AM Modulator Circuit Design and Simulation

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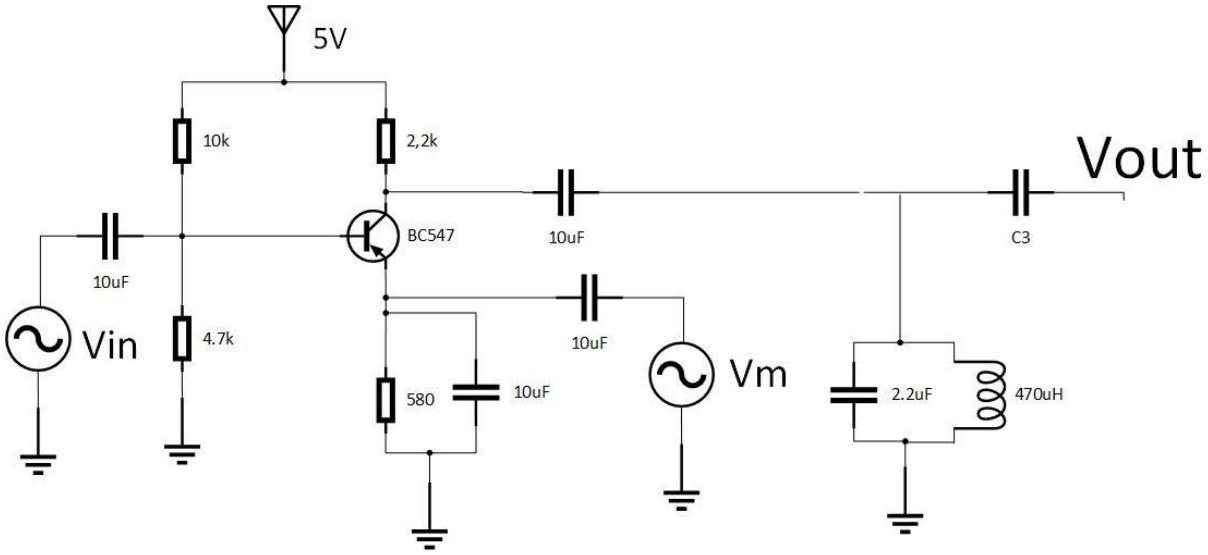
In collaboration with a teammate

Telecommunications Circuits Course

Fall/Winter 2024

1. Circuit 1: AM Modulator



1.1 Input Carrier Signal (V_{in})

- The carrier signal V_{in} is fed into the circuit.
- A 10 μF capacitor removes DC noise or offset from the input signal.

1.2 Transistor (BC547)

- The BC547 transistor amplifies the carrier signal.
- Bias resistors (10 kΩ, 4.7 kΩ) ensure the transistor operates in the active region.

1.3 Emitter Components

- A 580 Ω resistor controls the emitter voltage and limits the circuit gain.
- A 10 μF capacitor allows AC signal passage, enabling amplification.

1.4 Message Signal (V_m)

- The message signal V_m is applied to the emitter of the transistor.
- A 10 μF capacitor isolates the modulating AC signal from any DC components.

1.5 Output Stage

- A 10 μF coupling capacitor removes DC components, passing only the combined carrier and message signal (AC).

1.6 LC Filter

- An LC circuit (L = 4700 μH, C = 2.2 μF) filters out unwanted frequencies.
- The resonant frequency is calculated as:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

1.7 Output (V_{out})

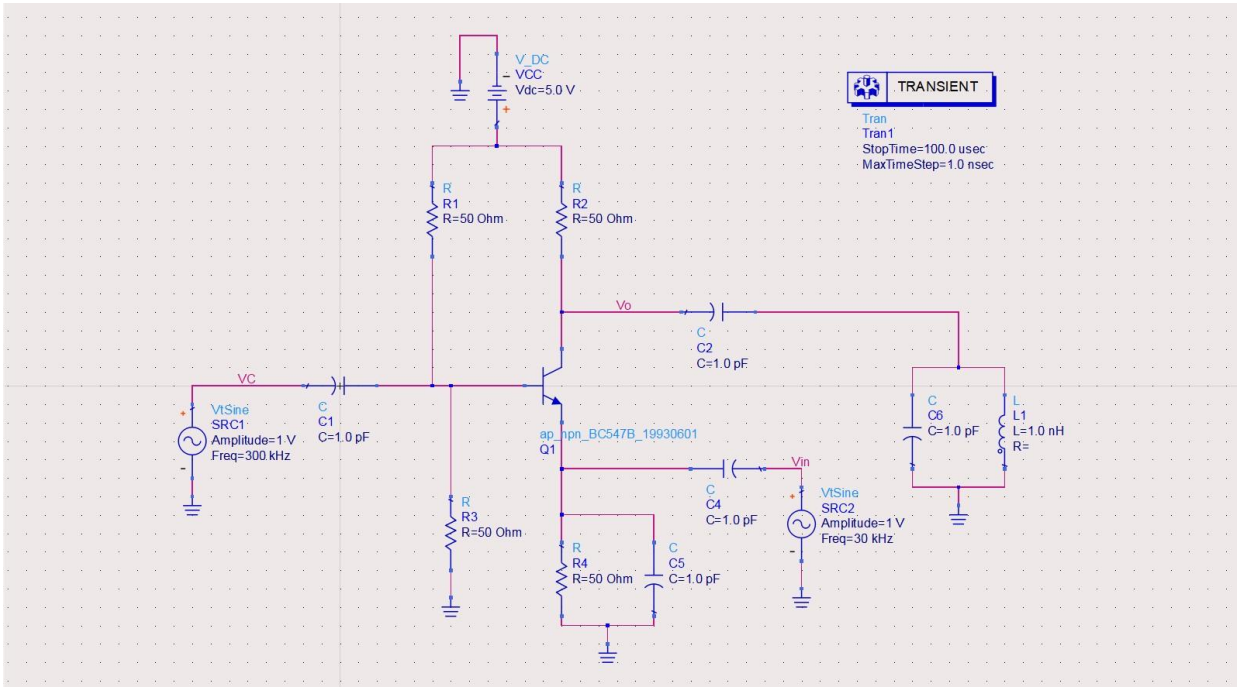
- The final AM signal is obtained at the output.
- A capacitor (C3) prevents DC voltage from reaching the load.

