EXPERIMENT – 1

AMPLITUDE MODULATION AND DEMODULATION

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Aim:

To simulate and analyze the waveforms and frequency domain characteristics of Amplitude Modulation (DSB-FC and DSB-SC) signals in MATLAB and study the effects of varying the modulation index.

Theory:

AMPLITUDE MODULATION (AM)

Amplitude Modulation (AM) is a technique used for transmitting information over radio frequencies by varying the amplitude of a carrier wave in accordance with the message signal, which can be an audio or data signal.

Principle of Operation:

- The amplitude of the carrier wave is modulated to reflect the intensity of the input message signal.
- Variations in amplitude correspond to changes in the audio or information signal.
- Demodulation at the receiver end restores the original message by detecting and amplifying these variations.
- AM essentially modifies the carrier wave's height to encode information and reverses this process for decoding.

DOUBLE SIDEBAND FULL CARRIER (DSBFC)

DSBFC is a specific form of AM where the entire carrier signal is transmitted along with both sidebands containing the same information.

Working of DSBFC:

- The carrier wave is transmitted along with both the upper and lower sidebands.
- These sidebands contain identical information.
- Envelope detectors can demodulate DSBFC signals efficiently.

Applications of DSBFC:

- Used for long-range communication systems.
- Commonly applied in traditional radio broadcasting.

DOUBLE SIDEBAND SUPPRESSED CARRIER (DSBSC)

DSBSC modulation removes the carrier wave during transmission, retaining only the sidebands to carry information.

Key Features of DSBSC:

- Produces symmetric sidebands above and below the carrier frequency, with minimal carrier presence.
- The absence of the carrier conserves power and improves efficiency.
- This modulation technique is more efficient in power distribution compared to standard AM.

Benefits of DSBSC:

- Enhanced power efficiency due to the absence of the carrier signal.
- Better spectrum utilization compared to traditional AM methods.

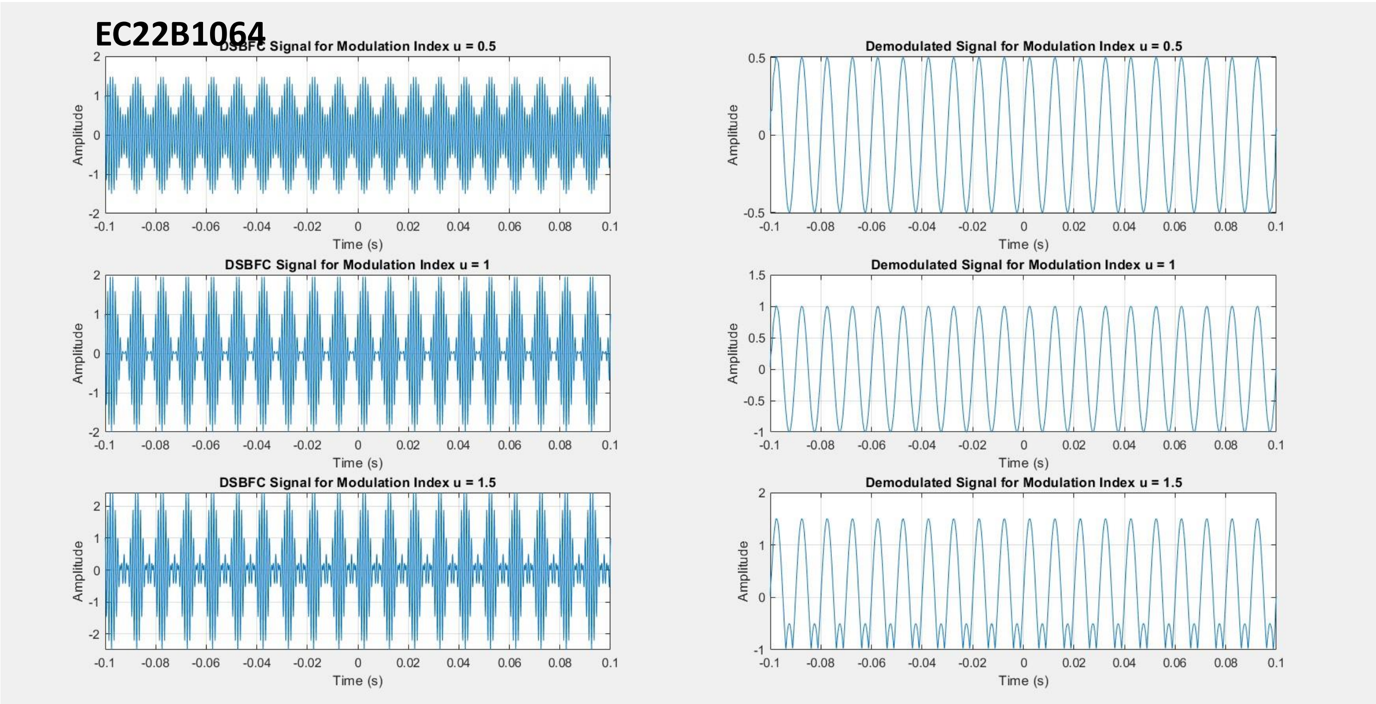
Need for Carrier in DSBSC:

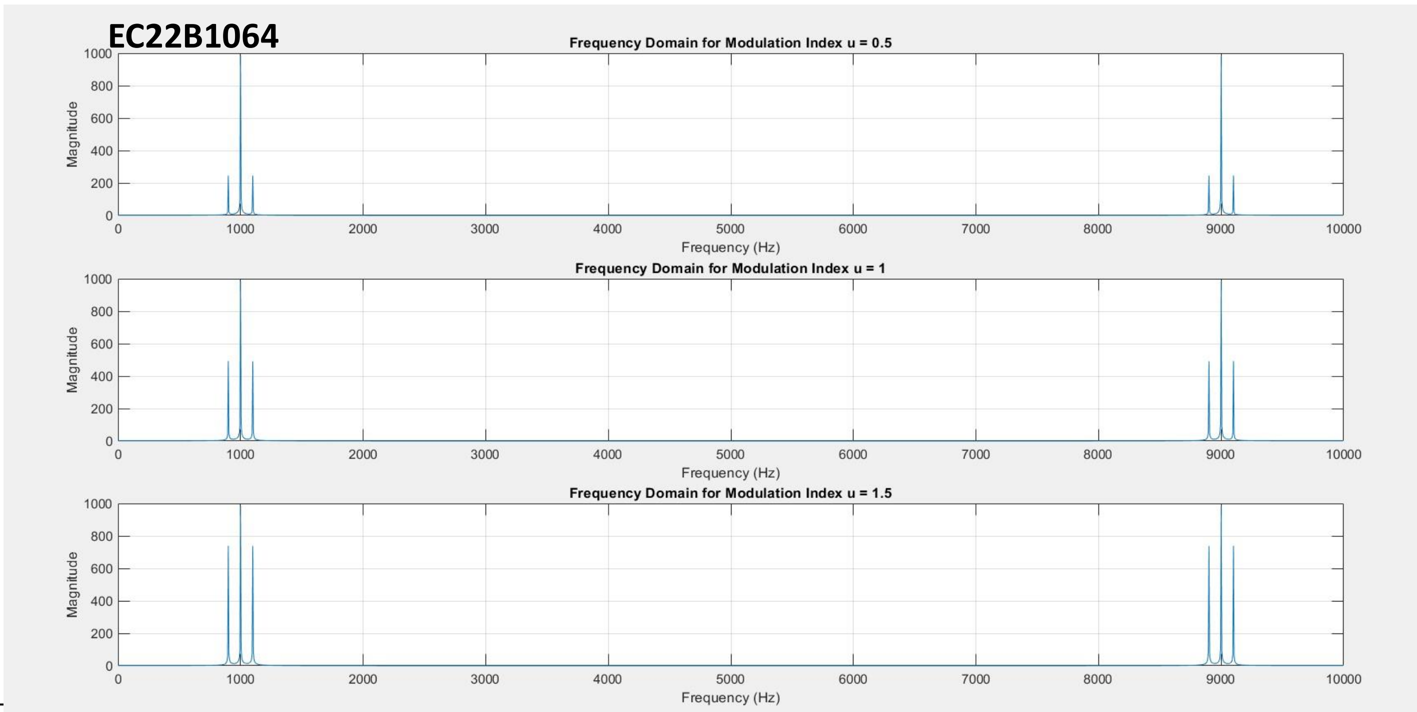
- Although the carrier is suppressed during transmission, it is essential to reintroduce it at the receiver for accurate signal demodulation and information recovery.

