message signal is :

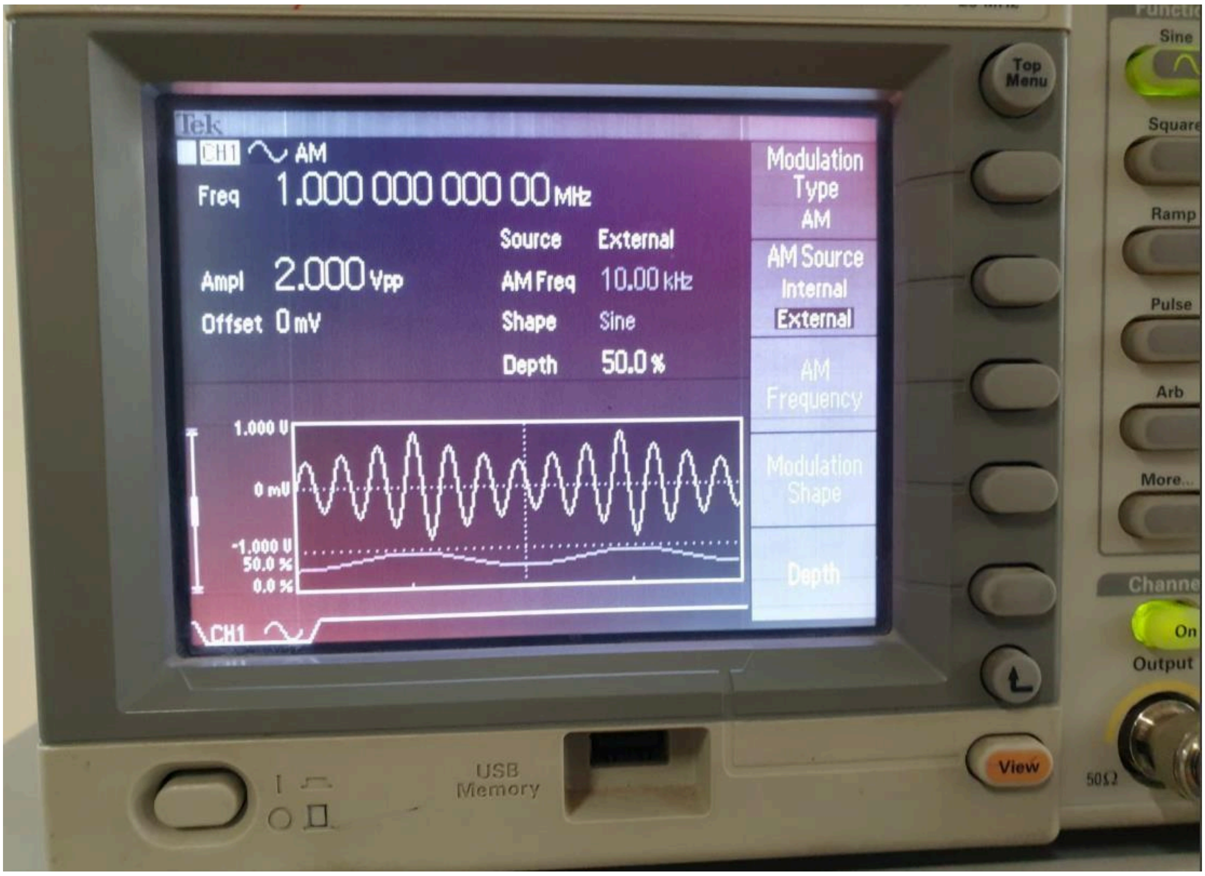


5. Now in second part for Demodulation we used the output from DSB-SC port as input to the demodular section of the kit and received wave as shown below:

