NSS COLLEGE OF ENGINEERING PALAKKAD

Subject Name: Analog and Digital Communication
Subject Code: ECT305

PROJECT REPORT

Topic : AM Modulation

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Year	3rd Year
Semester	5th Semester
Class	ECE-A

Staff In Charge:

(Signature)

Assignment Question:

Implement AM modulation using Python .
Plot the final waveform .
Also find out the Maximum and Minimum Modulated Voltage along with the Power.

AM Modulation

Amplitude Modulation (AM) is a method of transmitting information (a signal) by varying the amplitude of a carrier wave according to the message (modulating signal). AM is widely used in radio broadcasting and other forms of communication.

Key Concepts of AM Modulation

1. **Carrier Signal:** A high-frequency signal that is modulated to carry the information. It has a constant amplitude and frequency, given by:.

$$c(t) = A_c \cos(2\pi f_c t)$$

2. **Modulating Signal:**This is the low-frequency signal that contains the information we want to transmit. It can be represented as:

$$m(t) = A_m \cos(2\pi f_m t)$$

3. **Modulation index:** The modulation index (mu) is the ratio of the amplitude of the modulating signal to the amplitude of the carrier signal:

$$mu = \frac{A_m}{A_c}$$

Mathematical Representation of AM

The AM signal can be mathematically represented as:

$$s(t) = [A_c + m(t)] \cos(2\pi f_c t)$$

where:
- A_c is the carrier amplitude.
- $m(t)$ is the message signal.
- f_c is the carrier frequency.
- $s(t)$ is the AM signal.

Power in AM

1.**Carrier Power:**

$$P_c = \frac{A_c^2}{2R}$$

2.**Side Band Power:**

$$P_{\text{sb}} = \frac{mu^2 A_c^2}{8R}$$

3.**Total Power:**

$$P_t = \frac{A_c^2}{2R}[1 + \frac{mu^2}{2}]$$

Maximum and Minimum Voltage in AM:

1.**Maximum Voltage:** The maximum modulated voltage occurs when the modulating signal adds positively to the carrier:

$$V_{\max} = A_c(1 + mu)$$

2.**Minimum Voltage:** The minimum modulated voltage occurs when the modulating signal subtracts from the carrier:

$$V_{\min} = A_c(1 - mu)$$

AM Modulation Algorithm:

Algorithm 1 Algorithm for AM Modulation

1.Initialize Parameters: Set carrier amplitude A_c, modulating amplitude A_m, carrier frequency f_c, modulating frequency f_m, duration, and sampling rate.

2.Generate Time Array: Create a time array t using numpy.linspace.

3.Generate Signals:

Compute carrier signal: $\text{carrier} = A_c \cdot \cos(2\pi f_c t)$

Compute modulating signal: $\text{modulating\_signal} = A_m \cdot \cos(2\pi f_m t)$

4.Calculate Modulation Index: $\mu = \frac{A_m}{A_c}$

5.Generate AM Signal:

$s(t) = A_c \left[1 + \mu \cdot \frac{m(t)}{A_m}\right] \cdot \cos(2\pi f_c t)$

6.Calculate Voltages:

$V_{\max} = A_c(1 + \mu)$

$V_{\min} = A_c(1 - \mu)$

7.Calculate Powers:

$P_c = \frac{A_c^2}{2}$

$P_{sb} = \frac{(\mu^2 A_c^2)}{8}$

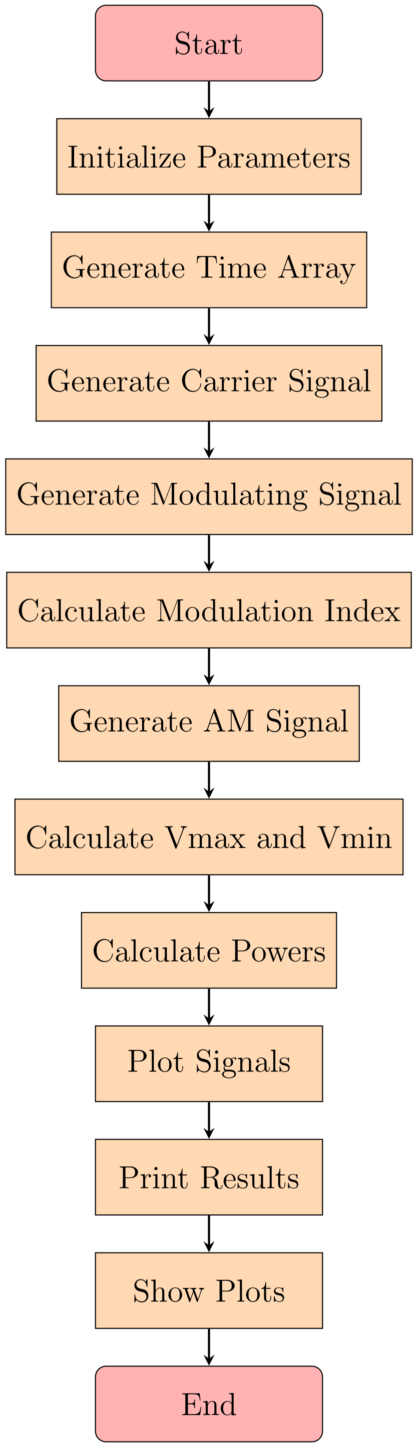
$P_t = \frac{A_c^2}{2}(1 + \frac{\mu^2}{2})$