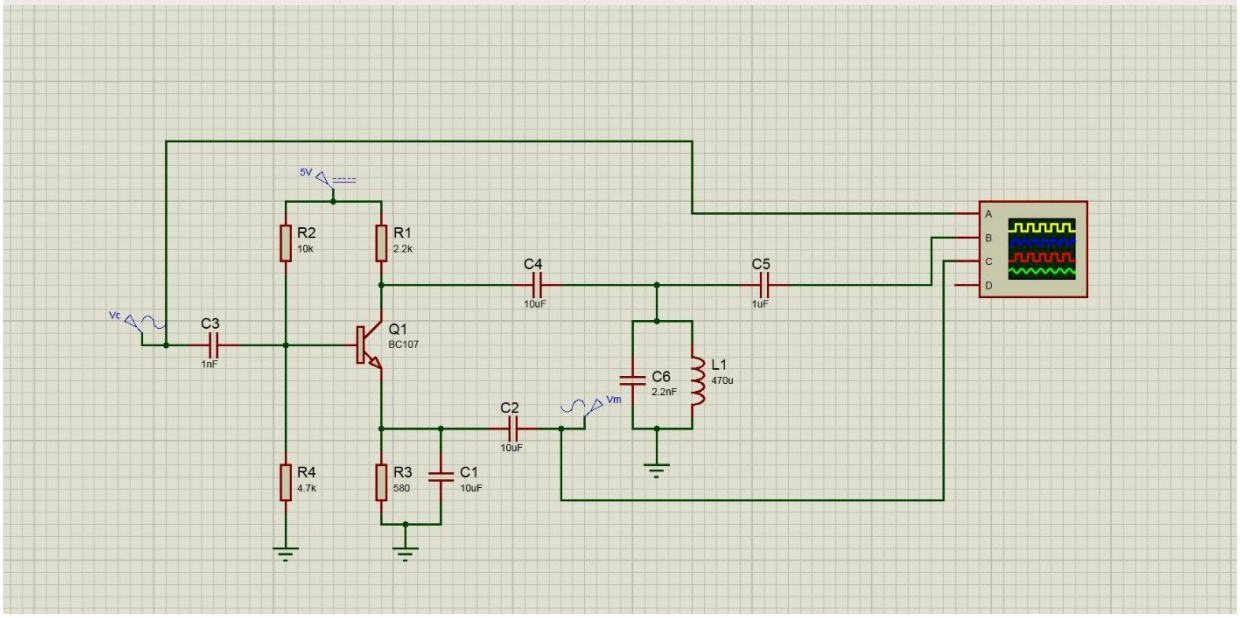
1.8 Summary

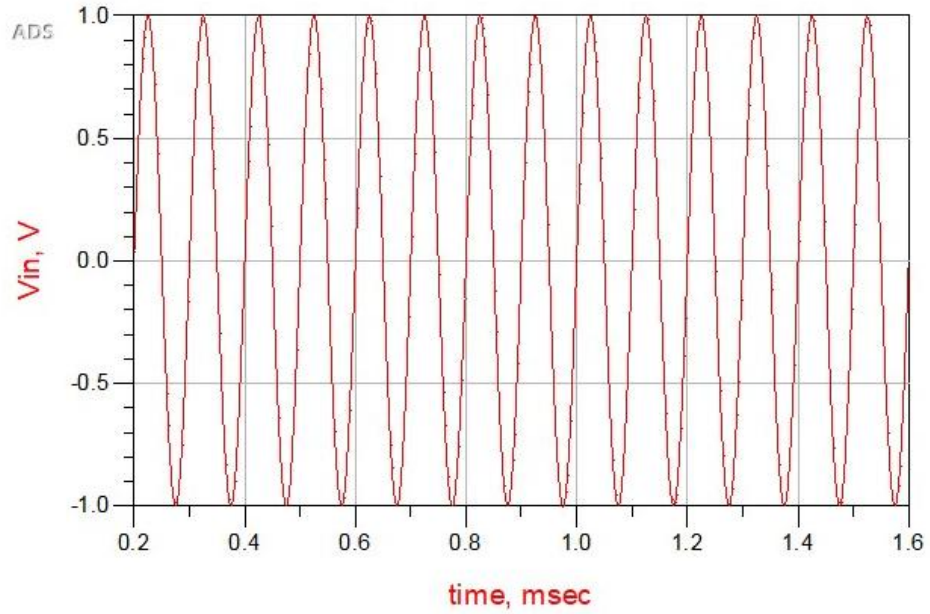
- The transistor amplifies and combines the carrier and message signals.
- The carrier signal (V_{in}) carries the modulated information.
- The message signal (V_m) contains the information to be modulated.
- The LC circuit filters unwanted frequencies, producing a clean AM signal.
- The output is the final AM signal ready for further processing.