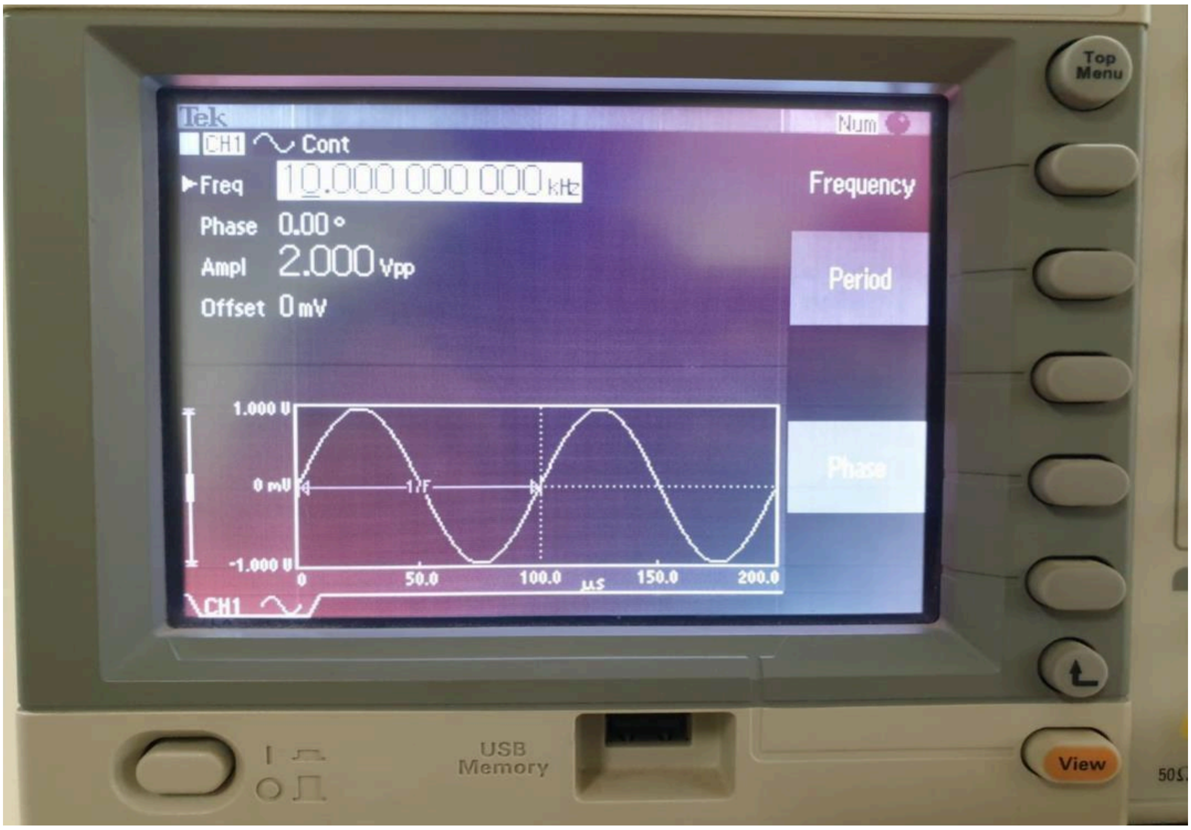


6. For the frequency Domain analysis we set up the system as shown in procedure.