8.Plot Signals

9.Print Results: Print $V_{\max}$, $V_{\min}$, P_c, P_{sb}, P_t.

10.Show Plots

Flowchart:


Start
Initialize Parameters
Generate Time Array
Generate Carrier Signal
Generate Modulating Signal
Calculate Modulation Index
Generate AM Signal
Calculate Vmax and Vmin
Calculate Powers
Plot Signals
Print Results
Show Plots
End

Code in Visual Studio: AM Modulation using Python

```python
# Question : Implement AM modulation using Python .Plot the final waveform .
# Also find out the Maximum and Minimum Modulated Voltage along with the Power

import numpy as np
import matplotlib.pyplot as plt

# Parameters
Ac = 1     # Carrier amplitude
Am = 0.5   # Modulating signal amplitude
#user input
#Ac = int(input("Enter the amplitude of the carrier signal (Ac): "))
#Am = int(input("Enter the amplitude of the modulating signal (Am): "))
fc = 100   # Carrier frequency (Hz)
fm = 5     # Modulating signal frequency (Hz)
duration = 1  # Duration of the signal in seconds
sampling_rate = 5000  # Samples per second
t = np.linspace(0, duration, int(sampling_rate * duration))  # Time array

# Generate carrier, modulating, and AM signals
carrier = Ac * np.cos(2 * np.pi * fc * t)  #c(t)=Ac *cos(2 fct )
modulating_signal = Am * np.cos(2 * np.pi * fm * t)  #m(t)=Am*cos(2 fmt )
modulation_index = Am / Ac #   =Am/Ac
am_signal = (1 + modulation_index * (modulating_signal/Am)) * carrier  #s(t)=Ac[1+ cos (2 fmt )]cos(2 fct )

#Modulated Voltage
Vmax = Ac*(1+modulation_index)  # Vmax = Ac(1+  )
Vmin = Ac*(1-modulation_index)  # Vmin = Ac(1     )

#Power
Pc = (Ac**2)/2                                       # R be 1 Ohm (Carrier Power ,Pc=Ac^2/2R )
Psb = ((modulation_index**2)*(Ac**2)) /8             # (Side Band Power ,Psb=(  ^2Ac^2)/8R )
Pt = ((Ac**2)/2)*(1+(modulation_index**2)/2)         # (Total Power , Pt = (Ac^2/2)(1+  ^2/2) )

# Plotting the signals
#plt.figure(figsize=(14, 10))

# Horizontal lines for Vmax and Vmin
#plt.axhline(y=Vmax, color='r', linestyle='--', label=f'Vmax = {Vmax:.2f}')
#plt.axhline(y=Vmin, color='b', linestyle='--', label=f'Vmin = {Vmin:.2f}')
```

```
# Plot the Modulating (Message) Signal
plt.subplot(3, 1, 1)
plt.plot(t, modulating_signal, color='blue', label="Modulating Signal (Message)")
plt.title('Message Signal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)

# Plot the Carrier Signal
plt.subplot(3, 1, 2)
plt.plot(t, carrier, color='orange', label="Carrier Signal")
plt.title('Carrier Signal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)

# Plot the AM Modulated Signal
plt.subplot(3, 1, 3)
plt.plot(t, am_signal, color='green', label="AM Signal")

# Horizontal lines for Vmax and Vmin
plt.axhline(y=Vmax, color='r', linestyle='--', label=f'Vmax = {Vmax:.2f}')
plt.axhline(y=Vmin, color='b', linestyle='--', label=f'Vmin = {Vmin:.2f}')

plt.title('AM Modulated Signal')
plt.xlabel('Time (s)')
plt.ylabel('Amplitude')
plt.legend()
plt.grid(True)

print(f"Maximum Modulated Voltage (Vmax): {Vmax:.2f}")
print(f"Minimum Modulated Voltage (Vmin): {Vmin:.2f}")

print(f"Carrier Power : {Pc:.2f} W")
print(f"Side Band Power : {Psb:.2f} W")
print(f"Total Power of the Modulated Signal: {Pt:.2f} W")

# Adjusting layout for better display
plt.tight_layout()
plt.show()
```