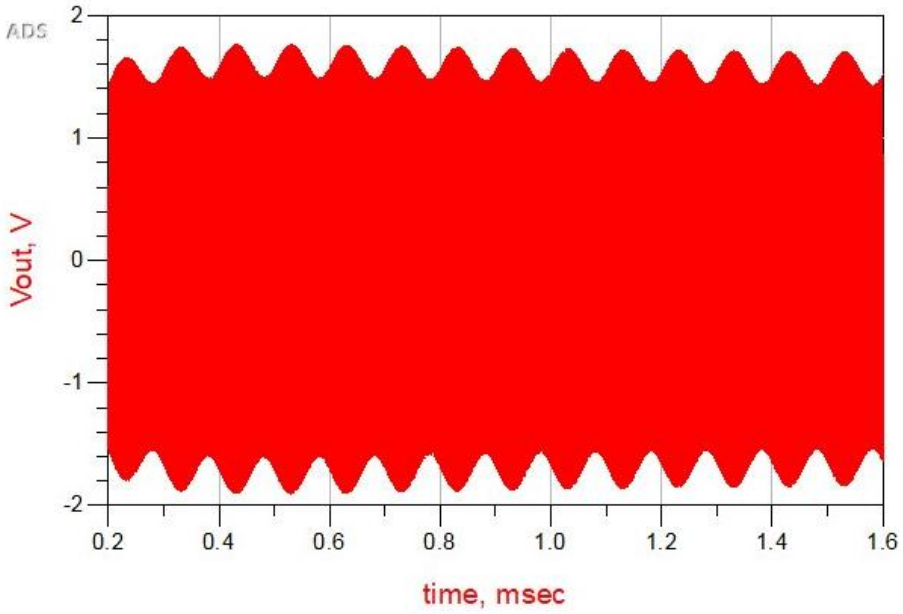
2. Simulation of Circuit 1

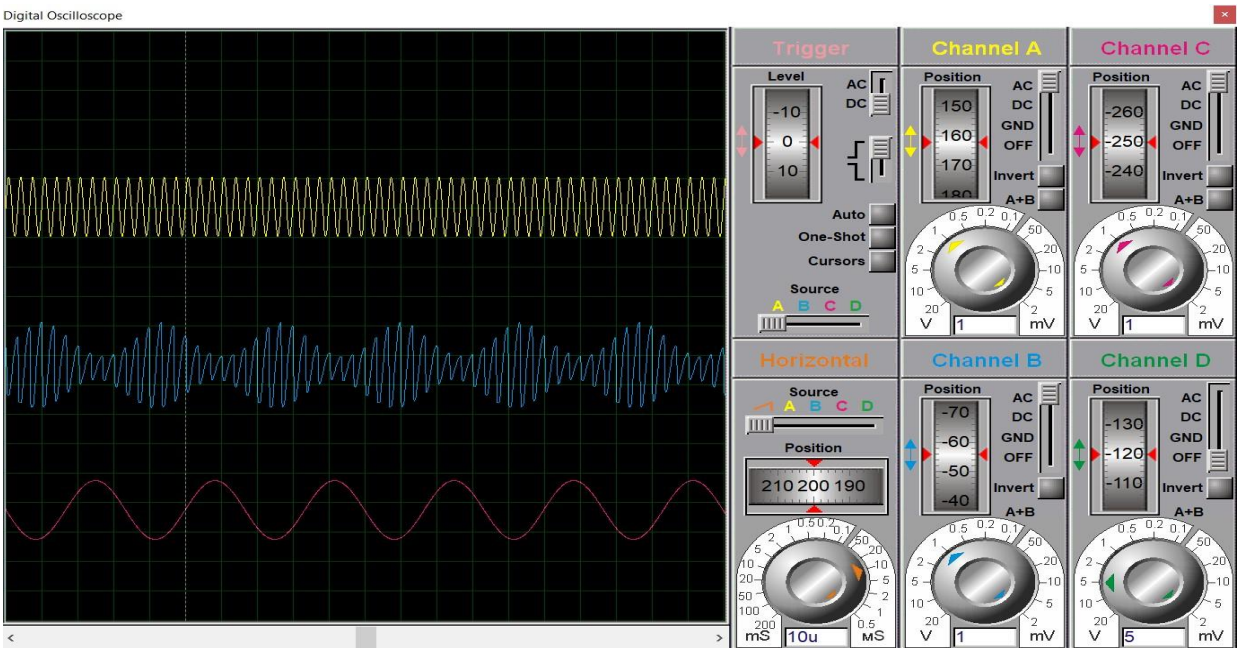
- Simulations were performed using Advanced Design System (ADS) and Proteus.



