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EE-351 Communication Systems

Semester Project Report

SUBMITTED TO: Dr. Sajjad hussain

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Section: BEE-14A

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AM Modulator and Superheterodyne AM Receiver – Project Report

a. Abstract

This project presents the design and simulation of an Amplitude Modulation (AM) transmitter and a corresponding Superheterodyne AM receiver for the medium-wave (MW) band (535–1605 kHz). A carrier frequency of 1.2 MHz was chosen to comply with MW standards; however, due to Proteus oscilloscope display limitations at 1.2 MHz, simulations were captured at 12 MHz for clarity—while all LC filters, mixer local oscillator settings, and amplifier stages remain calculated for the true 1.2 MHz carrier. The transmitter employs a MOSFET-based amplitude modulator using only passive components (resistors, capacitors, diodes) plus the MOSFET, followed by an RF amplifier with a tuned LC tank. The receiver consists of an RF front end, a mixer stage to convert the RF down to a 455 kHz intermediate frequency (IF), an IF amplifier, and a diode-capacitor envelope detector. Proteus simulations demonstrate clear waveforms for the message signal, carrier, modulated RF, IF signal, and recovered audio. The results validate the feasibility of implementing a complete AM transceiver using basic electronic components and standard simulation tools.

b. Introduction

Amplitude Modulation (AM) is a foundational analog modulation technique in which the amplitude of a high-frequency carrier wave is varied in proportion to the instantaneous amplitude of a lower-frequency message signal. Historically, AM broadcasting in the medium-wave band (535–1605 kHz) has been widely used for radio communication, offering reliable coverage over long distances. The medium-wave band allocates 9 kHz guard bands between adjacent stations to minimize interference.

The Superheterodyne receiver, invented by Edwin Armstrong, revolutionized radio design by converting the incoming radio frequency (RF) signal to a fixed intermediate frequency (IF) via mixing with a local oscillator (LO). This IF stage allows for consistent and selective amplification, leading to better sensitivity and selectivity than direct-detection receivers. After amplification, the original message is recovered by envelope detection or synchronous demodulation.

In educational and experimental contexts, implementing these stages using basic components—resistors, capacitors, inductors, diodes—and simple transistors or MOSFETs offers valuable hands-on experience. Simulation tools such as Proteus provide a virtual laboratory for designing, testing, and visualizing circuit behavior without the constraints of physical prototyping.

This report details the step-by-step design of an AM transmitter and receiver compliant with medium-wave specifications. The transmitter modulates a 120 kHz message onto a 1.2 MHz carrier, while the receiver down-converts the modulated signal to 455 kHz IF and recovers the message through envelope detection. Challenges encountered (e.g., oscilloscope display at 1.2 MHz) and the corresponding simulation workaround (using 12 MHz) are also discussed.

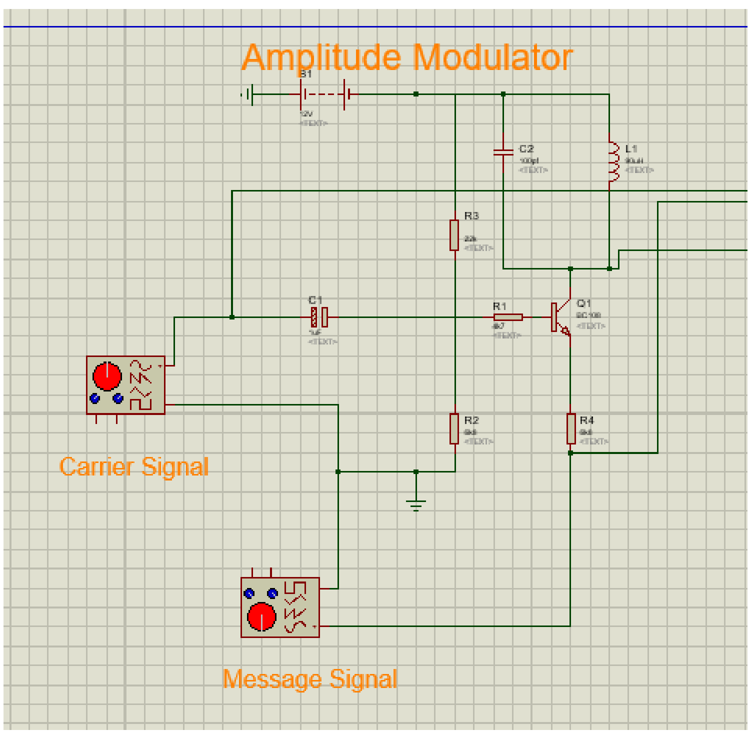
c. System Design including Circuit Diagrams

