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Communication Lab

Amplitude Modulator and Demodulator

AIM: To generate and characterize AM signal using Gilbert Multiplier Cell (MC1496) and to demodulate the AM signal using envelope detector.

APPARATUS REQUIRED:

1. Bread board with components of desired values.
2. Function generator (2-Nos) (One for carrier and one for message signal)
3. DSO/CRO
4. Connecting wire and probes

THEORY:

Modulator:

The modulation scheme in which the amplitude of a low frequency signal, which conveys the message, controls the amplitude of high frequency signal is called as Amplitude Modulation (AM). The high frequency signal is known as carrier and low frequency signal is called the modulating signal or message signal.

The AM signal can be written as

$$\begin{aligned}\varphi_{AM}(t) &= A\cos\omega_c t \;+\; m(t)\;A\cos\omega_c(t) \\ &= A\left[1 \;+\; m(t)\right]\cos\omega_c t\end{aligned} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where A is the amplitude of the carrier wave having angular frequency ω_c and *m(t)* is the message signal.

The envelope of the AM signal is given by $A\left|1 \;+\; m(t)\right|$……………………… (2)

If we consider *m(t)* as a monotone signal (i.e. $m(t) = m_p cos\omega_m t$ and $\omega_m << \omega_c$) and the maximum and minimum value of m(t) is $\pm m_p$, then the modulation index is represented as $\mu = \frac{m_p}{A}$. $\mu > 1$ corresponds over-modulation and in this case retrieval of message signal from the envelope of the AM signal is not possible.

Measurement of modulation index, μ, can be done from the AM waveform ($\mu < 1$) using the following formula

$\mu = \frac{A_{\max} \;-\; A_{\min}}{A_{\max} \;+\; A_{\min}}$, where A_{max} and A_{min} are the values of the crest and trough of the AM wave.

Demodulator:

The demodulation of AM signal; i.e. extraction of message signal from the AM signal, can be done from its envelope. A simple envelope detector is shown below in Fig. 1.

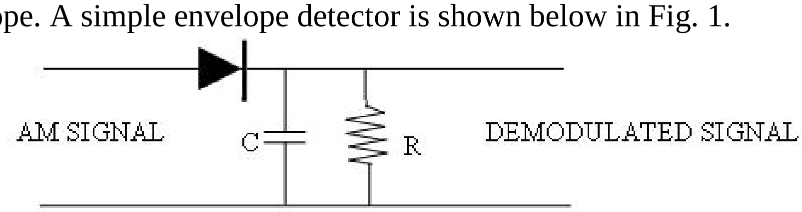

Fig. 1. Envelope detector for AM.

Proper demodulation using such envelope detector is only possible if modulation index $\mu \le 1$, and the RC value hold the relation $\frac{1}{\omega_c} << RC < \frac{1}{\omega_m}$ ………………..(3)

Experimental Setup:

For this experiment the AM signal is generated using Gilbert Multiplier Cell (MC 1496). The internal circuit diagram of the Gilbert multiplier inside MC 1496 and the circuit for the AM modulator is shown in Fig 2 and Fig 3 respectively.

The potentiometer connected to V_{EE} can control the modulation index and can be used to make the carrier null. Further, as per the equation (1) the modulation index, μ, can be changed by adding an DC voltage (offset) to the message signal *m(t)*.

