OBJECTIVE

To construct an Amplitude Modulator and Demodulator on a single PCB. The design will include a modulator block that accepts carrier and message signals and allows adjustment of the modulation index. The demodulator block will extract the original message signal from the modulated signal, with a provision to modify the low-pass filter (LPF) cutoff frequency.

DESIGN DOCUMENT

(i) Purpose of the Circuit:

The circuit demonstrates the principles of amplitude modulation (AM) and demodulation. It models how an input message signal is modulated onto a carrier signal and subsequently recovered using a demodulator, with provisions for parameter adjustments for better understanding and optimization.

(ii) Working Condition of the Circuit:

As PCB printing was not possible, the circuit was designed and simulated in LTspice software, with both modulation and demodulation along with change of modulation index and modification of low pass filter cutoff frequency working as expected. The PCB designing – schematic and layout routing has been done. DRC check showing zero errors.

- **Simulation Environment:** LTspice.
- The circuit operates under idealized conditions without physical PCB constraints in the simulation.
- Inputs (carrier and message) are generated using LTspice's voltage sources.
- Output graph plotted with help of software.

(iii) Any Constraint on the Input and Output Signals:

- **Modulator Block Inputs:**
    - **Carrier Signal:** Sine wave, frequency 100 kHz to 1 MHz, amplitude 0.2 V p-p.
    - **Message Signal:** Sine wave, frequency 20 Hz to 5 kHz, amplitude 0.25– 0.3 V p-p.
- **Demodulator Block Input:**
    - Modulated AM signal from the modulator block, with amplitudes within ±1 V p-p.
- **Outputs:**
    - Modulator output: AM signal with adjustable modulation index.
    - Demodulator output: Retrieved message signal after LPF.

(iv) Requirements of Load Impedances:

- Modulator output load: Ideal resistive load, typically >1kΩ, here in circuit design used 3.9kΩ.
- Demodulator output load: Resistor R and capacitor C in the detector should satisfy the relation: $\frac{1}{\omega_c} \ll RC \ll \frac{1}{\omega_m}$.

(v) Number of Inputs and Outputs and their Types:

- **Inputs:**
    - INPUT 1,2 - Modulator: Carrier signal and message signal (sinusoidal voltage sources).
    - Demodulator INPUT: Modulated AM signal (from modulator output).

- **Outputs:**
    - OUTPUT-1 - Modulator: AM signal (voltage source in simulation).
    - OUTPUT-2 - Demodulator: Demodulated message signal (voltage source in simulation).

(vi) Voltage Required for Running the Circuit in Simulation:

The simulated circuit uses idealized voltage supplies for components:

- +12V & -12V DC for other ICs.
- Signal inputs as needed for multiple testing.
- GND common for all circuits interconnected in PCB – in practical connect it with AFG, DSO Probes while giving input and taking output.

(vii) Power Consumption of the Circuit:

Power consumption is not directly applicable in simulation; however, approximated calculation done based on values in circuit and simulation.

1. Power Consumption in AM Modulator

The main components consuming power are:

1. **Resistor R_L:**
    - The load resistor in the AM modulator is R_L=3.9 kΩ.
    - Power dissipated in R_L can be calculated as: Type equation here.$P_{R_L} = \frac{V^2}{R_L}$
    - Here, V is the voltage drop across R_L. Assuming it is close to Vcc=12 V (ideal case), the power is:

$$P_{R_L} = \frac{(12)^2}{3900} = \frac{144}{3900} = 36.9mW$$

2. **MC1496 Modulator IC:**
    - The current drawn by the IC depends on its biasing and operation. For the MC1496, the datasheet specifies an average current of

$$I_{CC} \approx 2\, mA.$$

    - Power consumed by the IC is:

$$P_{IC} = V_{CC} \cdot I_{CC} = 12 \cdot 0.002 = 24mW$$

    - **Total Power Consumption in Modulator:** Adding the power dissipation in R_L and the IC:

$$P_{modulator} = P_{R_L} + P_{IC} = 36.9mW\ +\ 24mW\ =\ 60.9mW$$

2. Power Consumption in AM Demodulator

The demodulator primarily consists of an envelope detector with a resistor R and capacitor C.

1. **Power Dissipation in R:**
    - The input to the demodulator is a modulated wave. Assuming an amplitude V_m the power dissipation in R is:

$$P_R = \frac{V_m^2}{R}$$

- Without specific values for V_m and R, we express the power in terms of these variables.