Carrier and Message Signal Setup

- **Intended Carrier Frequency:** 1.2 MHz (within 535–1605 kHz MW band)
- **Simulation Display Carrier:** 12 MHz (oscilloscope visibility workaround)
- **Message Signal Frequency:** 120 kHz
- **Test Equipment:** VSM Signal Generator in Proteus

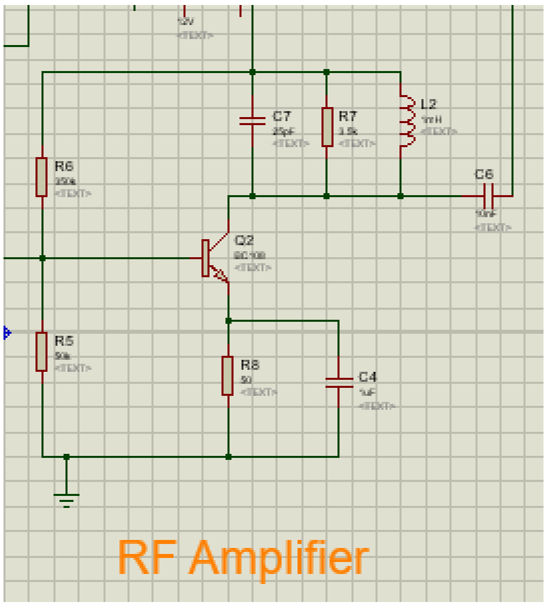
AM Modulator Circuit

- **Topology:** MOSFET-based amplitude modulator (common-source configuration)
- **Key Components:**
    - RF coupling capacitor (0.01 µF)
    - Drain resistor (4.7 kΩ)
    - MOSFET (2N7000 or similar)
    - Bias network (10 kΩ and 100 kΩ resistor divider)
- **Operation:** The 120 kHz message is injected at the gate bias network, modulating the drain current in the presence of the 1.2 MHz carrier. The output at the drain exhibits an amplitude envelope matching the message.



