Aim ↬ To study the concept and fundamentals of Double Sideband Suppressed Carrier (DSB-SC) Modulation and Demodulation.

Software Required ↬ MATLAB

Theory ↬

Double Sideband Suppressed Carrier (DSB-SC) is a form of amplitude modulation where both sidebands (upper and lower) are transmitted, but the carrier is suppressed, which leads to better power efficiency. Unlike conventional AM, where the carrier consumes most of the transmitted power, DSB-SC focuses the power on transmitting the information-carrying sidebands.

In DSB-SC modulation, the modulated signal can be mathematically represented as:

$$s(t) = A_m \cdot m(t) \cdot cos\ (2\pi f_c t)$$

where:

- A_m is the amplitude of the message signal,
- m(t) is the message signal,
- f_c is the frequency of the carrier signal,
- $\cos(2\pi f_c t)$ represents the carrier wave.

The absence of the carrier makes DSB-SC more power-efficient. Unlike conventional AM, there is no modulation index, as there is no carrier amplitude to compare against. The transmission power is fully utilized in the sidebands, carrying the message information. The bandwidth of DSB-SC remains the same as AM, i.e., twice the bandwidth of the message signal.

Generation of DSB-SC Signal ↴

The DSB-SC signal is generated by multiplying the message signal with a high-frequency carrier signal. This produces a signal containing only the upper and lower sidebands, but the carrier itself is suppressed. This method is advantageous for power efficiency, as the power that would have been used to transmit the carrier is now dedicated to the sidebands that carry the information.

Demodulation of DSB-SC Signal ↴

Coherent detection is required to demodulate DSB-SC signals. Since there is no carrier transmitted, the receiver must generate a synchronized carrier to multiply with the received signal. After multiplying, a low-pass filter is used to extract the original message signal by removing high-frequency components. This process is sensitive to synchronization; if the receiver's carrier is not perfectly in phase with the original, the message cannot be accurately recovered, resulting in distortion.

The demodulated signal is expressed as:

$$y(t) = s(t) \cdot cos\,(2\pi f_c t) = A_m \cdot m(t) \cdot cos^2(2\pi f_c t)$$

Using a trigonometric identity, this expands into a low-frequency component (the original message signal) and a high-frequency component at twice the carrier frequency, which is then filtered out using a low-pass filter to recover the original message.

Frequency Spectrum of DSB-SC Signal ↴

In the frequency domain, the DSB-SC signal consists of two sidebands:

- Upper Sideband (USB) at $fc + fm$,
- Lower Sideband (LSB) at $fc - fm$,

where f_m is the maximum frequency in the message signal. There is no carrier component at the carrier frequency, which is the main distinction from conventional AM.

Method ↴

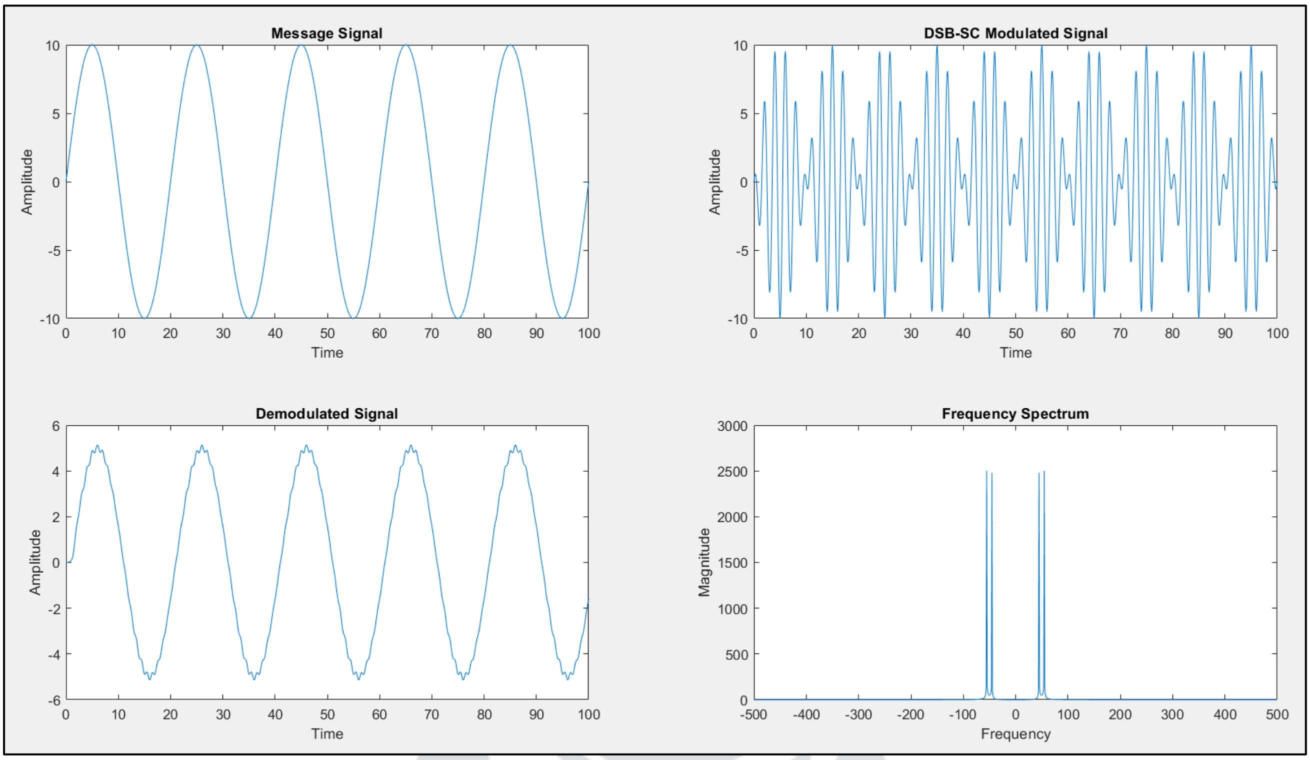
The code generates a Double Sideband Suppressed Carrier (DSB-SC) modulated signal by multiplying the message signal with a high-frequency carrier. Synchronous demodulation is performed by multiplying the received signal with the same carrier used for modulation. A low-pass filter is applied to remove high-frequency components, thus recovering the original message. The Fast Fourier Transform (FFT) is used to calculate the frequency spectrum of the modulated signal, showing the frequency distribution of the signal.

Code ↬

```
% DSB-SC Modulation
clc;
clear;
close all;

Am = 10;
Fm = 0.05;
Fc = 0.5;
```

```
t = 0:0.1:100;

mt = Am * sin(2*pi*Fm*t);
ct = cos(2*pi*Fc*t);
dsbsc = mt .* ct;

N = length(t);
f = linspace(-N/2, N/2-1, N);
DSBSC_f = fftshift(fft(dsbsc));

demodulated = dsbsc .* ct;
[B,A] = butter(5, 0.1);
recovered = filter(B, A, demodulated);

figure;
subplot(2,2,1);
plot(t, mt);
xlabel('Time');
ylabel('Amplitude');
title('Message Signal');

subplot(2,2,2);
plot(t, dsbsc);
xlabel('Time');
ylabel('Amplitude');
title('DSB-SC Modulated Signal');

subplot(2,2,3);
plot(t, recovered);
xlabel('Time');
ylabel('Amplitude');
title('Demodulated Signal');

subplot(2,2,4);
plot(f, abs(DSBSC_f));
xlabel('Frequency');
ylabel('Magnitude');
title('Frequency Spectrum');
```

Output ↬



Result ↬

The DSB-SC modulated signal was successfully generated, transmitting only the sidebands. Coherent detection and low-pass filtering accurately recovered the original message signal, showing the modulation's power efficiency.

Conclusion ↬

DSB-SC modulation transmits sidebands efficiently, conserving power by suppressing the carrier. Coherent detection ensures accurate demodulation, but synchronization is crucial to avoid signal distortion.

Precautions ↬

- Ensure precise synchronization of the carrier for successful demodulation to prevent distortion.
- Use a proper low-pass filter to extract the message signal without aliasing.
- Choose appropriate sampling rates during modulation and demodulation to prevent signal degradation.