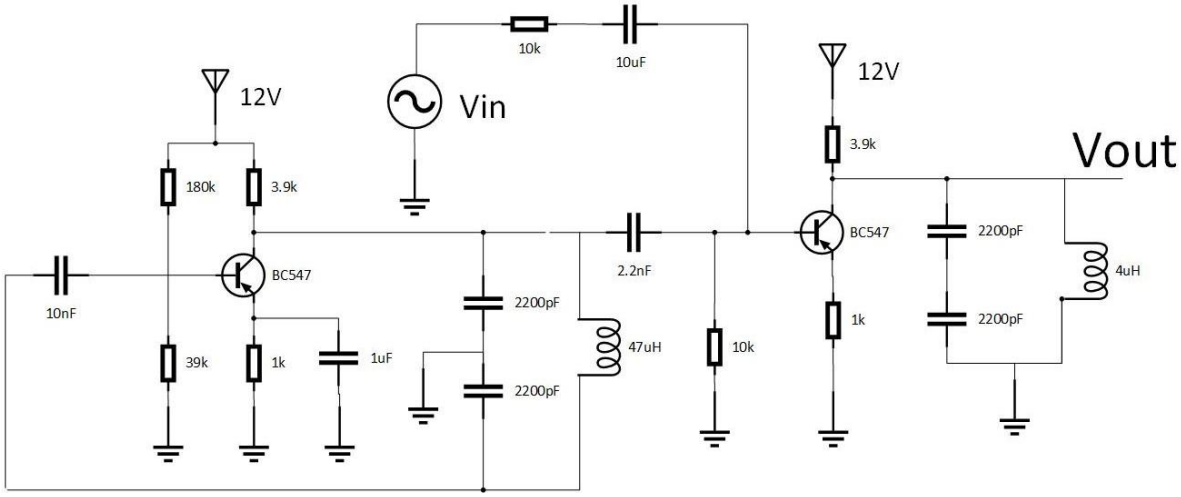



ADS
1.0
0.5
0.0
-0.5
-1.0
Vin, V
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
time, msec


ADS
2
1
0
-1
-2
Vout, V
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
time, msec



3. Circuit 2: AM Modulator with Oscillator



3.1 First Transistor (Oscillator)

- A BC547 transistor generates the carrier signal as an oscillator.
- Bias resistors (180 kΩ, 39 kΩ) ensure active mode operation.
- A 10 nF capacitor provides positive feedback to sustain oscillation.
- An LC circuit (L = 47 μH, C = 2200 pF) sets the carrier frequency:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

3.2 Input Signal (V_{in})

- The input source provides the message signal for modulation.

3.3 Second Transistor (Modulator)

- A second BC547 transistor combines the carrier and message signals.
- The carrier signal from the first transistors collector and the message signal are applied to the base.
- Bias resistors (3.9 kΩ, 1 kΩ) configure the transistor.

3.4 Output Stage

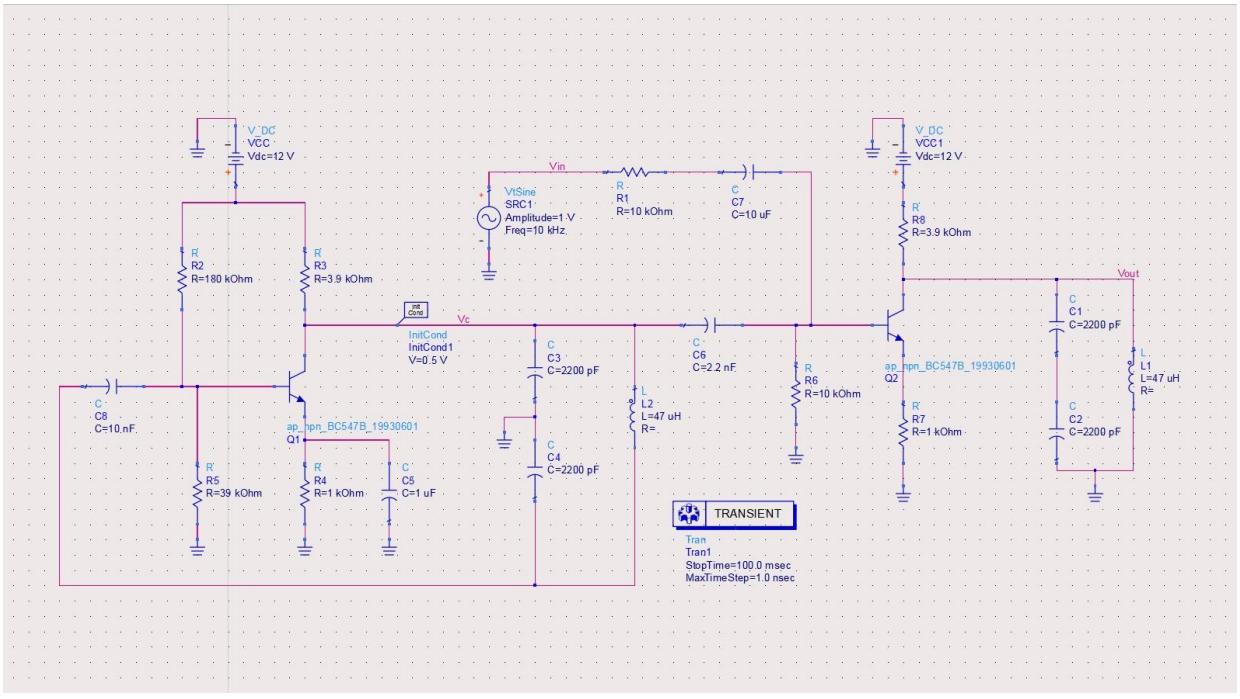
- An LC circuit (L = 4700 μH, C = 2.2 μF) filters the modulated signal.
- The final AM signal (V_{out}) is obtained at this stage.