DSBFC (Double Sideband Full Carrier) Modulation and Demodulation:

```
Fs = 10000;
t = -0.1:0.0001:0.1;
fc = 1000;
fm = 100;
Ac = 1;
modulation_indices = [0.5, 1, 1.5];
figure;
subplot_index = 1;

for u = modulation_indices
    Am = u * Ac;
    message = Am * sin(2 * pi * fm * t);
    carrier = Ac * cos(2 * pi * fc * t);

    dsbfc = Ac * (1 + message) .* cos(2 * pi * fc * t);

    dsbfc_envelope = abs(hilbert(dsbfc));
    demodulated_dsbfc = dsbfc_envelope - Ac;


    subplot(3, 2, subplot_index);
    plot(t, dsbfc);
    title(['DSBFC Signal for Modulation Index u = ' num2str(u)]);
    xlabel('Time (s)');
    ylabel('Amplitude');
    grid on;
    subplot_index = subplot_index + 1;

    subplot(3, 2, subplot_index);
    plot(t, demodulated_dsbfc);
    title(['Demodulated Signal for Modulation Index u = ' num2str(u)]);
    xlabel('Time (s)');
    ylabel('Amplitude');
    grid on;
    subplot_index = subplot_index + 1;
end
figure;
subplot_index = 1;
```

```
for u = modulation_indices
    Am = u * Ac;
    message = Am * sin(2 * pi * fm * t);
    dsbfc = Ac * (1 + message) .* cos(2 * pi * fc * t);

    N = length(dsbfc);
    f = (0:N-1) * (Fs / N);
    Y = abs(fft(dsbfc));

    subplot(3, 1, subplot_index);
    plot(f, Y);
    title(['Frequency Domain for Modulation Index u = ' num2str(u)]);
    xlabel('Frequency (Hz)');
    ylabel('Magnitude');
    grid on;
    subplot_index = subplot_index + 1;
end
```





DSBSC (Double Sideband Suppressed Carrier) Modulation and Demodulation:

```
Fs = 10000;
t = -0.1:0.0001:0.1;
fc = 1000;
fm = 100;
Ac = 1;
Am = 0.5;

message = Am * sin(2 * pi * fm * t);
carrier = Ac * cos(2 * pi * fc * t);
dsbsc = Ac * message .* cos(2 * pi * fc * t);

demodulated_dsbsc = dsbsc .* (2 * cos(2 * pi * fc * t)); n
[b, a] = butter(6, 2 * fm / Fs);
demodulated_dsbsc_filtered = filter(b, a, demodulated_dsbsc);

subplot(3, 1, 1);
plot(t, message);
title('Message Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(3, 1, 2);
plot(t, dsbsc);
title('DSBSC Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(3, 1, 3);
plot(t, demodulated_dsbsc_filtered);
title('Demodulated Signal');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

N = length(dsbsc);
f = (0:N-1) * (Fs / N);
Y = abs(fft(dsbsc));

figure;
plot(f, Y);
title('Frequency Domain of DSBSC Signal');
xlabel('Frequency (Hz)');
ylabel('Magnitude');
grid on;
```

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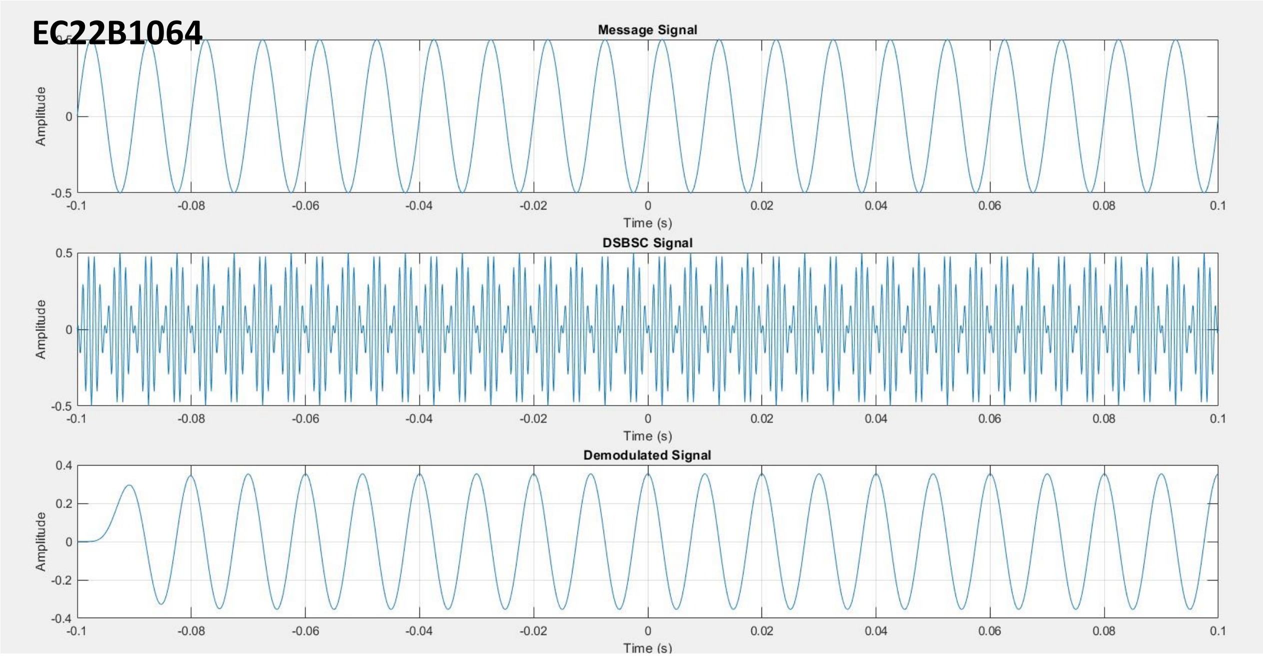

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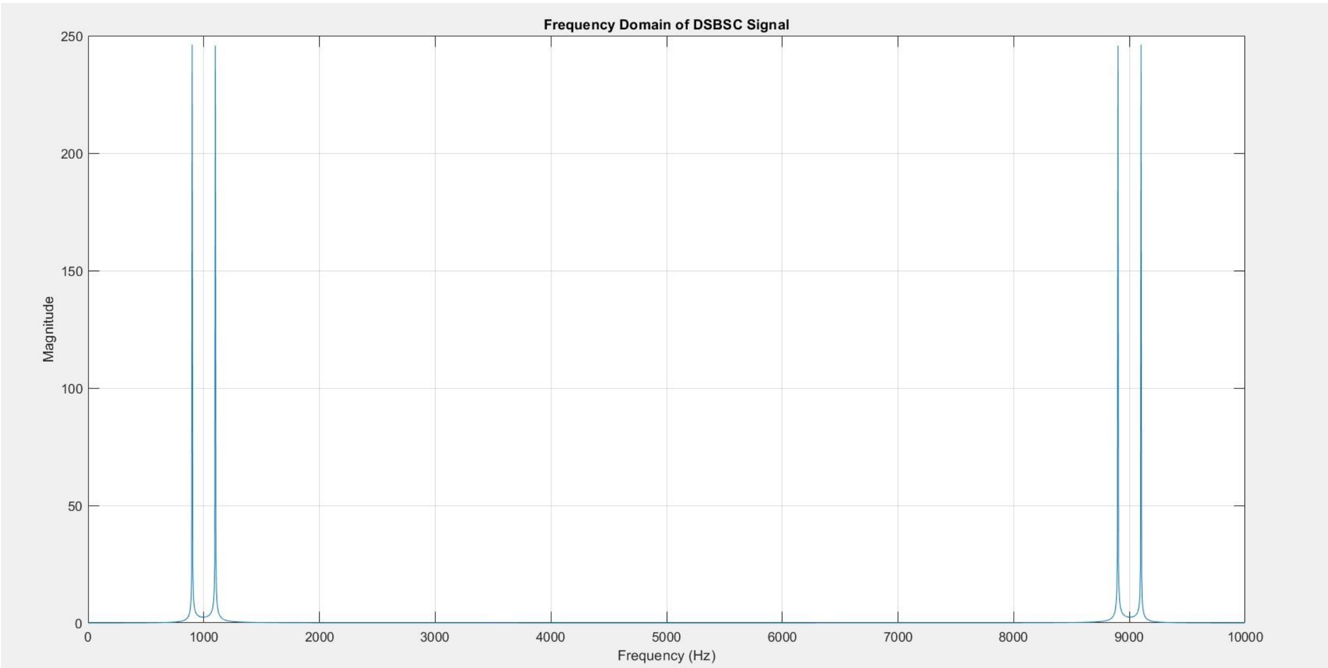

Inference:

- **Modulation Index Effect**: The modulation index $\mu = \frac{Am}{Ac}$ directly impacts the amplitude of the modulated signal. As μ increases, the depth of modulation becomes more pronounced, but over-modulation (μ >1) leads to distortion.
- **DSBSC Power Efficiency**: DSBSC (Double Sideband Suppressed Carrier) removes the carrier A_C, reducing power consumption and improving efficiency compared to DSBFC, where the full carrier is transmitted.
- **Demodulation via Hilbert Transform**: The demodulation of DSBFC is achieved using the Hilbert transform, where the envelope |Hilbert(s)| is used to recover the message, ensuring accurate signal retrieval.

- **Frequency Spectrum**: The frequency spectrum analysis of DSBFC and DSBSC shows the sidebands centered around f_c (carrier frequency), confirming that the information is carried by these sidebands

Result:

Hence, the modulation and demodulation techniques of Double Sideband Full Carrier (DSBFC) and Double Sideband Suppressed Carrier (DSBSC) waves were analyzed. The corresponding waveforms for different modulation index values were obtained using MATLAB software, demonstrating the impact of modulation depth and power efficiency in both techniques.

References:

[1] Simon Haykins, Communication systems, 2nd ed. (New York John Wiley and Sons, 2005).