2. **Capacitor C:**
    - Capacitors do not dissipate power directly; they store and release energy. Thus, no steady-state power is consumed by C.

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3. Modulation Index μ:

The modulation index μ affects the input power to the circuits because it determines the amplitude of the modulated wave. The total power of an AM signal is:

$$P_{AM} = P_c\left(1 + \frac{\mu^2}{2}\right)$$

where:

- Pc is the carrier power.

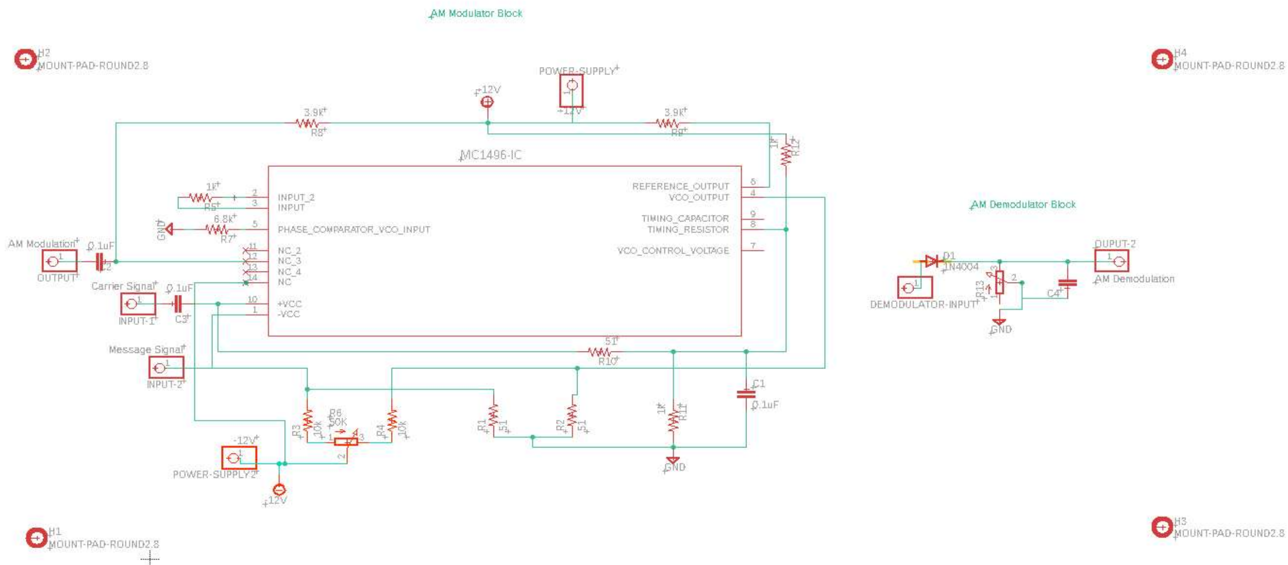
The modulation index μ is required to determine the additional power due to the sidebands. If provided, this can refine the power calculations.

Therefore, Powe in modulator block is approximately 60.9mW under ideal assumptions. Power in demodulator block depends on V_m input and R.

(viii) The Stages within the Circuit from Where the Signal Can Be Tapped:

1. **Modulator Block Stages:**
    - Carrier signal pin header (input).
    - Message signal pin header (input).
    - Modulated AM signal (output).
2. **Demodulator Block Stages:**
    - Modulated AM signal pin header (input).
    - Rectified signal pin header (post-detection).
    - Filtered message signal pin header (LPF output).

SCHEMATIC DIAGRAM



File attached in mail, image added for referance.