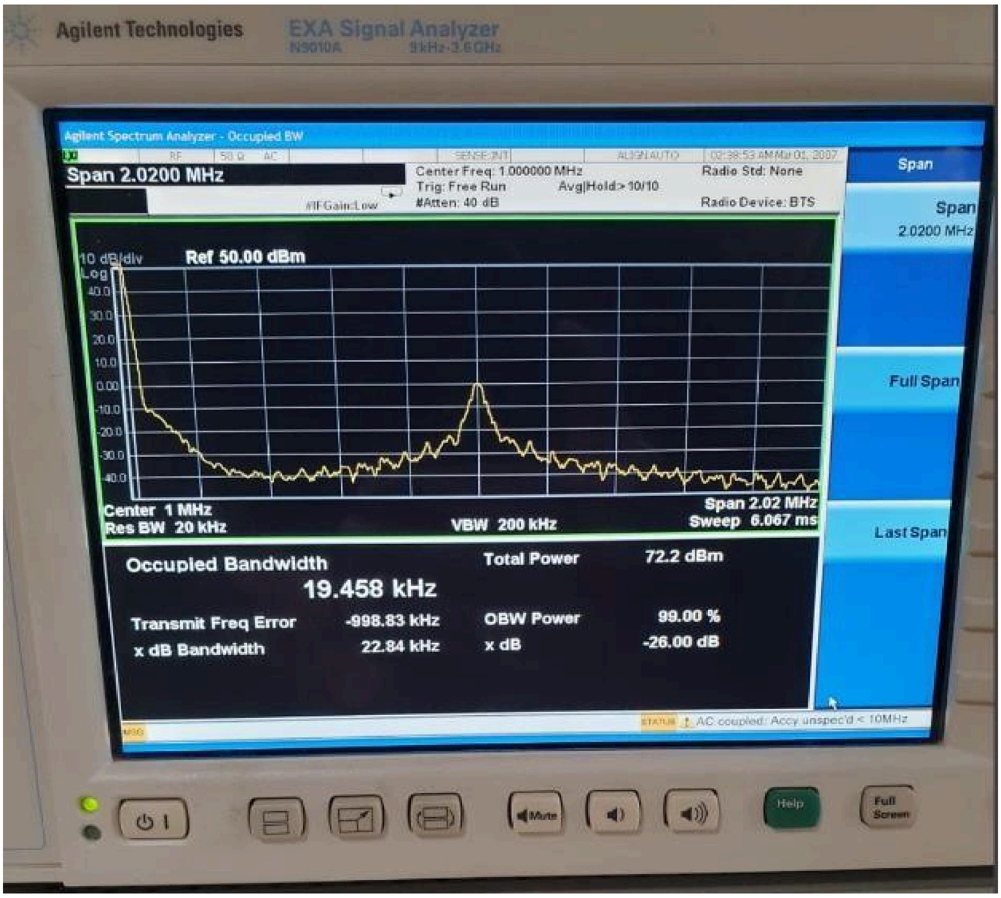
Message signal:



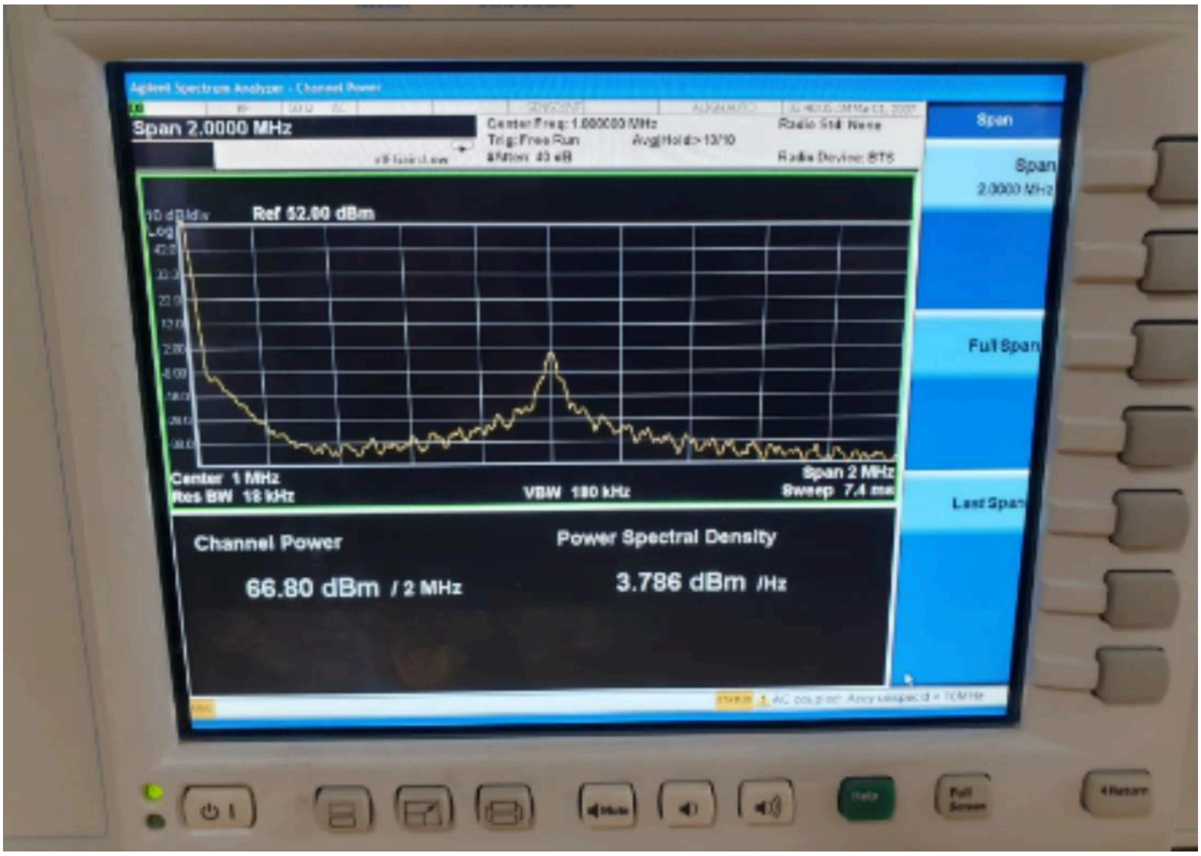
Carrier Signal:



Occupied Bandwidth and Total Power:



Power spectral Density:



Discussion:

- During the AM modulation phase, the modulation index (μ) played a crucial role in determining the fidelity of the modulated signal. When the modulation index was set to 1, representing critical modulation, the modulated signal faithfully preserved the information of the message signal without distortion. However, deviations from this critical value led to under modulation overmodulation, resulting in signal distortion and reduced transmission efficiency.
- The experiment demonstrated the impact of varying the modulation depth on the amplitude of the modulated signal. Increasing the modulation depth beyond a certain threshold resulted in overmodulation, causing signal clipping and distortion. Conversely, insufficient modulation depth led to under modulation, where the modulated signal failed to fully represent the message signal. This observation highlights the importance of carefully adjusting modulation parameters to achieve optimal signal quality.
- When the amplitude of the message signal is increased, the modulation index (Am) of the AM signal also increases. The modulation index is a measure of the extent of modulation and is given by the ratio of the amplitude of the message signal to the amplitude of the camera wave. When the modulation index is increased, the
  the difference between the maximum and minimum amplitude of the AM signal also increases. This results in a wider range of amplitudes for the AM signal, which can be seen as an increase in the peak-to-peak amplitude of the waveform.
- The demodulation phase of the experiment involved recovering the original message signal from the modulated waveform. While the demodulated signal closely
  resembled the message signal under ideal conditions, deviations from critical modulation introduced distortion and noise. Proper tuning of demodulation parameters, such as amplitude and frequency, were essential to achieving accurate signal recovery.
- For demodulation the modulated signal is multiplied with the carrier signal and passed over a low pass filter.
- In the frequency domain, the increase in the modulation index would result in a higher amplitude of the spectral lines corresponding to the modulated message signal. The effect of the increased modulation index would be to increase the separation between the spectral lines corresponding to the carrier wave and the
  modulated message signal. The increased modulation index would also result in an increased signal-to-noise ratio (SNR) of the AM signal, But it may also cause phase reversals when overmodulated.

Conclusions:

- In conclusion, amplitude modulation (AM) and demodulation serve as fundamental concepts within communication engineering, playing pivotal roles in signal transmission and reception. AM involves the modulation of a carrier signal's amplitude by a message signal, yielding an AM signal. Conversely, demodulation entails extracting the original message signal from the AM signal.