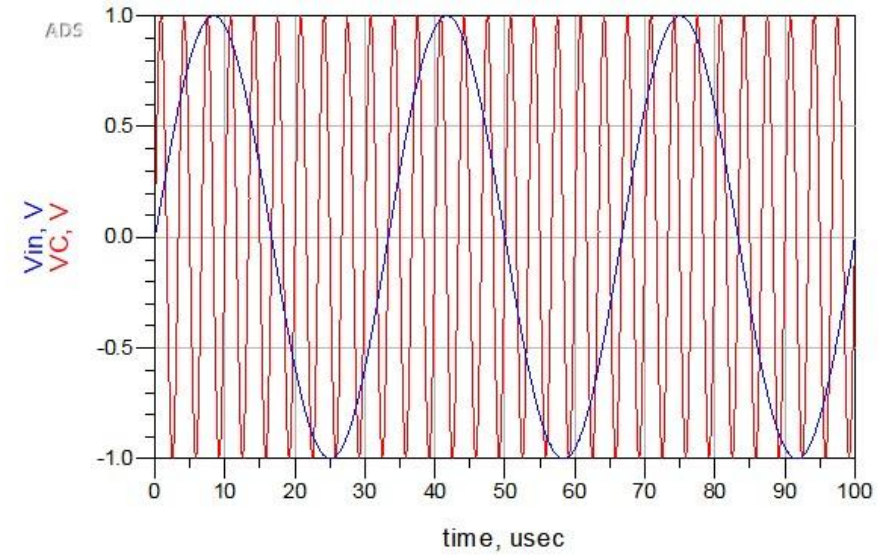
3.5 Summary

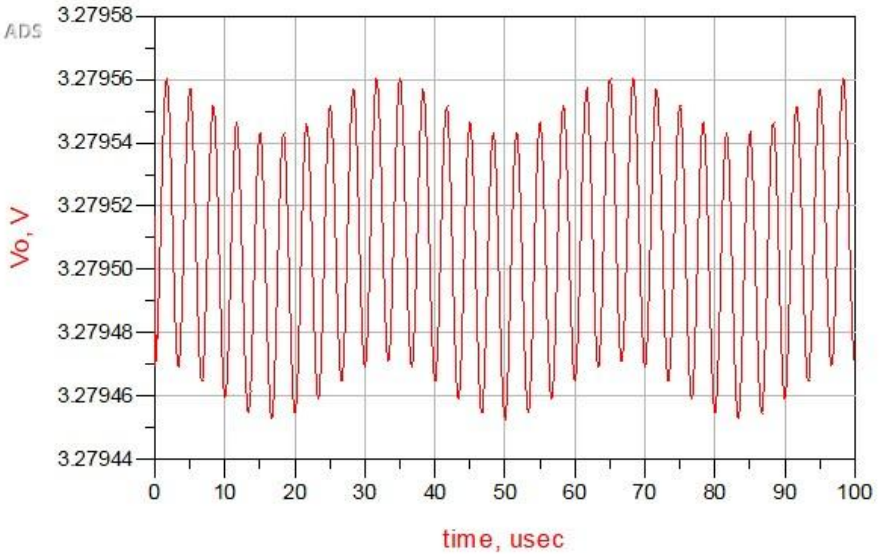
- The first transistor generates the carrier signal.
- The second transistor modulates the carrier with the message signal.
- The LC circuit sets the carrier frequency and filters the output.

