Amplitude Modulation and Demodulation

1 Objectives

- Generation of amplitude modulated signals using the multiplier IC AD633.
- Demodulation of the generated AM signal using envelope detector circuit.

2 Theory Overview

Modulation

Amplitude modulation (AM) is the type of modulation in which the amplitude of the carrier wave changes linearly with the amplitude of the modulating signal [1]. Consider a sinusoidal modulating signal $m(t) = A_m \cos \omega_m t$ and the carrier signal $c(t) = A_c \cos \omega_c t$. The conventional AM signal is given by

$$u(t) = A_c (1 + A_m \cos \omega_m t) \cos \omega_c t. \tag{1}$$

The modulation index is $\mu = A_m$. For successful demodulation μ should satisfy $0 \leq \mu \leq 1$.

Demodulation

Since the message signal $m(t)$ satisfies the condition $|m(t)| < 1$ (as $0 \leq \mu \leq 1$), the envelope (amplitude) $1 + m(t) > 0$. If we rectify the received signal, we eliminate the negative values without affecting the message signal. The rectified signal is equal to $u(t)$ when $u(t) > 0$ and zero when $u(t) < 0$. The message signal is recovered by passing the rectified signal through a lowpass filter whose bandwidth matches that of the message signal. The combination of the rectifier and the low-pass filter is called an *envelope detector*.

3 Circuit and Its Working Principle

The AM wave is generated with the help of the multiplier IC AD633.

The functional block diagram of AD633 is shown in Figure 1. The output is given by [2]

W=(X1-X2)*(Y1-Y2)/10 + Z

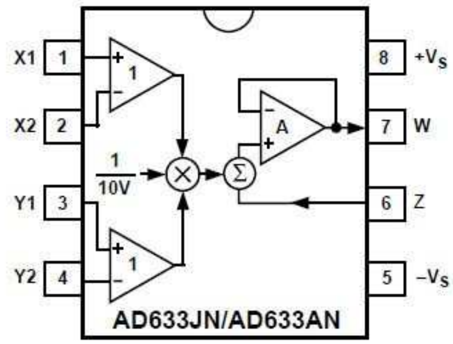

Figure 1: Block diagram of AD633

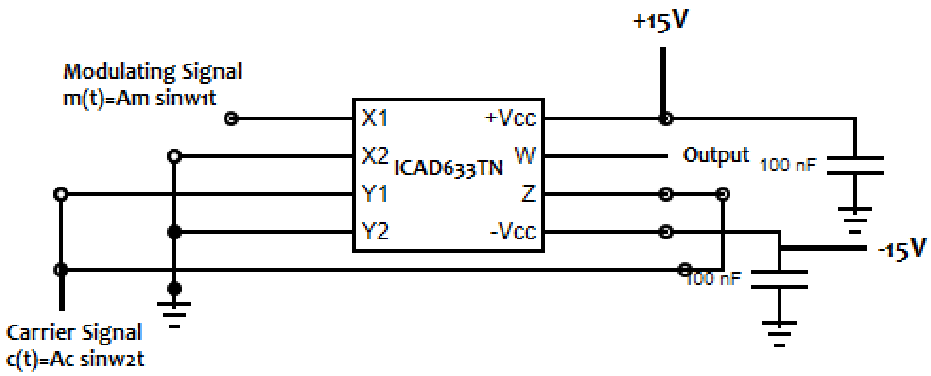

Figure 2: Circuit for AM modulation

The conventional AM signal is generated using AD633 as shown in Figure 2. Due to the factor $\frac{1}{10}$, the modulation index is given by $\mu = A_m/10$.

Figure 3 shows the circuit diagram for the overall modulation and demodulation. The demodulator is an envelope detector circuit which comprises of a rectifier followed by a low-pass filter.

In the envelope detector circuit, the value of the time constant RC used should such that it can follow the variations in the envelope of the carrier-modulated signal. In effect, $\frac{1}{\omega_c} << RC << \frac{1}{\omega_m}$. In such a case, the capacitor discharges slowly through the resistor and, thus, the output of the envelope detector closely follows the message signal