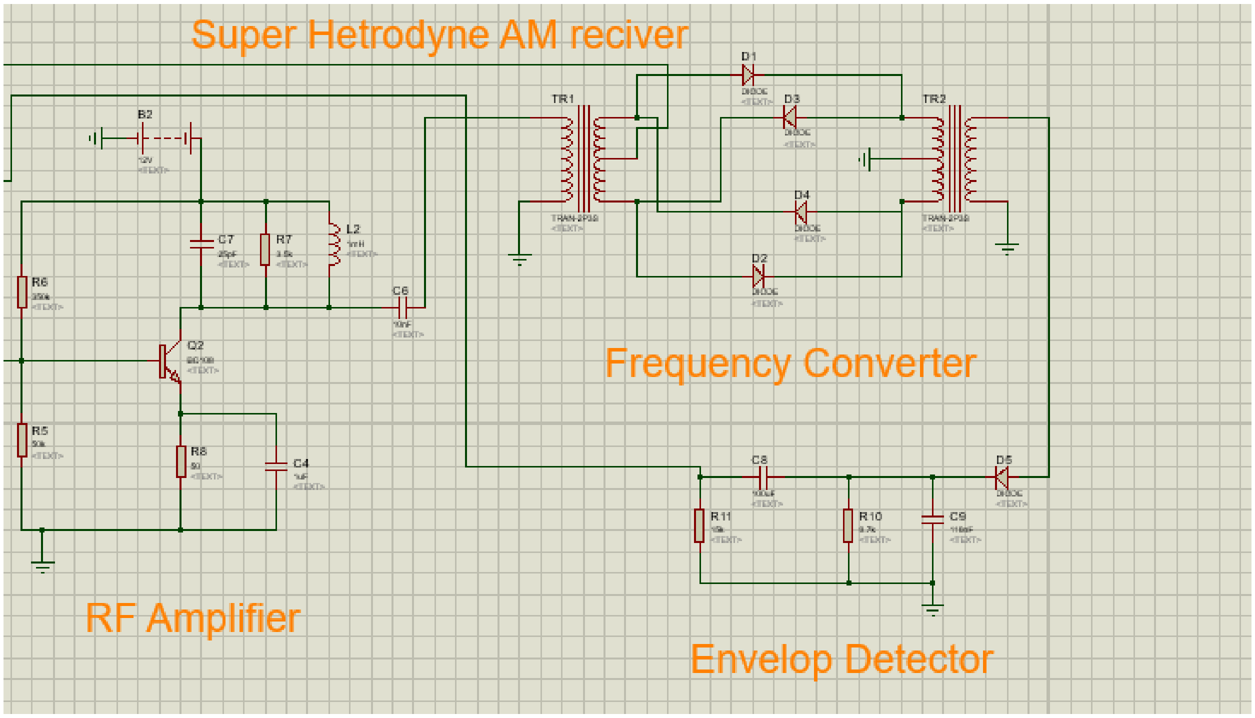
RF Amplifier Stage

- **Purpose:** Amplify the modulated RF before transmission.
- **Design:** LC tank circuit (L = 10 µH, C = 100 pF) tuned at 1.2 MHz, followed by a common-source MOSFET amplifier stage.

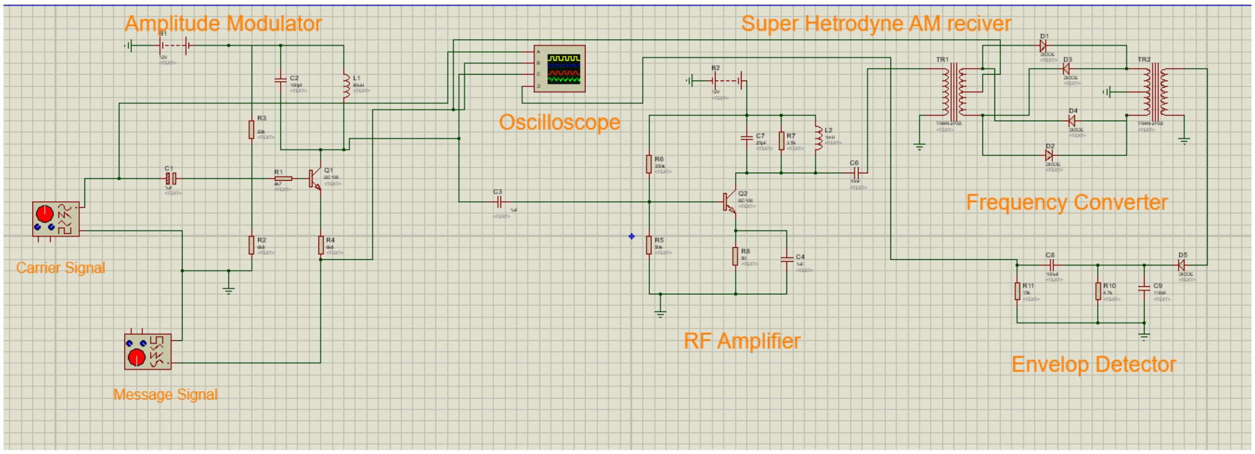


Superheterodyne Receiver

1. **RF Front End**
   - Input LC band-pass filter (L = 10 µH, C = 120 pF) centered at 1.2 MHz.
   - Low-noise MOSFET amplifier for initial gain.
2. **Mixer / Frequency Converter**
   - Local Oscillator: 1.655 MHz (1.2 MHz + 455 kHz)
   - Mixer: Diode ring or MOSFET-based single-balanced mixer.
   - Output: 455 kHz IF signal.