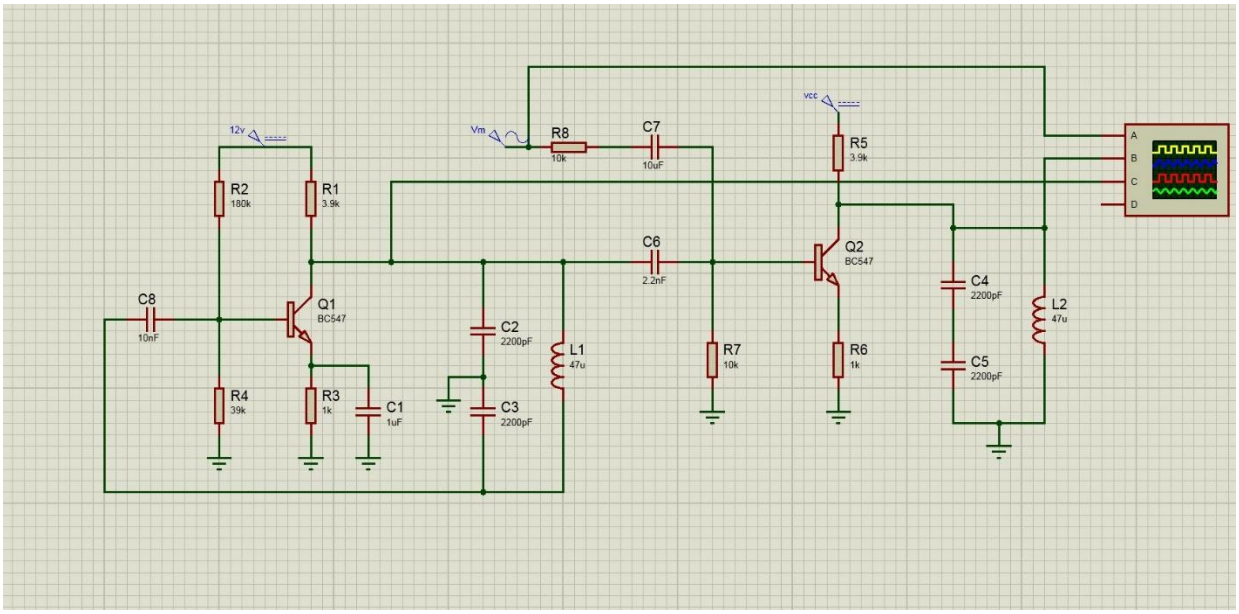
4. Simulation of Circuit 2

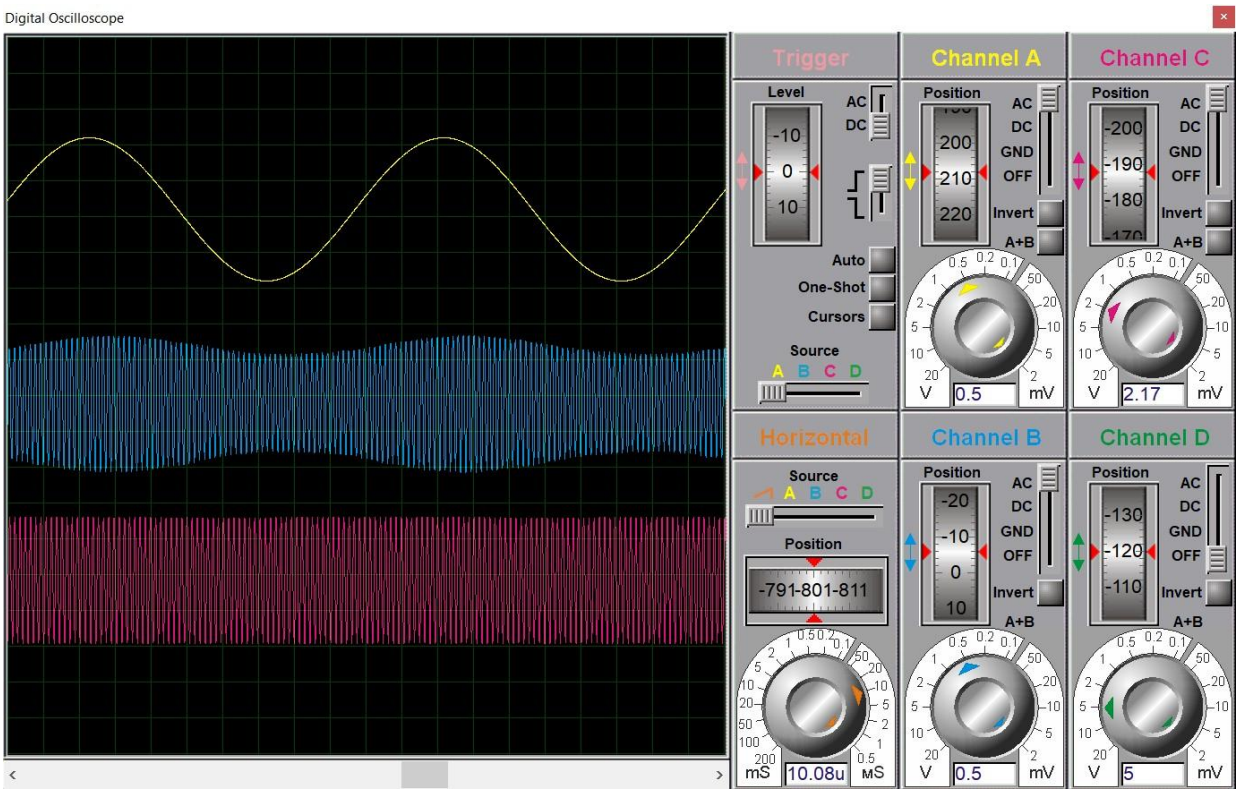
- Simulations were conducted using ADS and Proteus




ADS
1.0
0.5
0.0
-0.5
-1.0
Vin, V
VC, V
0
10
20
30
40
50
60
70
80
90
100
time, usec