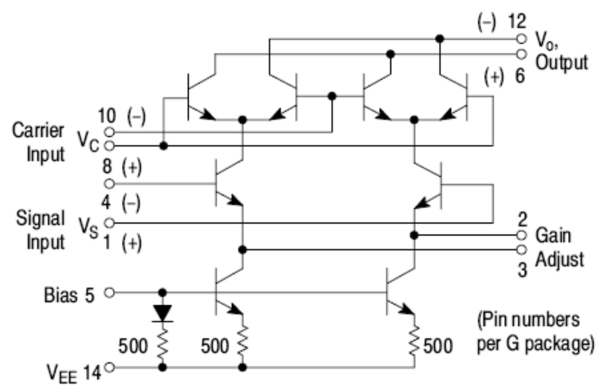

Fig. 2. Internal circuit diagram of MC 1496

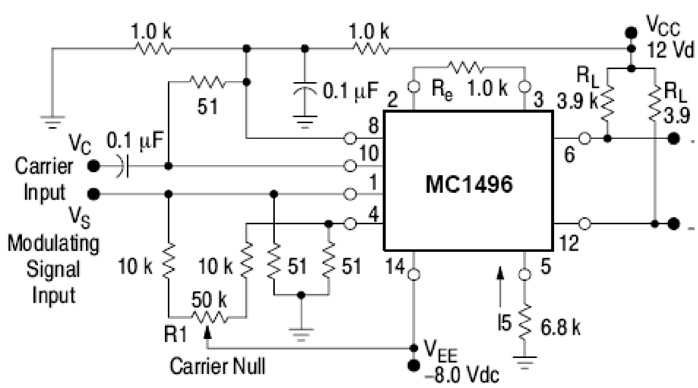

Fig. 3. Circuit for AM modulator

<u>Experimental Procedure:</u>

1. Apply the bias voltages according to the circuit given in Fig. 3. Note that maximum value of V_{EE} can be -12V (although typical value of -8V is given).
2. Set the frequency of sinusoidal carrier = 150 kHz and message signal as a monotone of frequency 2 kHz.
3. Note that the amplitude of carrier and message signal should not exceed 0.2 V and 0.25 -0.3 V respectively. Keep the DC offset of the carrier and message equal to zero at this point.
4. Put two 0.1 microFarad capacitors at the two outputs (Pin 6 and Pin 12) and observe output in CRO from either pin 6 or pin 12. The CRO should display an AM signal.

5. Adjust the potentiometer connected to the V_{EE}. A change in modulation index should be observed.
6. Now vary the DC offset of the message signal. Observe more change in modulation index.
7. Measure different values of modulation indexes starting from 0.5 to 1.3. Take the traces of the signals from the CRO.
8. Adjust potentiometer and the DC offset of the message to make the carrier null. Take the trace of the signal.
9. Now vary the amplitude of the message and signals in steps of few tens of mV and measure the modulation index, percentage of modulation, and efficiency. Take readings for modulation index starting from 0.5 up to 1.3. If necessary vary the DC offset of the message signal.
10. Power efficiency is defined by

$$\eta = \frac{Usefulpower}{Totalpower} = \frac{\mu^2}{2 + \mu^2}$$

11. Construct the envelope detector as shown in Fig. 1. For determining R and C value use relation as mentioned in Eq. (3).
12. Trace the demodulated signal corresponding to modulation index, μ = 0.5, 1.0, and 1.2.
13. Double the value of R in the envelope detector and repeat the step 12.
14. **Note that if the AM signal output from MC1496 is low enough to drive the envelope detector; construct an amplifier using OPAMP in between MC 1496 and Envelope detector.**
15. Now change the carrier frequency to 250 kHz and message signal frequency 4 kHz and repeat the steps 3 to 12.
16. Fix the modulation index < 1 (say 0.7) and use triangular, ramp, square signal as message. Trace the AM signal ,demodulated signal and the original message signals.

OBSERVATIONS AND CALCULATIONS:

Modulation:

Table 1

Carrier frequency =………, Message signal frequency = …………………

Si. No	Modulating Signal amplitude	Carrier Signal amplitude	DC offset value of the message signal	A_{max}	A_{min}	Modulation index, μ	Percentage modulation, $\mu \times 100$ (%)	Efficiency $\eta=\mu^2/(\mu^2+2) \times 100$

Demodulation:

Carrier frequency =………, Message signal frequency = …………………

Calculated value of R and C

Values of R and C used in the circuit.

References:

Modern digital and analog communication systems, B. P. Lathi and Zhi Ding

Principles of communication systems, H. Taub, D. L. Schilling

Data sheet of MC1496 (www.onsemi.com/pub/Collateral/MC1496-D.PDF)