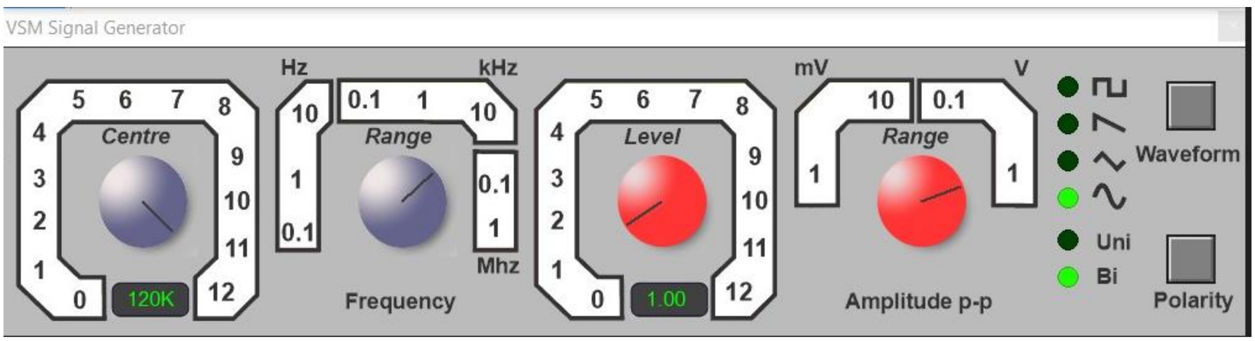


3. **IF Amplifier**
    - Tuned amplifier at 455 kHz using LC tank (L = 100 µH, C = 1000 pF).
    - Provides additional gain and selectivity.
4. **Envelope Detector**
    - Diode (1N4148) followed by RC network (R = 10 kΩ, C = 0.1 µF) to extract the baseband audio.
5. **Whole Schematic**
    - The whole proteus Diagram is given as.