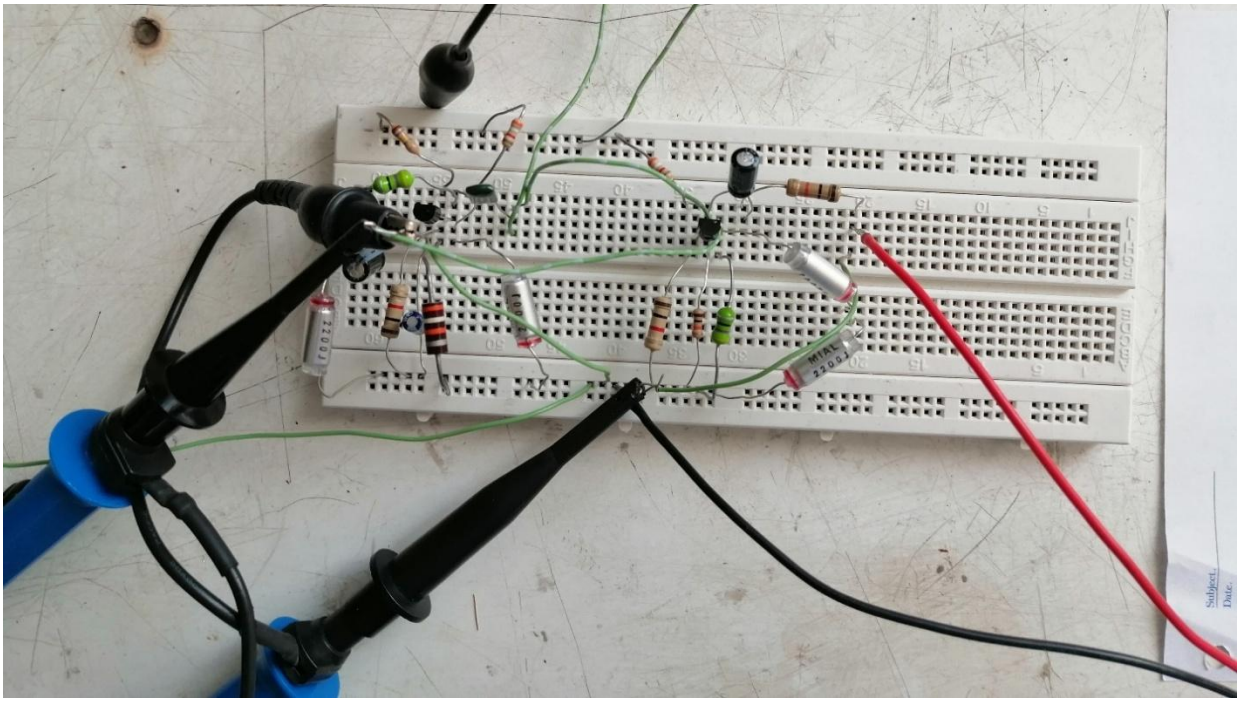

ADS
3.27958
3.27956
3.27954
3.27952
3.27950
3.27948
3.27946
3.27944
Vo, V
0
10
20
30
40
50
60
70
80
90
100
time, usec


12v
Vm
vcc
R8
10k
C7
10uF
R5
3.9k
R2
180k
R1
3.9k
C6
2.2nF
Q2
BC547
C8
10nF
Q1
BC547
C4
2200pF
L2
47u
C2
2200pF
L1
47u
R7
10k
R6
1k
C5
2200pF
R4
39k
R3
1k
C1
1uF
C3
2200pF
A
B
C
D


Digital Oscilloscope
Trigger
Level
AC
DC
Auto
One-Shot
Cursors
Source
A B C D
Channel A
Position
AC
DC
GND
OFF
Invert
A+B
V
0.5
mV
Channel C
Position
V
2.17
mV
Horizontal
Source
A B C D
Position
-791-801-811
mS
10.08u
MS
Channel B
Position
V
0.5
mV
Channel D
Position
V
5
mV

5. Practical Implementation

- The circuits were implemented practically, and results were captured using an oscilloscope.