CIRCUIT DIAGRAM

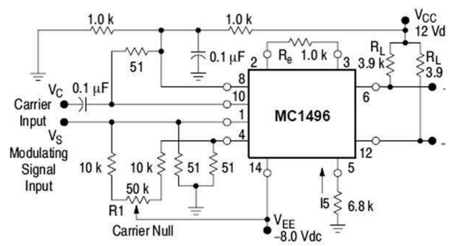


Fig. 3. Circuit for AM modulator

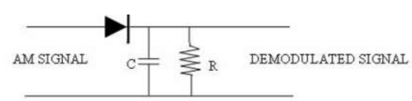
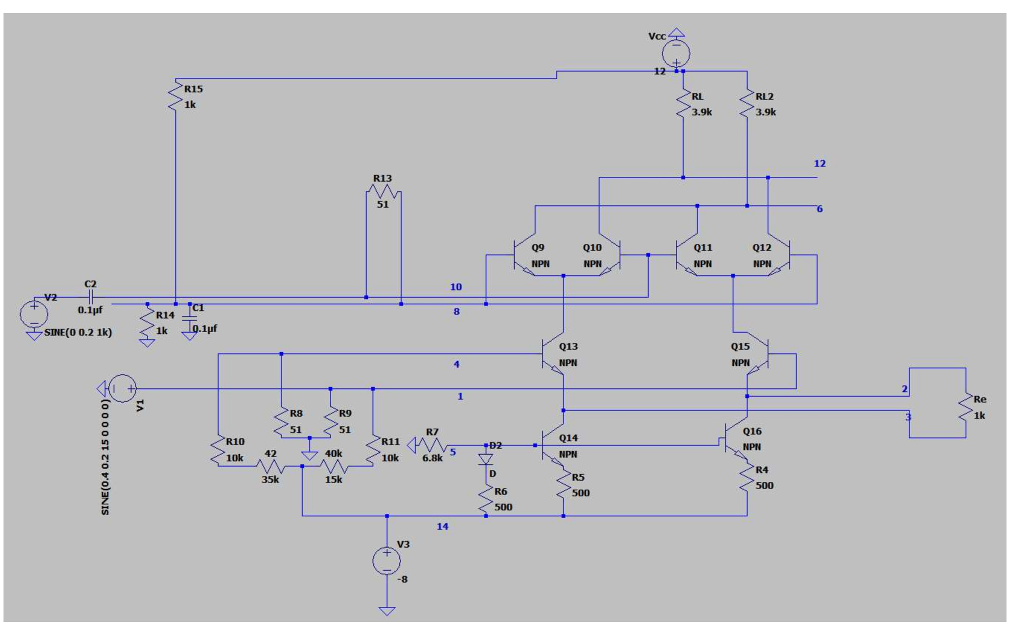


Fig. 1. Envelope detector for AM.

The reference circuit diagrams used from lab manual.



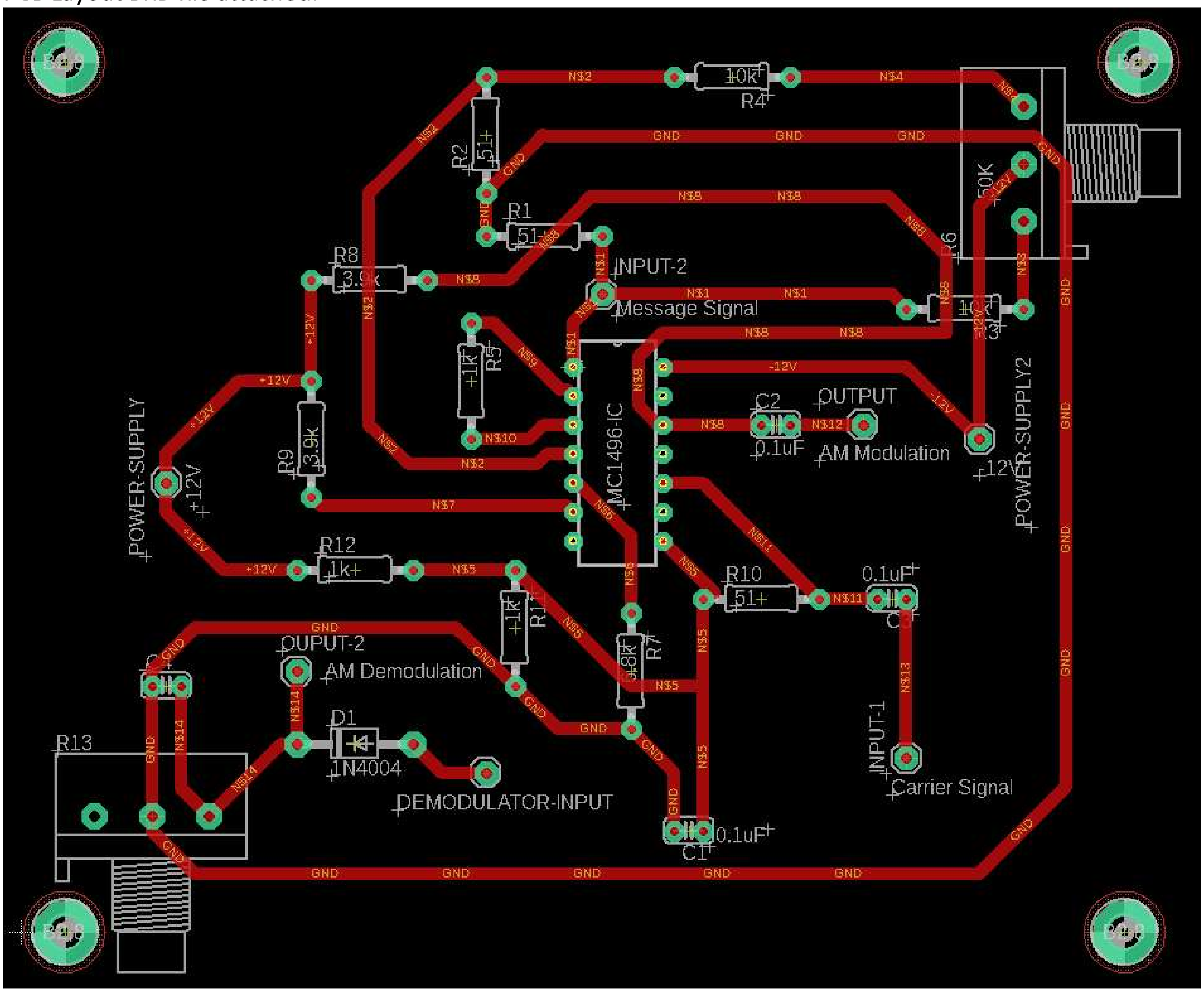
Simulated circuit diagram from LTspice, including MC1496 IC internal circuit.