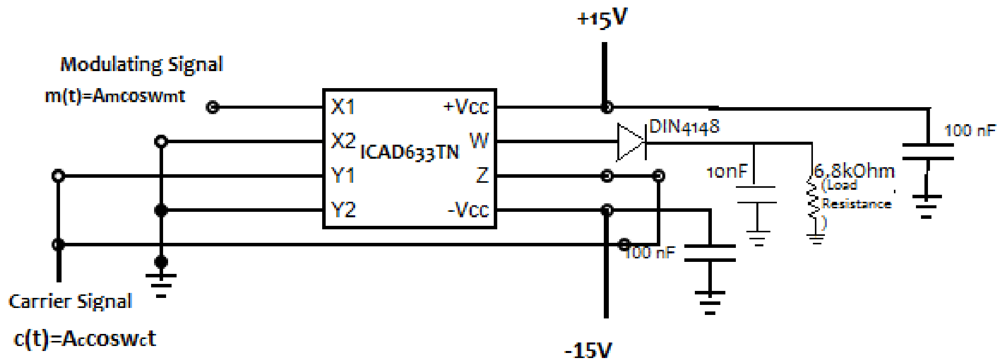

Figure 3: Circuit for amplitude modulation and demodulation (using envelope detector)

4 Lab Procedures

Perform the following steps:

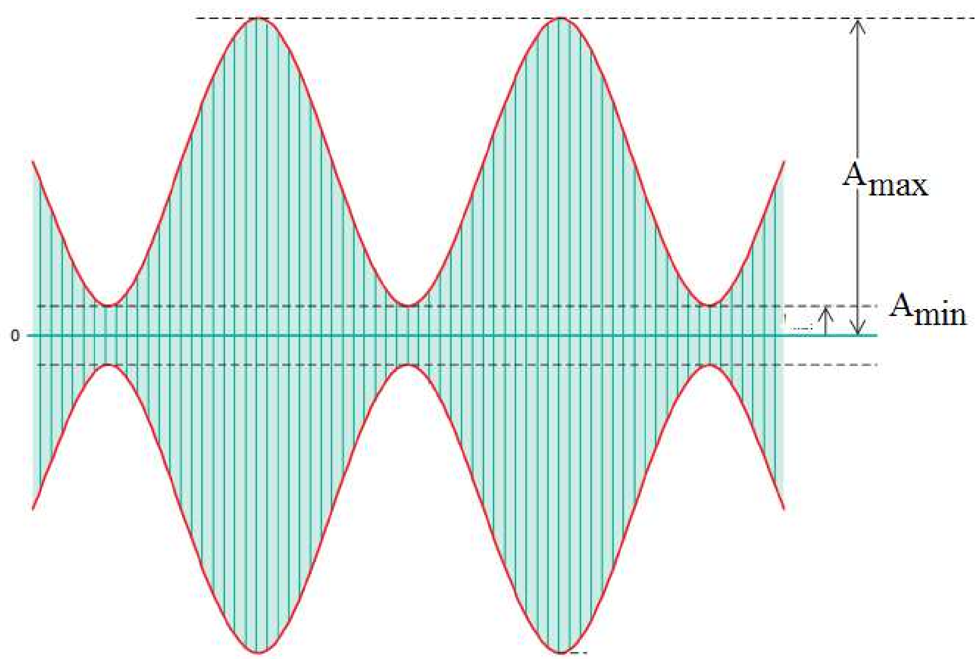

Figure 4: Computation of modulation index

1. For modulation:

    - Assemble the circuit as shown in Figure 2.
    - Apply a sinusoidal message signal of Vpp=1V, f_m = 1 kHz at X and a carrier signal of Vpp=4V, f_c =500kHz to Y1 and Z.
    - Observe the output at W using a digital oscilloscope.

- Vary the values of A_m (modulating signal amplitude) to 5Vpp and 10 Vpp and observe the output waveforms. As shown in Figure 4, calculate the values of modulating index from the output waveform using $\mu = (A_{\max} - A_{\min})/(A_{\max} + A_{\min})$, where $A_{\max}$ and $A_{\min}$ are the maximum and the minimum amplitudes of the positive envelope as obtained in the oscilloscope. Compare it with theoretical value $\mu = A_m/10$.
- Now remove the link between Y1 and Z, and ground Z. Observe the waveform.

2. For demodulation:

   - Connect the envelope detector circuit in cascade as shown in Figure 3.
   - Measure the output across the resistor R(=6.8kOhms) by connecting the digital oscilloscope across it.
   - Observe the waveform carefully. It should be a scaled form of the input modulating signal if the demodulation has been accurate.

Write down the challenges faced in the experiment and the ways to resolve those issues if any.

References

[1] Proakis and Salehi, *Communication System Engineering*, (2nd edition, Prentice Hall, 2003).

[2] Datasheet of AD633 http://www.analog.com/media/en/technical-documentation/data-sheets/AD633.pdf