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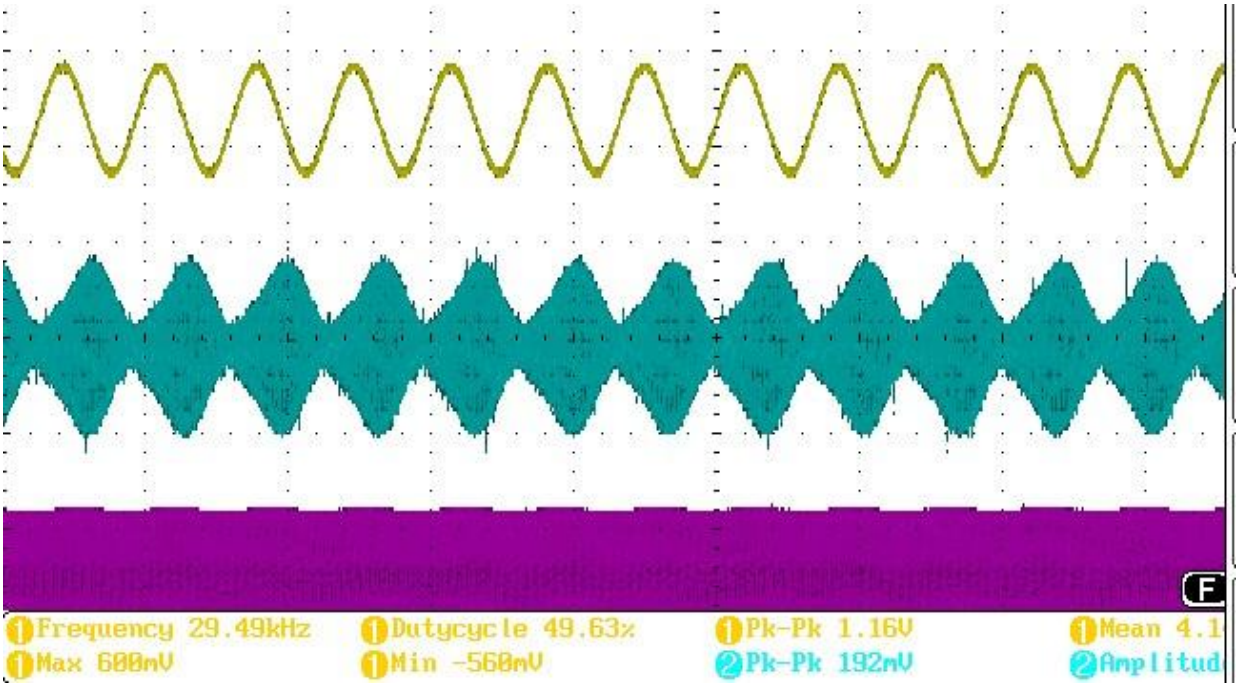
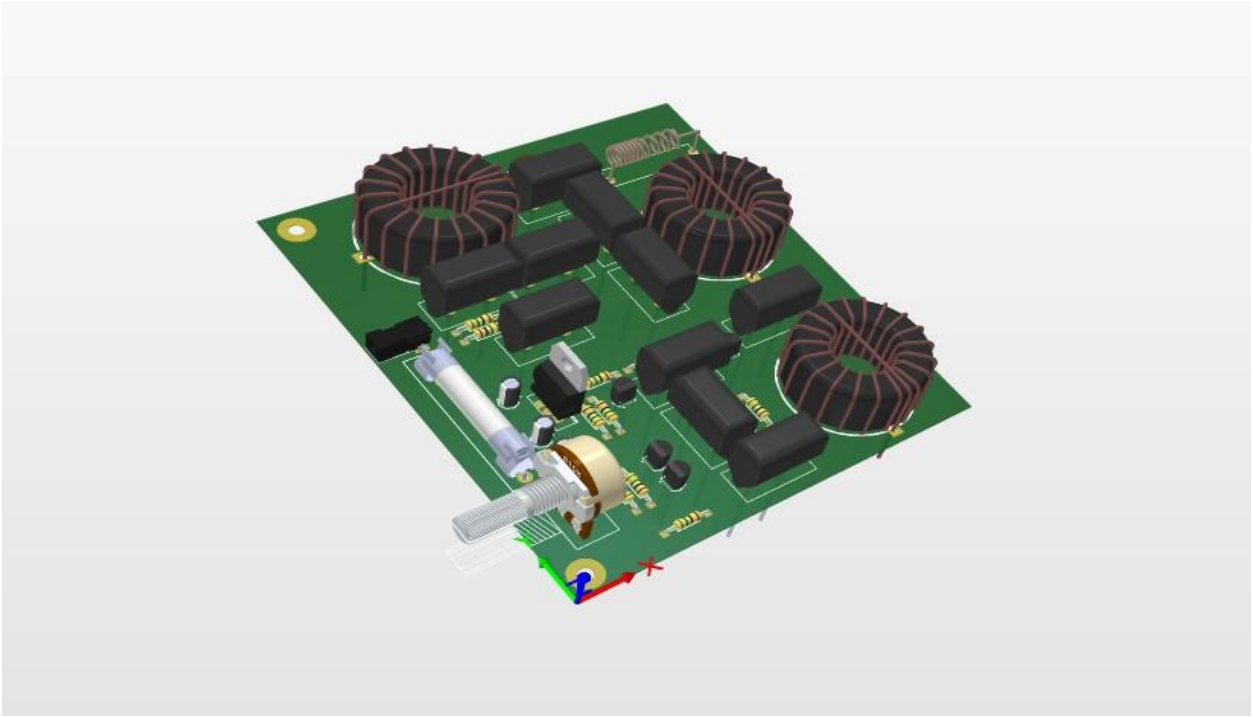
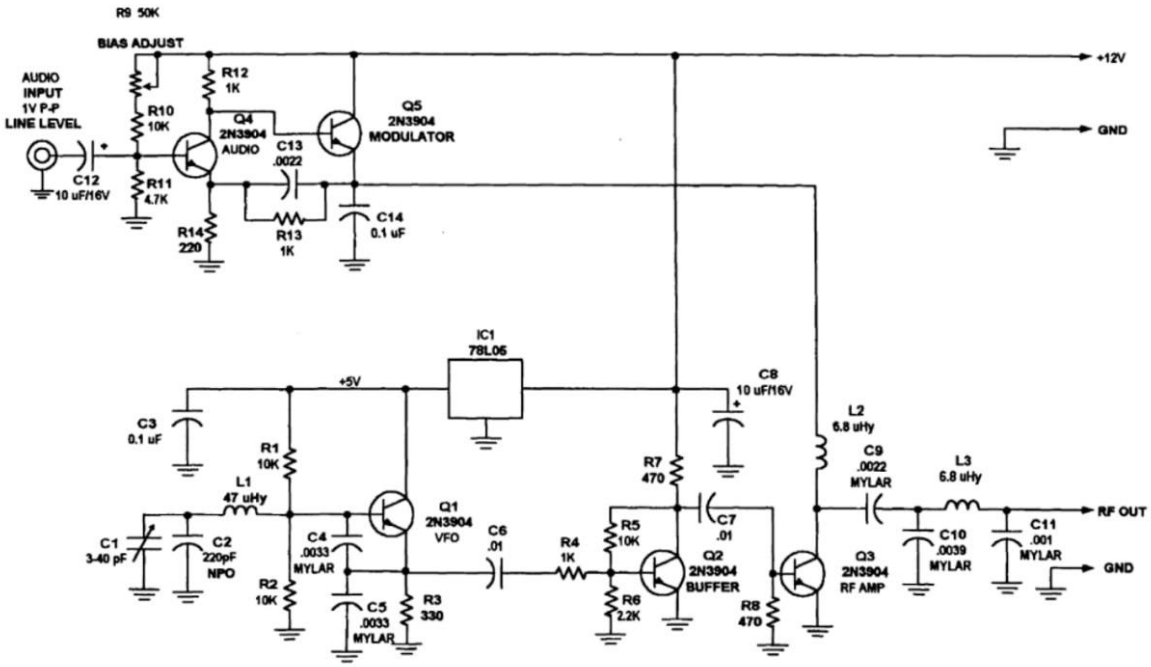


6. PCB Design

- The AM modulator circuit was designed using Altium Designer.





7. Conclusion

This project successfully designed, simulated, and implemented two AM modulator circuits. The simulations in ADS and Proteus validated the circuit performance, while practical measurements with an oscilloscope confirmed the AM signal generation. The PCB design in Altium Designer provides a practical implementation path. The project was completed in collaboration with a teammate during Fall/Winter 2024.