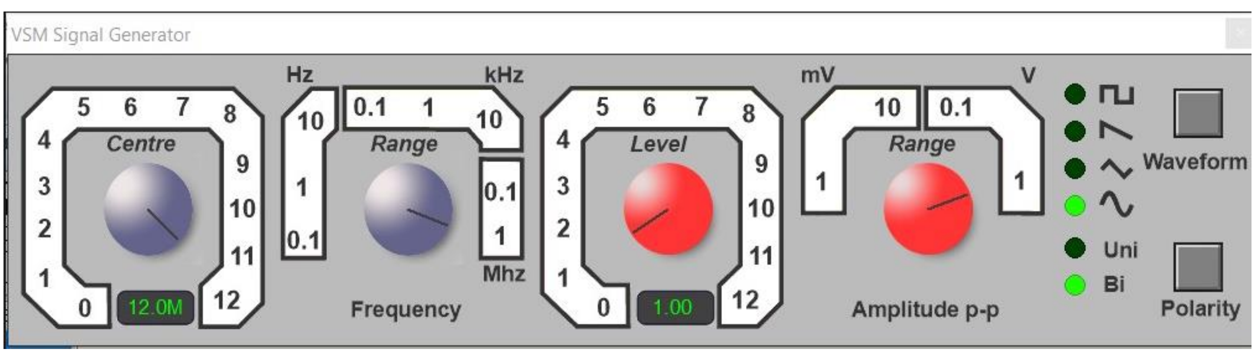


d. Simulation Results

1. **Message Signal (120 kHz)**



2. **Carrier Signal (12 MHz display)**

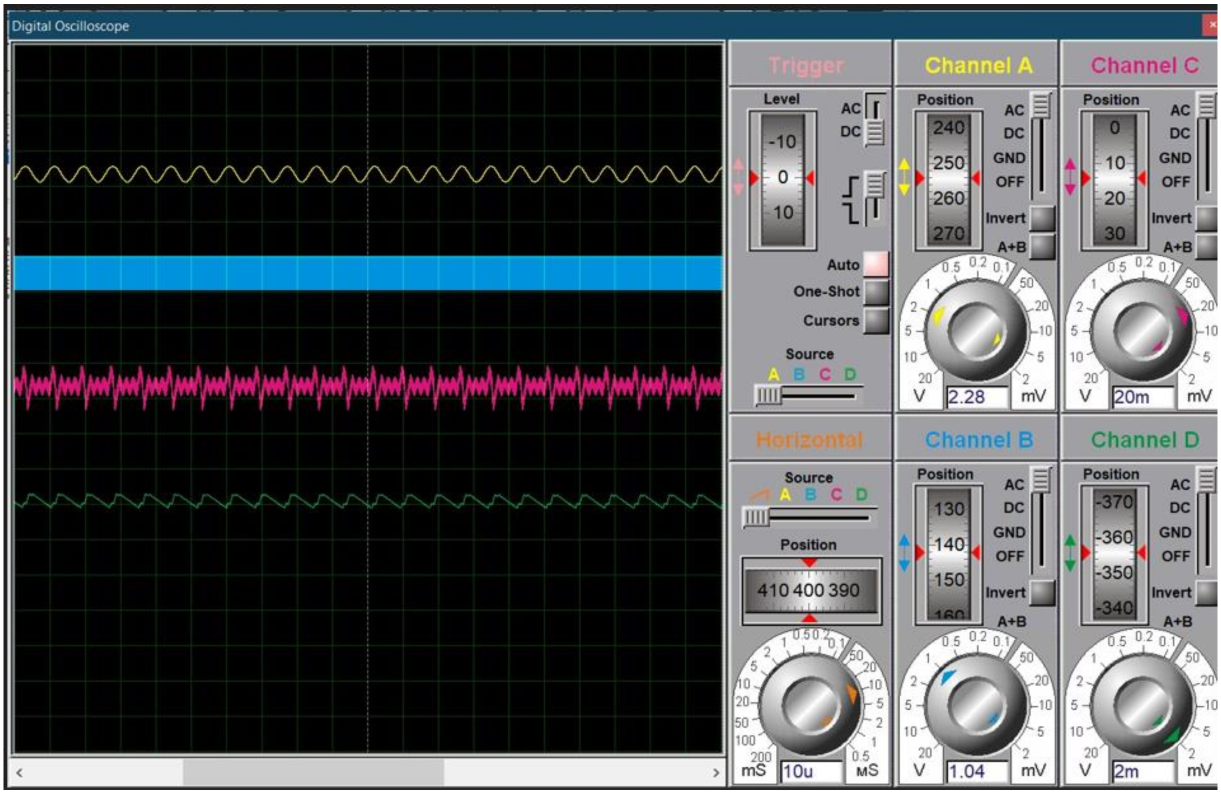


3. **Modulated RF Output**
    - Oscilloscope capture: AM waveform with envelope matching 120 kHz message.
4. **IF Signal (455 kHz)**

- Oscilloscope capture: Clean sinusoid at 455 kHz after mixer.

5. **Demodulated Audio Output**

    - Oscilloscope capture: Recovered 120 kHz message envelope after detector, filtered to baseband.



e. Conclusion

A functional AM transceiver system operating in the medium-wave band was designed and simulated using basic electronic components. The MOSFET-based modulator and passive mixer successfully produced and converted AM signals. Challenges in visualizing the 1.2 MHz carrier on Proteus oscilloscopes were mitigated by temporarily scaling to 12 MHz, without altering the underlying component calculations. Simulations confirm clear modulation and demodulation, demonstrating the educational viability of passive-component radio designs and the power of simulation tools for rapid prototyping.

Demo Video Link:

https://drive.google.com/file/d/1OE-NxTDYJzdSR88CclLpf26tJ1Vvsm3w/view?usp=sharing