Listing 1: Python Code for AM Modulation

Output of the Code:

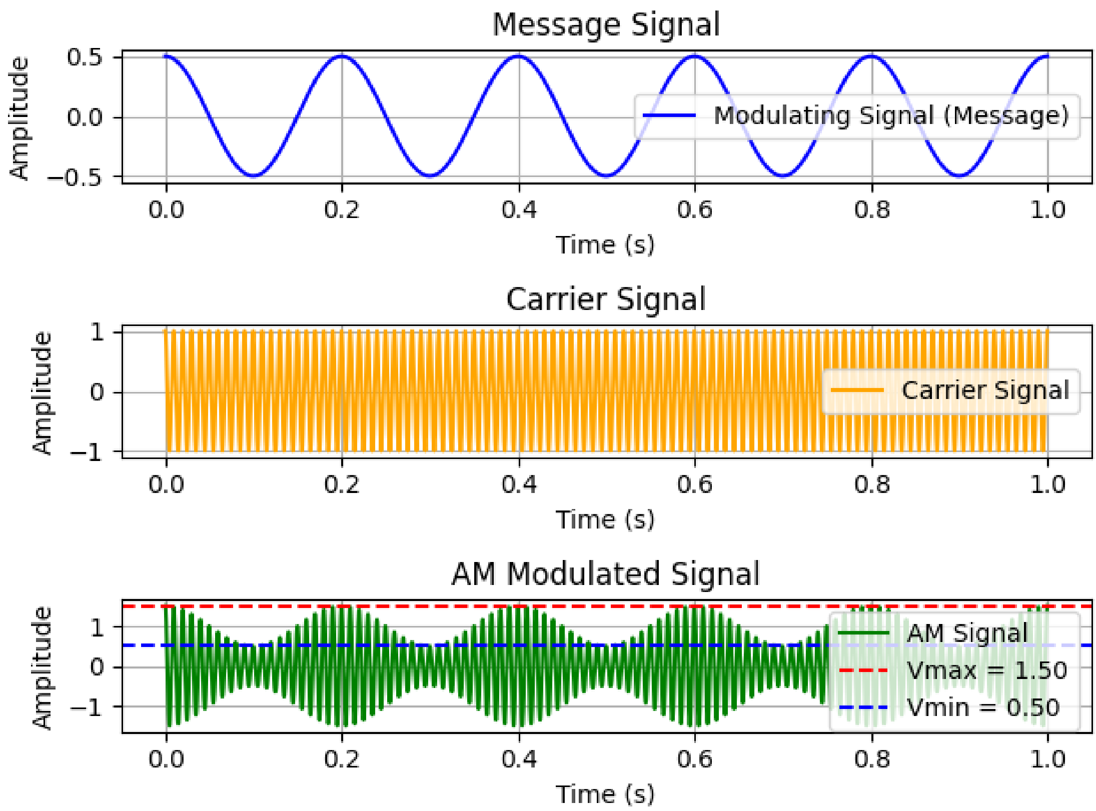


Figure 1: AM Modulation Output Plot

Printed Output:

```
Maximum Modulated Voltage (Vmax): 1.50
Minimum Modulated Voltage (Vmin): 0.50
Carrier Power : 0.50 W
Side Band Power : 0.03 W
Total Power of the Modulated Signal: 0.56 W
```

Conclusion:

Successfully implemented Amplitude Modulation (AM) using Python.The code generated the modulated signal by combining a carrier wave and a modulating signal, allowing us to visualize the impact of modulation. Key metrics, such as the maximum and minimum modulated voltages, as well as the associated powers, were calculated to demonstrate the effectiveness of the modulation process. The results confirm the significance of AM in communication systems, highlighting its role in efficient data transmission. This project not only reinforces theoretical concepts but also provides practical experience in signal processing and modulation techniques.