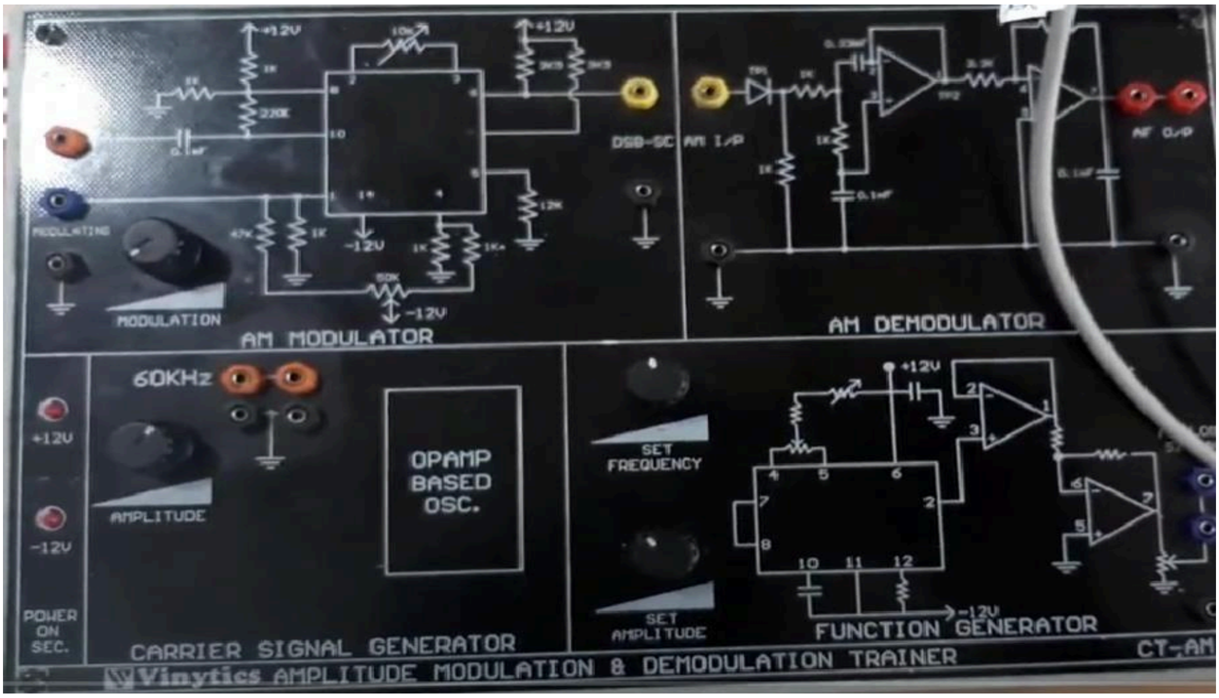
- Critical modulation, where the modulation index (μ) is 1, represents the ideal condition for faithful transmission of the message signal. Undermodulation and overmodulation, resulting from deviations in the modulation index, lead to signal distortion and degradation.
- The demodulation process is essential for recovering the original message signal from the modulated waveform. Proper tuning of demodulation parameters is necessary to ensure accurate signal recovery and minimize distortion.
- In this lab report, we discussed the mathematical inferences of AM and demodulation and the frequency domain representation of AM signals. We also
discussed the impact of increasing the amplitude of the message signal on the AM signal, including the effects on the modulation Index, the peak-to-peak amplitude of the waveform, the signal-to-noise ratio, and the separation of the spectral lines, Additionally, we noted that if the modulation index exceeds a certain limit, it can cause phase reversal and overmodulation in the AM signal, which can lead to significant degradation of the demodulated signal. Hence, it is important to keep the modulation index within limits that prevent phase reversal and overmodulation,
- Overall, this lab report provided an overview of the concepts and techniques associated with AM and demodulation, and the impact of various parameters on the quality of the modulated and demodulated signals.

References:

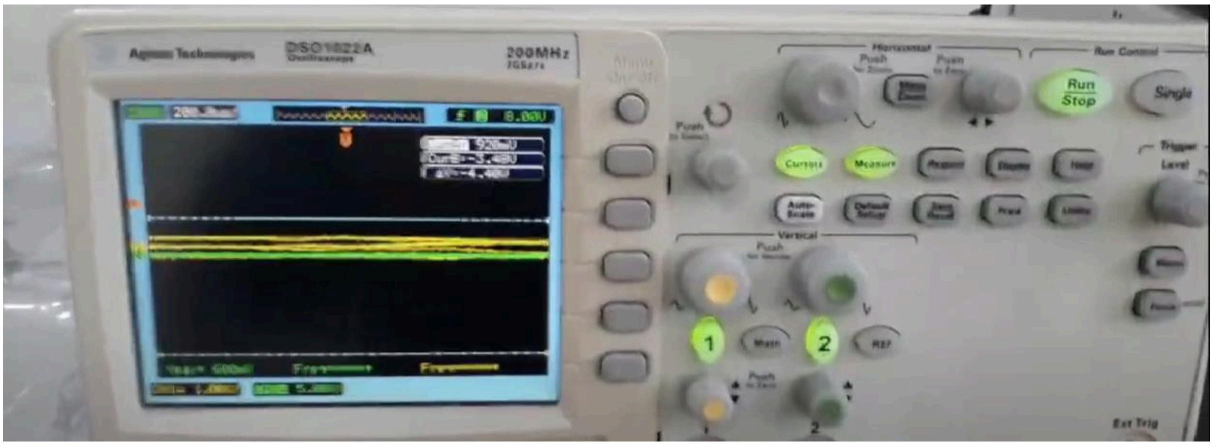
- Lab Manual
- Communication System Book , Haykin 4 ed.