CIRCUIT DESIGN

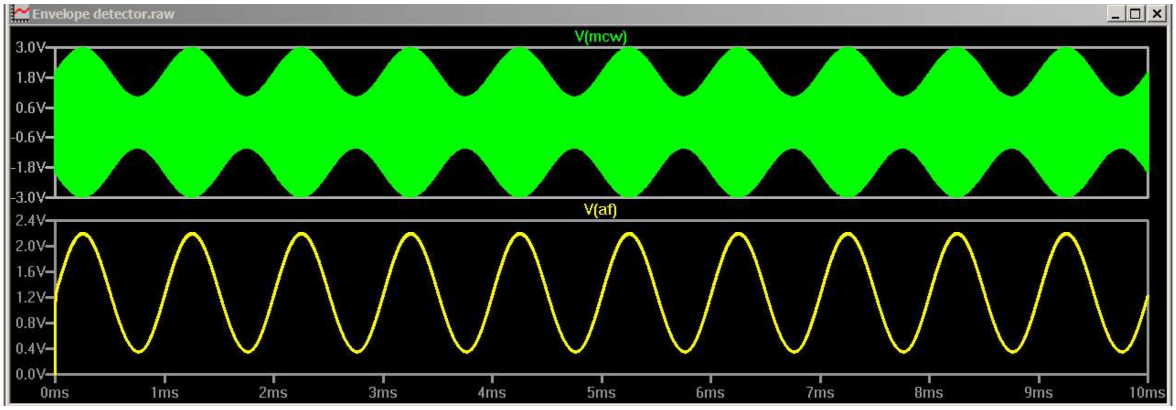
As our assignment was AM modulation and demodulation. One modulation and then followed by a demodulation block is the circuit design. Implemented showing in above figures.

PCB DESIGN

PCB Layout BRD file attached.



RESULTS - SIMULATION



Under-Modulated Output and Demodulated Output

CONCLUSION

- Simulation of circuit done in LTspice for circuit verification.
- Eagle software: From schematic to mapping it to PCB layout then arranging the components, then manual routing has been done, while keeping pad size, clearance in mind and values adjusted.
- Images attached as necessary.
- Gerber Files folder, Schematic file, Board BRD file – attached inside zip folder in mail with report.
- A good understanding of Circuit design in breadboard testing phase, simulation software, PCB designing purpose practical use, PCB design – done software and manual routing and compiling the report containing all files and explanations are things learnt from this lab assignment.