Experiment 4: DSB-SC & SSB-SC Modulation and Demodulation

Aim: This experiment is intended to make the student to perform experiments on DSB-SC and SSB-SC Modulation and demodulation using MATLAB.

A –Generation of a DSB-SC Modulated Signal

DSB-SC modulated signal is mathematically represented as $y(t) = A\ Cos\ (2\pi f_c t)\ sin\ (2\pi f_m t)$, where f_c is the carrier frequency and f_m is the message frequency. Let the Message Signal be a 2 Khz Sinusoid and the Carrier be a 100 KHz Sinusoid. Let the peak-to-peak amplitude of the message and carrier signals be 2V and 4V, respectively.

1) Write a MATLAB code to implement DSBSC modulated wave and observe the modulated waveform. Plot the message and the modulated waveform one below the other in a single plot window. calculate the message power in themodulated signal and tabulate these in Table 1.

   Hint : Note down the message signal amplitude, carrier signal amplitude and calculate the power from the time domain equation of DSBSC modulated signal.

2) Screenshot of the obtained plot is to be noted in the report. How is this different from AM modulation with carrier? Is there a phase Reversal of the carrier at the notch points, where the waveform has decayed to zero amplitude? Why? Reason it out and note it in the report.
   Hint : Compare the efficiency of AM and DSBSC.

3) Plot the spectrum of DSB-SC modulated signal. How many distinct spectral peaks are observed and what are their frequencies? Which of these, if any, pertain to the carrier component?

4) Measure the power in the side bands from the spectrum and tabulate them in Table 1. Check whether the total power in the side bands is equal to the calculated message signal power in the modulated signal from time domain.

   Hint : Consider the amplitudes from time domain equations and calculate power.

5) Increase the message signal amplitude to 3V peak-to-peak and notice the effect on the DSB-SC signal. Measure and tabulate the results in Table1.

	Time Domain		Frequency Domain					Demodulated Signal (Time Domain)		Frequency Domain
Sl. No	Message Amplitude (V)	Message Power in modulated signal	Frequency of USB	Power in USB	Frequency of LSB	Power in LSB	Total Message Power	Message Amplitude	Message Power	Message Power

Table 1: Message and Sideband Powers in DSB-SC

B – Demodulation of DSB-SC Signal:

Demodulation of DSB-SC signal is accomplished by multiplying the DSB-SC signal with a local carrier that is perfectly synchronous to the carrier used for modulation.

1) Write a MATLAB code to multiply the DSC-SC modulated wave with the carrier signal, and compute the spectrum of the product signal. What Frequency components you observe? Do they include a component corresponding to message signal? Measure and tabulate the power observed from the spectral domain in Table I.

   Hint: after product modulating the modulated signal with the synchronous carrier, pass it through necessary filters to observe the proper demodulated signal. Commands like butter, filter can be used.

2) Compare the demodulated output and the message signal. Is there a difference? Why?

3) Tabulate the demodulated message amplitude and the calculated power in Table 1.

4) Comment on the results in Table 1 with respect to the message powers, before modulation and after demodulation

C –Generation of a SSB-SC Modulated Signal

A popular method for generating SSB-SC signal is through phase shifting method (Hilbert Transform). SSB-SC modulated signal is mathematically represented as

$$\varphi_{SSB(t)} = \mathbf{m(t)\cos(2\pi f_c t) \pm \hat{m}(t)\sin(2\pi f_c t)},$$

where f_c is the carrier frequency and f_m is the message frequency, **m(t)** is the message signal and $\hat{m}(t)$ is the Hilbert transform of **m(t).** ***It is well known that the Hilbert transform, for a narrowband signal can be implemented using a 90 degree phase shifter.***

$$\varphi_{USB(t)} = \mathbf{m(t)\cos(2\pi f_c t) - \hat{m}(t)\sin(2\pi f_c t)},$$

$$\varphi_{LSB(t)} = \mathbf{m(t)\cos(2\pi f_c t) + \hat{m}(t)\sin(2\pi f_c t)},$$

Let the Message Signal be a 2 KHz Sinusoid and the Carrier be a 100 KHz Sinusoid. Let the peak-to-peak amplitude of the message and carrier signals be 2V and 4V, respectively.

1. Write the code to generate the SSB-SC modulate signal, and plot the message and the SSB-SC modulated signal one below the other. Screenshot of this is to be pasted in the report. How is thisdifferent from AM modulation with carrier? Is there a phase reversal of the carrier at the notch points, where the waveform has decayed to zero amplitude? Why? Reason it out and note it in thereport.

   Hint : Commands like imag, Hilbert needs to be used to generate SSB-SC equation.

2. Obtain and plot the spectrum of the SSB-SC signal. How many distinct spectral peaks are present and what are their frequencies? Is there any carrier component? Which side band do you find in the spectrum, USB or LSB?

D – Demodulation of DSB-SC Signal: Synchronous Demodulation

Demodulation of SSB-SC signal is accomplished by multiplying the SSB signal with a local carrier that is perfectly synchronous to the carrier used for modulation. Generate the demodulated signal, and plot it below the transmitted message signal. What is the relationship between the original message and the recovered message? Are they in the same phase? Why?

E – Conclusions

Which modulation technique is efficient?

Why do we use only synchronous detection?

List out your learning’s from the above experiments.