Appendices:

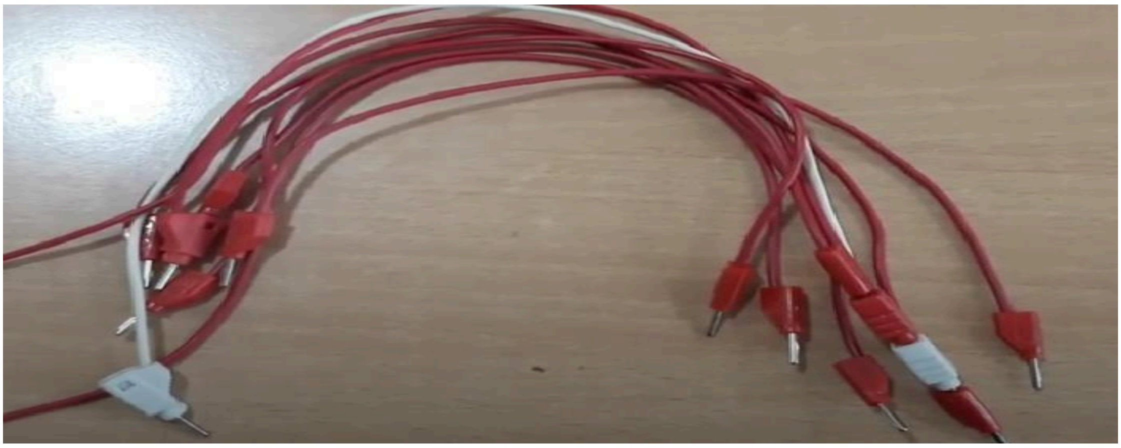
Amplitude Modulation And Demodulation Trainer Kit:



DSO:

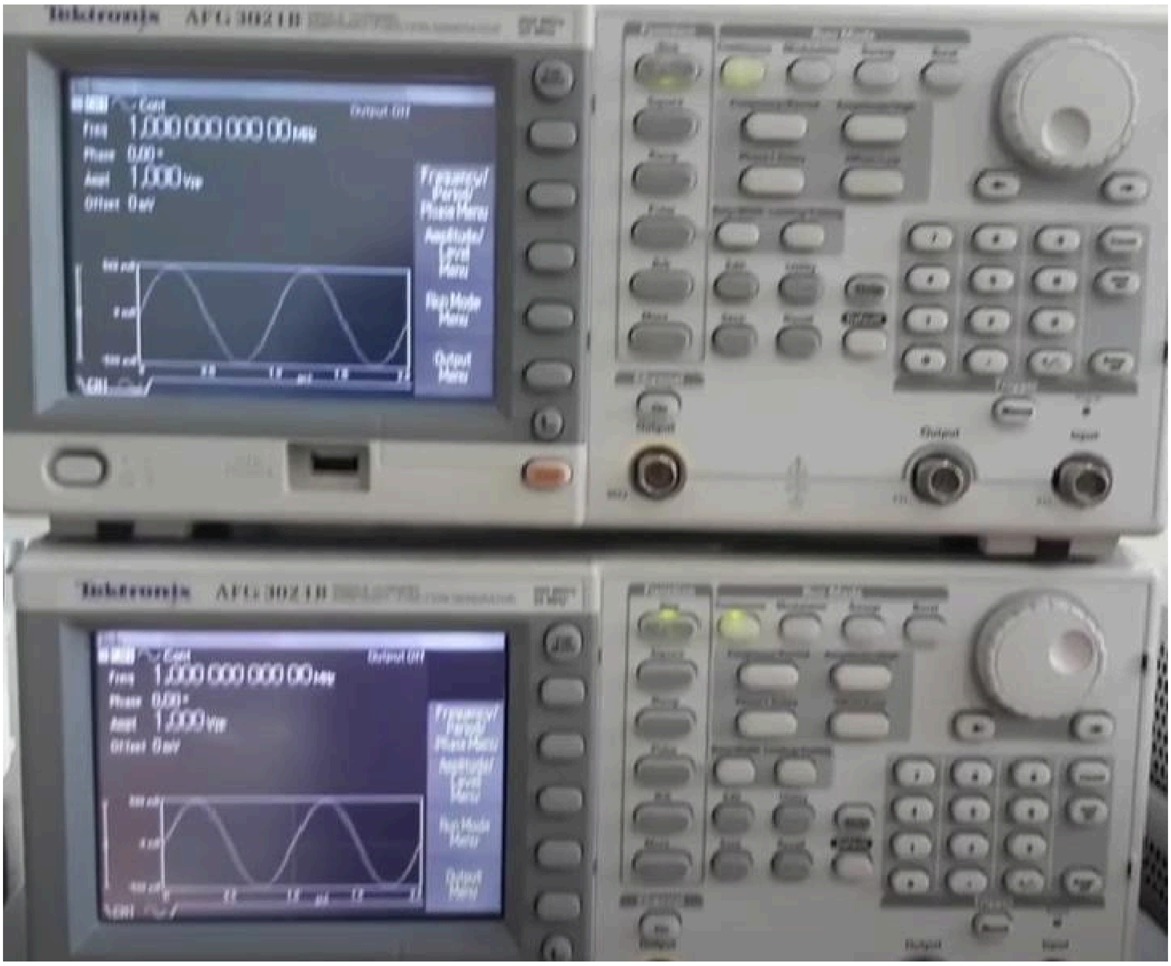


Patch Chords:

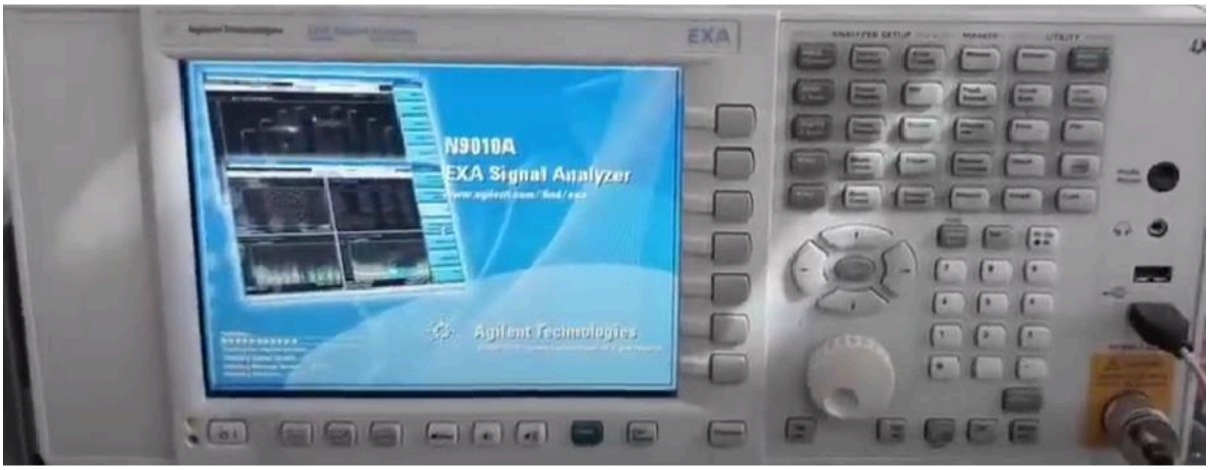


Probe Cable:

Function Generator :



Signal Analyser:



Bnc to Bnc Coaxial Cable:

Sma to Bnc Coaxial Cable:

Sma to Sma coaxial Cable: