Faculty of Engineering & Technology Electrical & Computer Engineering Department

Communication Lab - ENEE4113

Experiment 2: Double-side and Single-side Band Modulation

Prelab #2

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Section: 4

Date: 3-8-2023

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Theoretical Prelab

Double-Sideband Suppressed Carrier (DSB-SC) Modulation

DSB-SC is an amplitude modulated wave transmission scheme in which only sidebands are transmitted and the carrier is not transmitted as it gets suppressed. DSB-SC is an acronym for Double Sideband Suppressed Carrier.[1]

The carrier does not contain any information and its transmission results in loss of power. Thus, only sidebands are transmitted that contains information. This results in saving of power used in transmission.[1]

Mathematical Representation of DSB-SC modulation

$$s(t) = A_c m(t) \cos(2\Pi f_c t)$$

Where:

- s(t): is the modulated signal.
- m(t): is the message signal.

Generation of DSB-SC signal

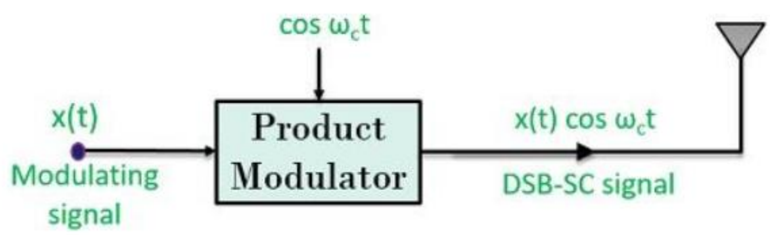

Figure 1: Generation of DSB-SC signal

Here, by observing the above figure, we can say that a product modulator generates a DSB-SC signal. The signal is obtained by the multiplication of baseband signal x(t) with carrier signal cos ωct.

Demodulation of DSB-SC

For DSBSC, Coherent Demodulation is done by multiplying the DSB-SC signal with the carrier signal (with the same phase as in the modulation process) just like the modulation process. This resultant signal is then passed through a low pass filter to produce a scaled version of the original message signal.[2]

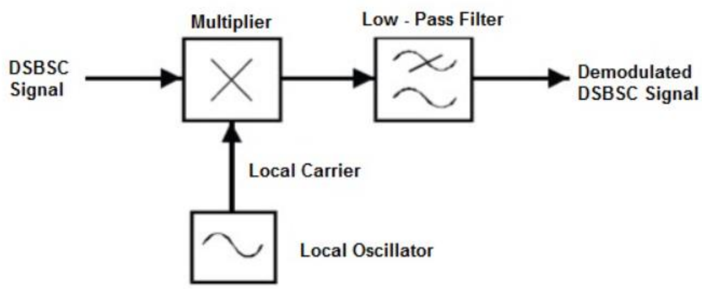

Figure 2: Demodulation of DSB-SC

Single-Sideband Modulation (SSB)

Single side band (SSB) is an amplitude modulation technique in which only one sideband (upper or lower) is transmitted, along with the carrier wave or a suppressed carrier. This method results in a much more efficient use of the available bandwidth than AM or DSB-SC, as only half the bandwidth is required for transmission. SSB modulation can be achieved using a variety of techniques, including frequency-domain filtering or phase-shift modulation.

Mathematical Representation of SSB Modulation

Upper sideband (USB)

$$s(t) = A_C m(t)\cos(2\pi f_C t) - A_C m_{helbert}(t)\sin(2\pi f_C t)$$

Lower sideband (LSB)

$$s(t) = A_C m(t)\cos(2\pi f_C t) + A_C m_{helbert}(t)\sin(2\pi f_C t)$$

Generation of SSB signal

SSB modulation can be generated by filtering the undesired side band of a DSBSC signal and retaining the desired one using a bandpass filter with bandwidth equal that of the message signal (not twice its bandwidth) and a center frequency equal to the center frequency of the desired side band (not the carrier).

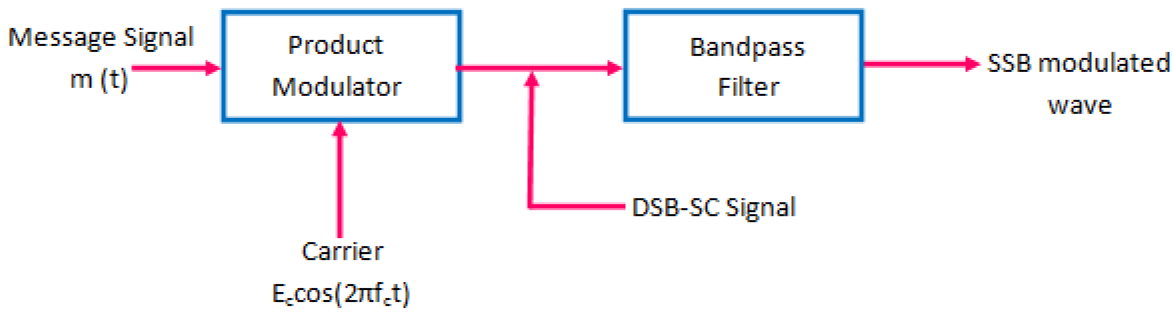

Figure 3: Generation of SSB signal

Demodulation of SSB

The sideband at the positive and negative frequencies merge (recombine) at zero frequency when the SSB signal is multiplied by the carrier.

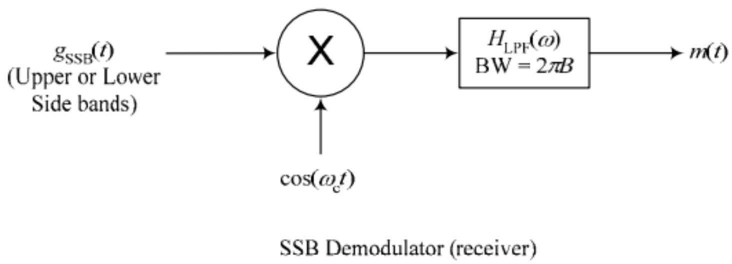

Figure 4: Demodulation of SSB

If the SSB signal includes a LARGE carrier, it can be demodulated using an envelope detector similar to that used for full AM signals.

Software Prelab (Simulink MATLAB)

Message signal

$$m(t) = 0.85\cos(2\pi\,(1000)\,t)$$

$$m(f) = \frac{0.85}{2}[\delta(f-1000) + \delta(f+1000)]$$

Plot Message signal in Time Domine

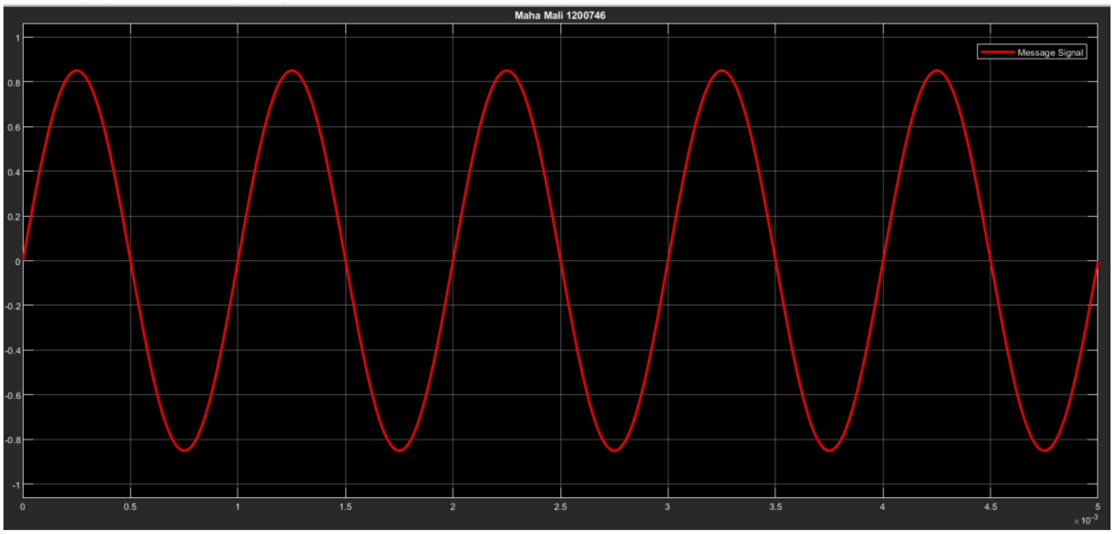

Figure 5: Message signal in Time Domine

Plot Message signal in Frequency Domine

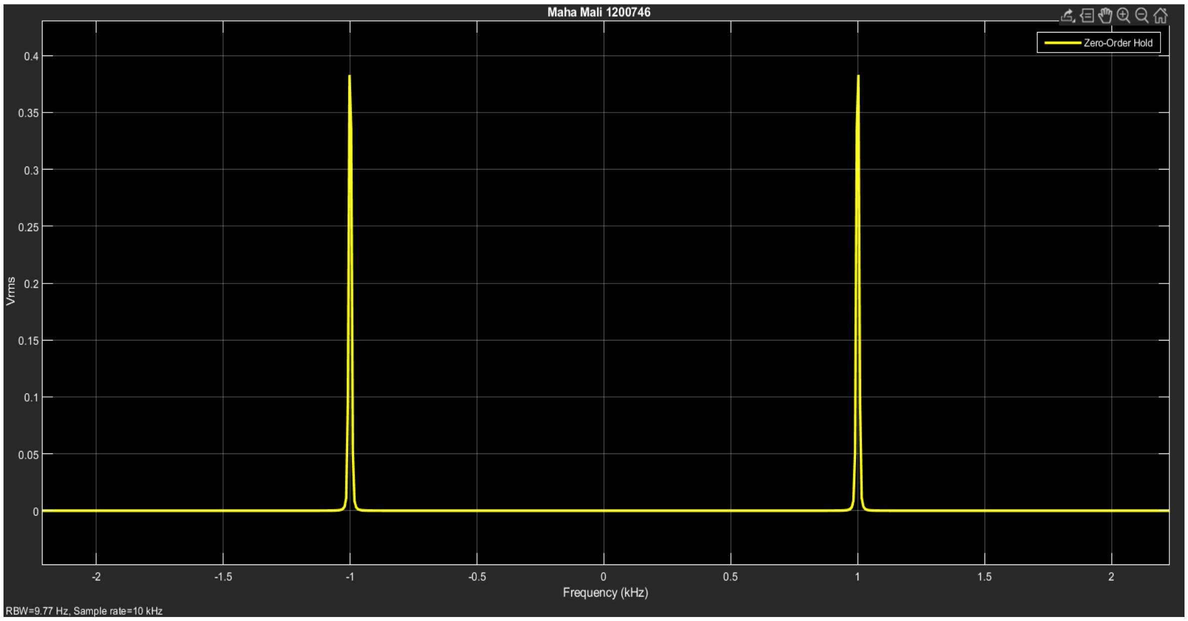

Figure 6: Message signal in Frequency Domine

From the graph for Message signal in Frequency Domine we notice that we have two delta one at -1000,and anotheor on 1000 as we calculate in mathmatical according this eqation:

$$m(f) = \frac{0.85}{2}[\delta(f - 1000) + \delta(f + 1000)]$$

Carrier signal

$$c(t) = 1\cos(2\pi(15k)\,t)$$

$$c(f) = \frac{1}{2}[\delta(f - 15000) + \delta(f + 15000)]$$

Plot Carrier signal in Time Domine

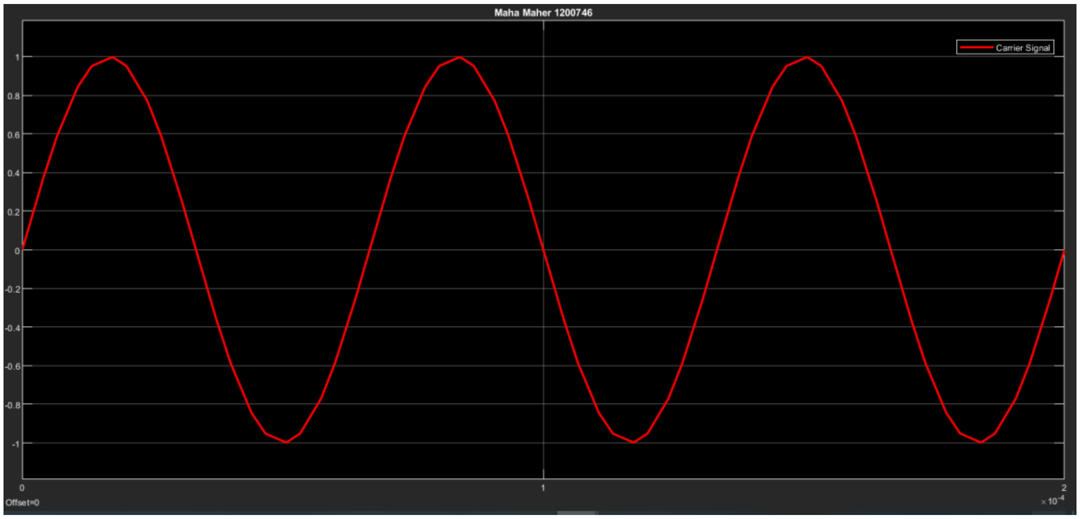

Figure 7: Carrier signal in Time Domine

Plot Carrier signal in Frequency Domine

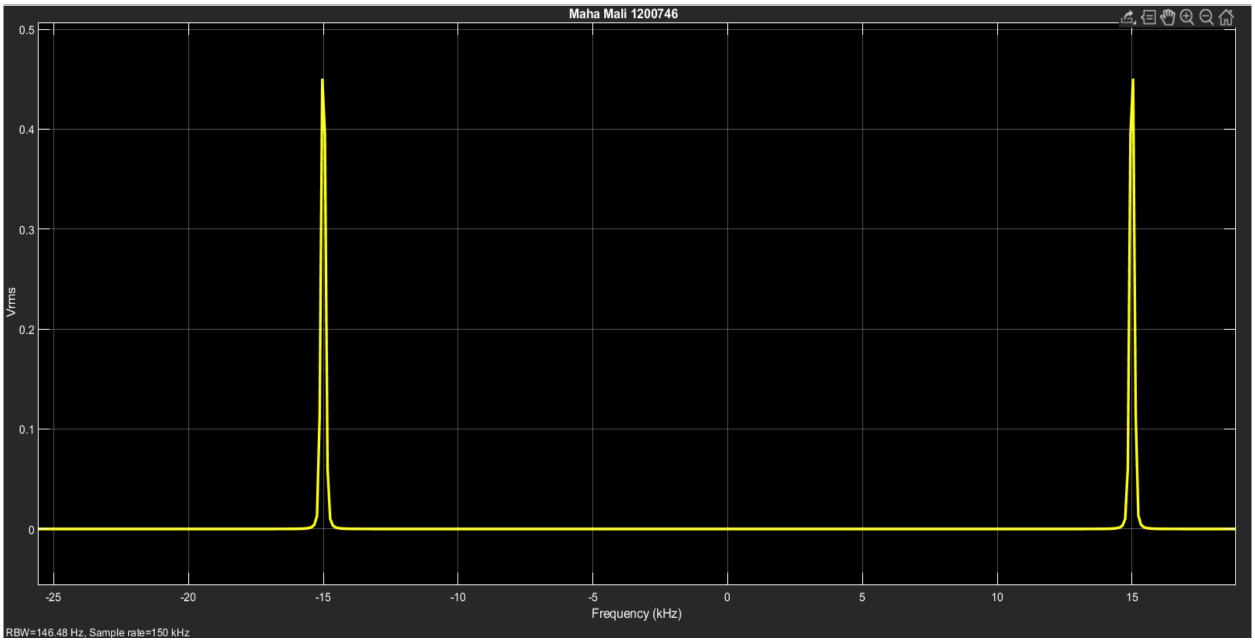

Figure 8: Carrier signal in Frequency Domine

From the graph for Message signal in Frequency Domine we notice that we have two delta one at -15000,and anotheor on 15000 as we calculate in mathmatical according this eqation:

$$c(f) = \frac{1}{2}[\delta(f - 15000) + \delta(f + 15000)]$$

DSB-SC Modulation and Demodulation

DSB-SC Modulation

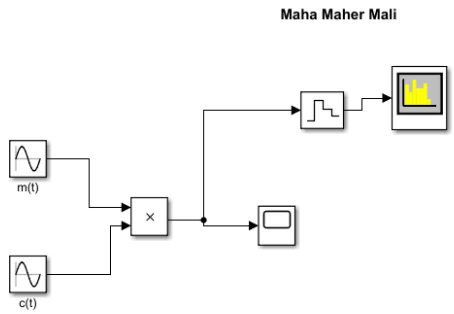

Figure 9: DSB-SC Modulation

S(t) = (0.85/2) cos (2pi (16000)) + (0.85/2) cos (2pi (14000))

Plot Modulated Signal in Time Domain

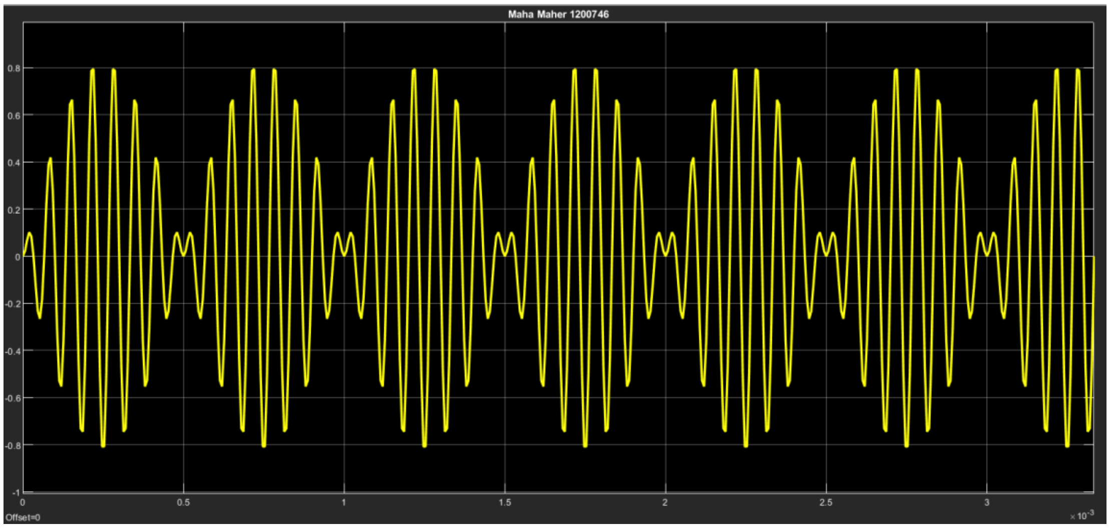

Figure 10: Modulated Signal in Time Domain

Plot Modulated Signal in Frequency Domain

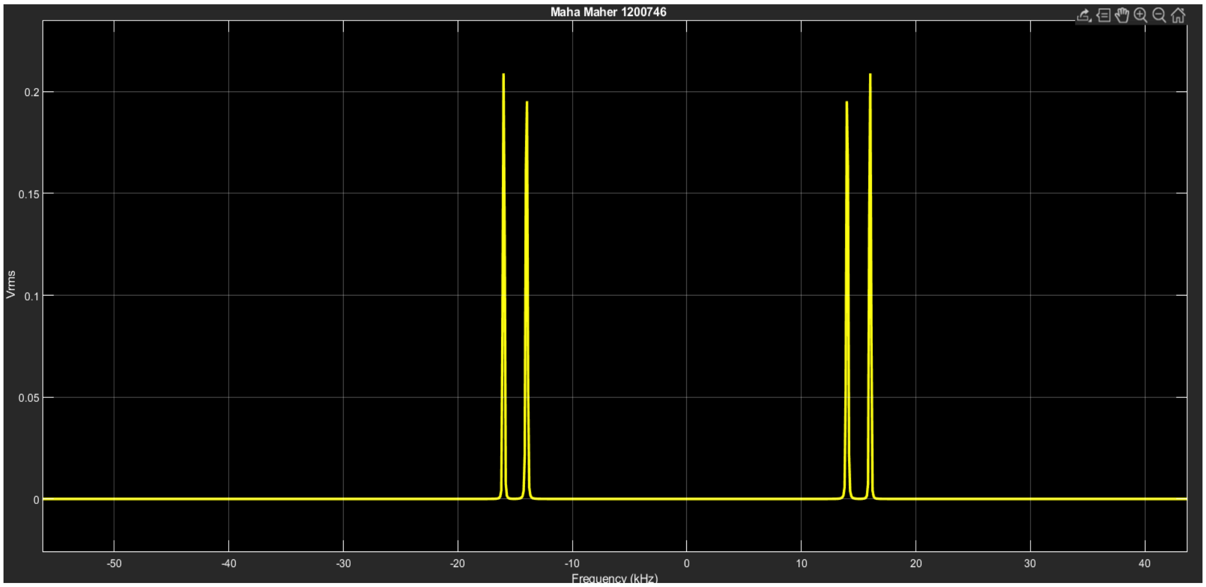

Figure 11: Modulated Signal in Frequency Domain

From this graph we notice that we have two deltas:

One at fc+fm=15000+1000=16000

And another at fc-fm=15000-1000=14000

DSB-SC Demodulation

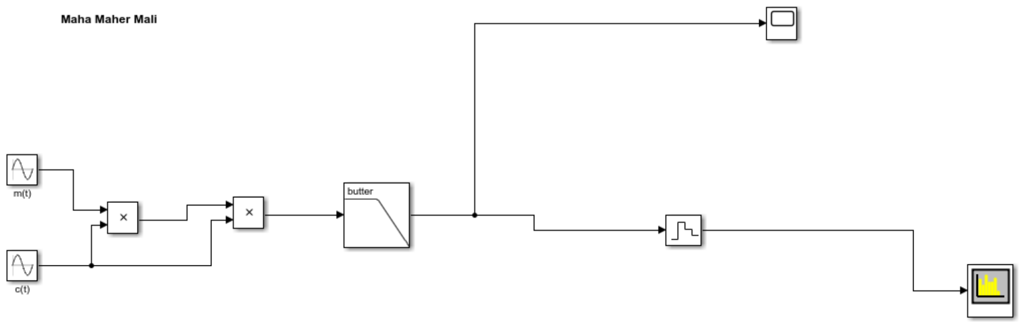

Figure 12: DSB-SC Demodulation

Demodulated Signal in Time Domain

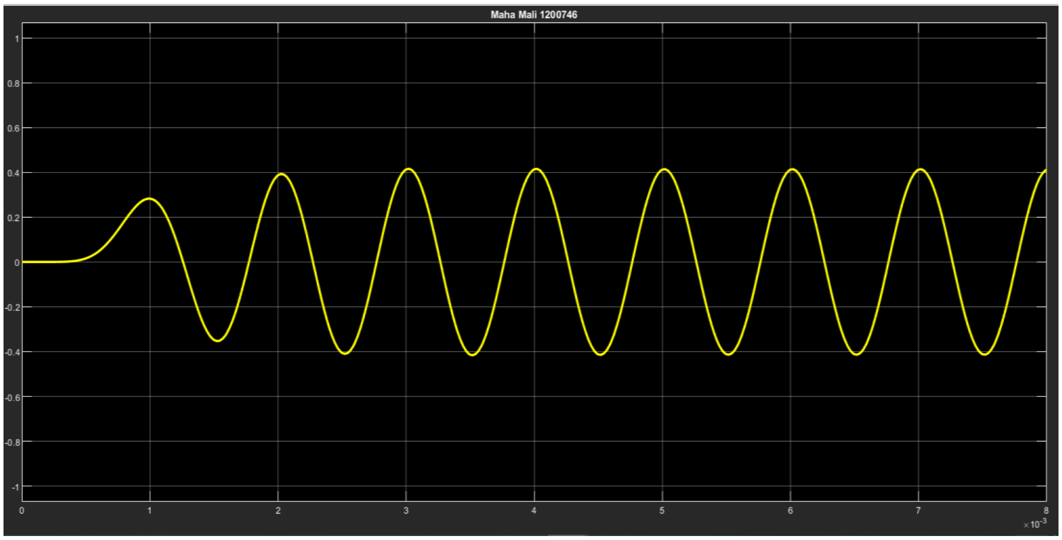

Figure 13: Demodulated Signal in Time Domain

Demodulated Signal in Frequency Domain

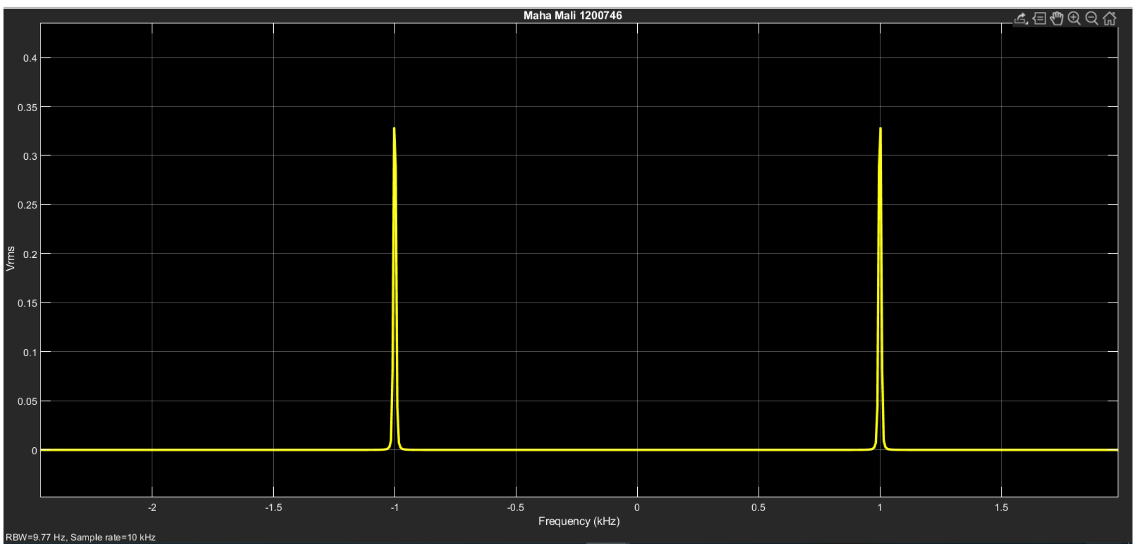

Figure 14: Demodulated Signal in Frequency Domain

From the Demodulated Signal in Frequency Domain we notice that we get the orignail meessage at freqancy 1000,and -1000.

SSB-SC Modulation and Demodulation

SSB-SC Modulation Method 1(Lower Side)

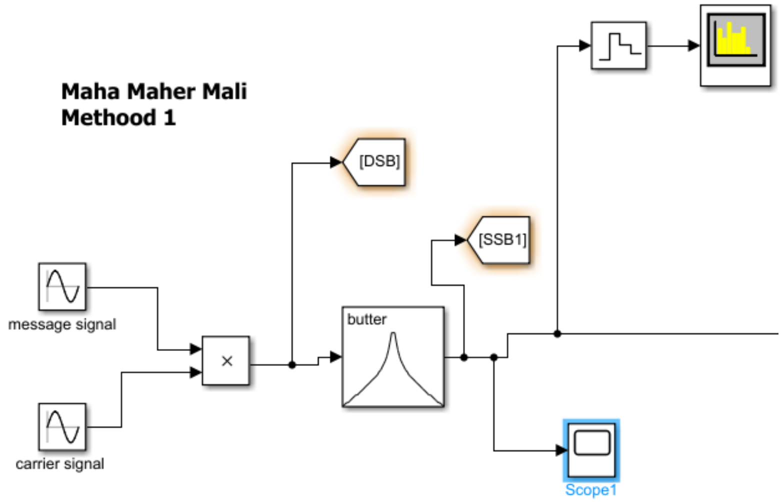

Figure 15: SSB-SC Modulation Method 1(Lower Side)

Modulated Signal in Time Domain

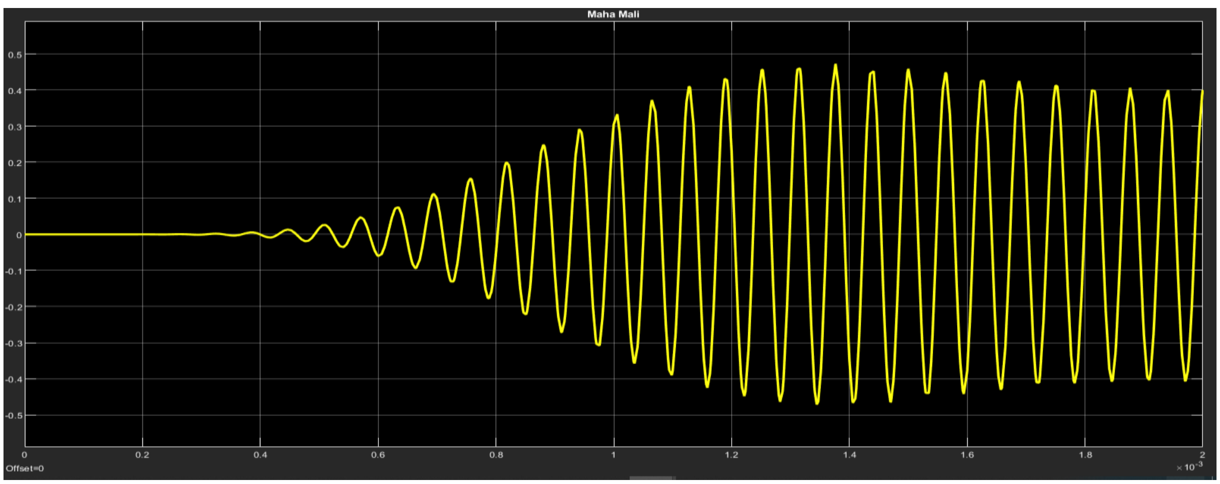

Figure 16: Modulated Signal in Time Domain

Modulated Signal in Frequency Domain

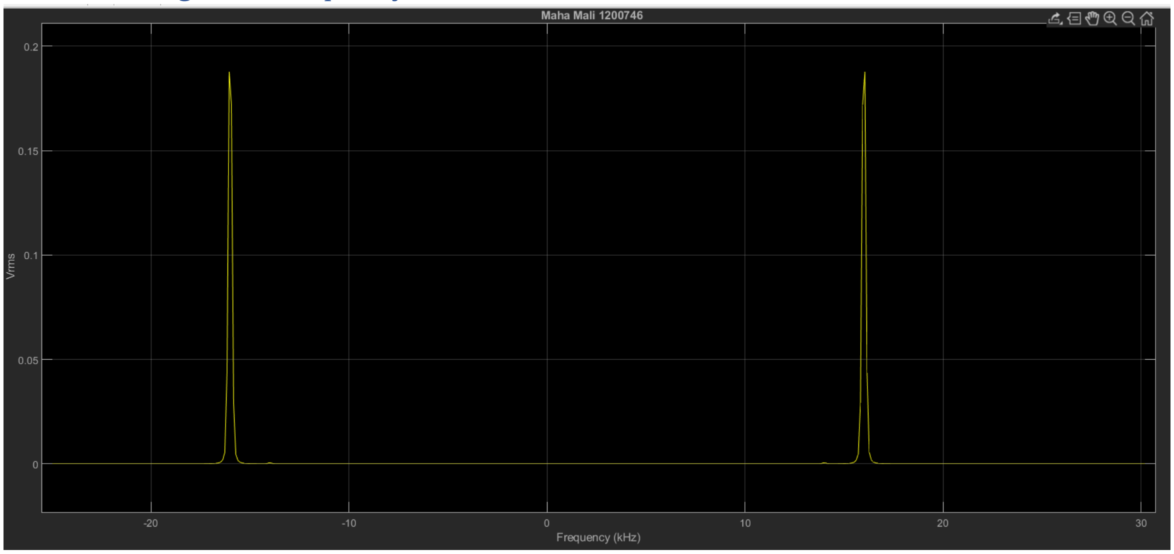

Figure 17: Modulated Signal in Frequency Domain

SSB-SC Demodulation

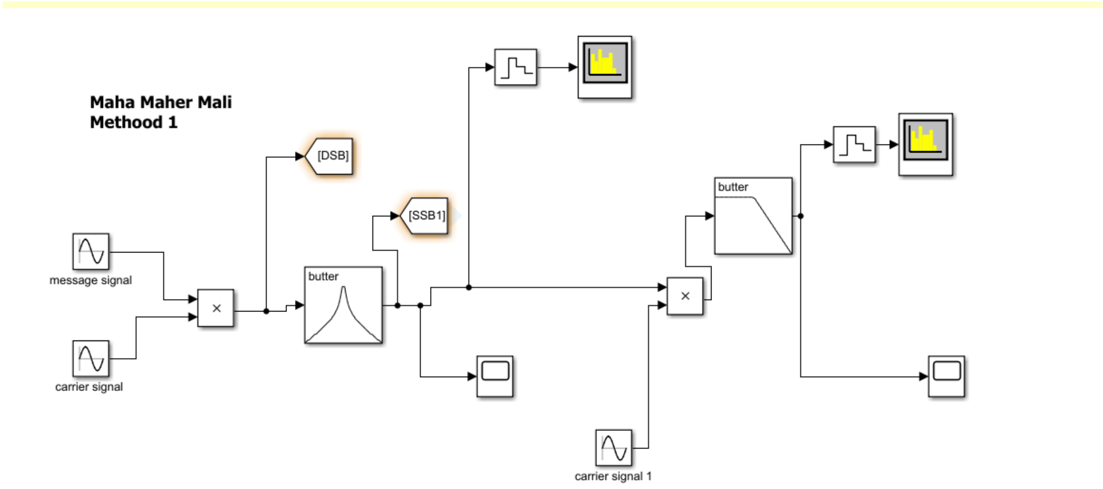

Figure 18: SSB-SC Demodulation

Demodulated Signal in Time Domain

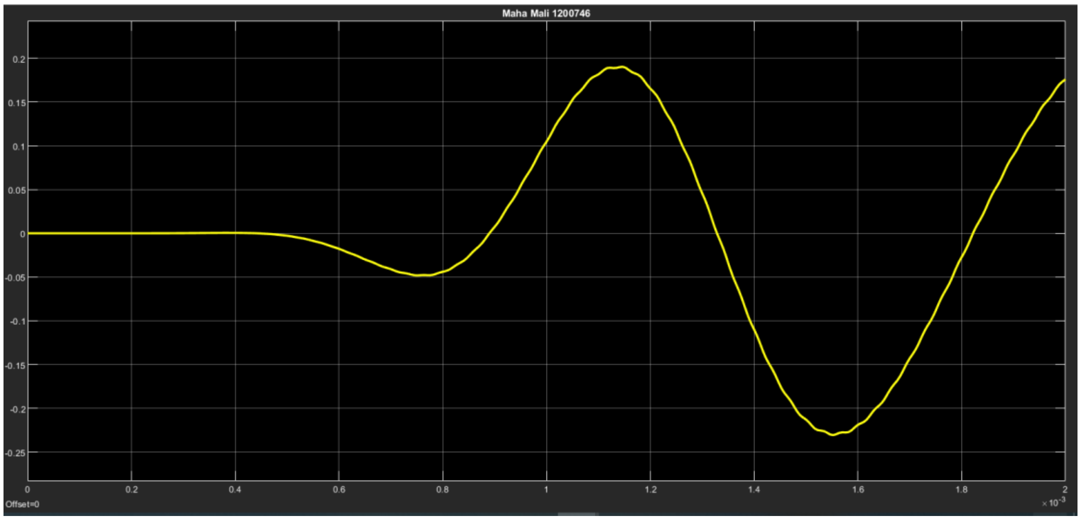

Figure 19: Demodulated Signal in Time Domain

Demodulated Signal in Frequency Domain

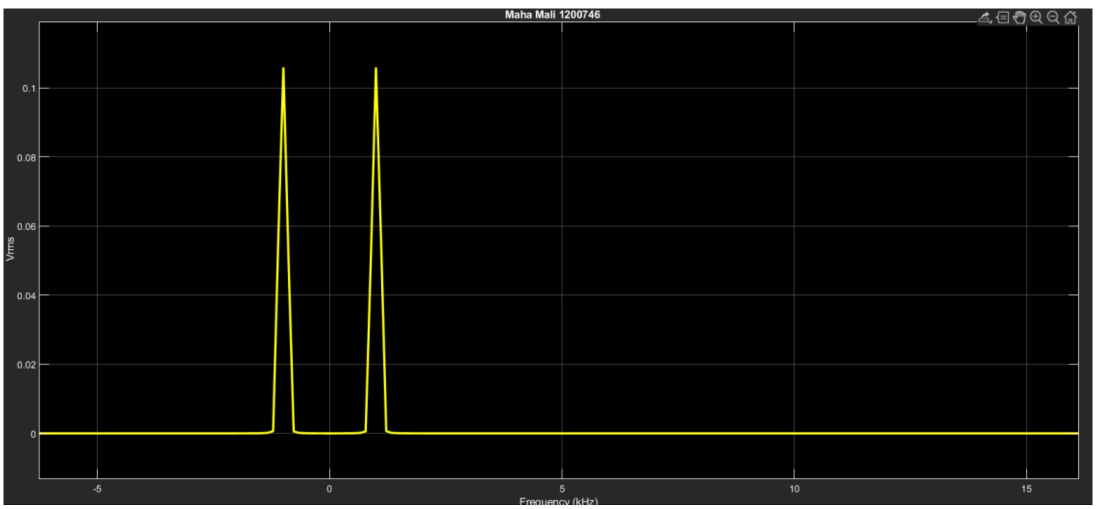

Figure 20: Demodulated Signal in Frequency Domain

SSB-SC Modulation and Demodulation

SSB-SC Modulation Method 2(Lower Side)

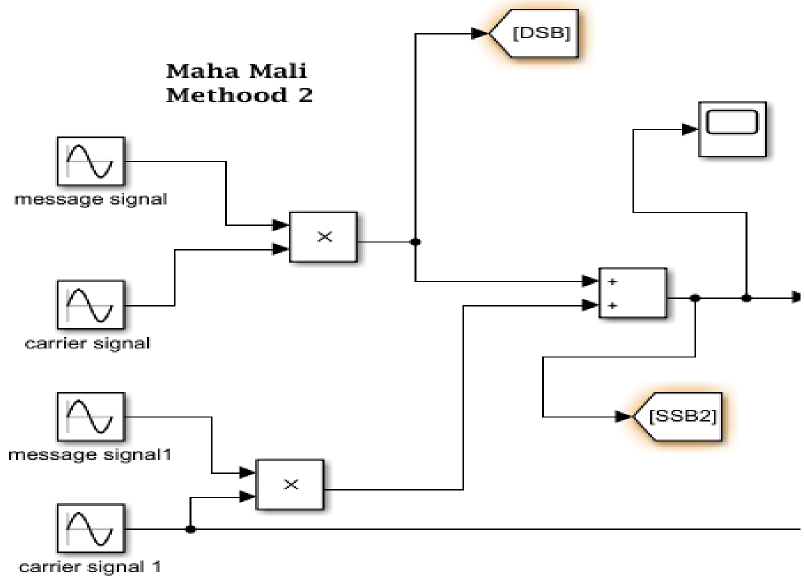

Figure 21: SSB-SC Modulation Method 2(Lower Side)

Modulated Signal in Time Domain

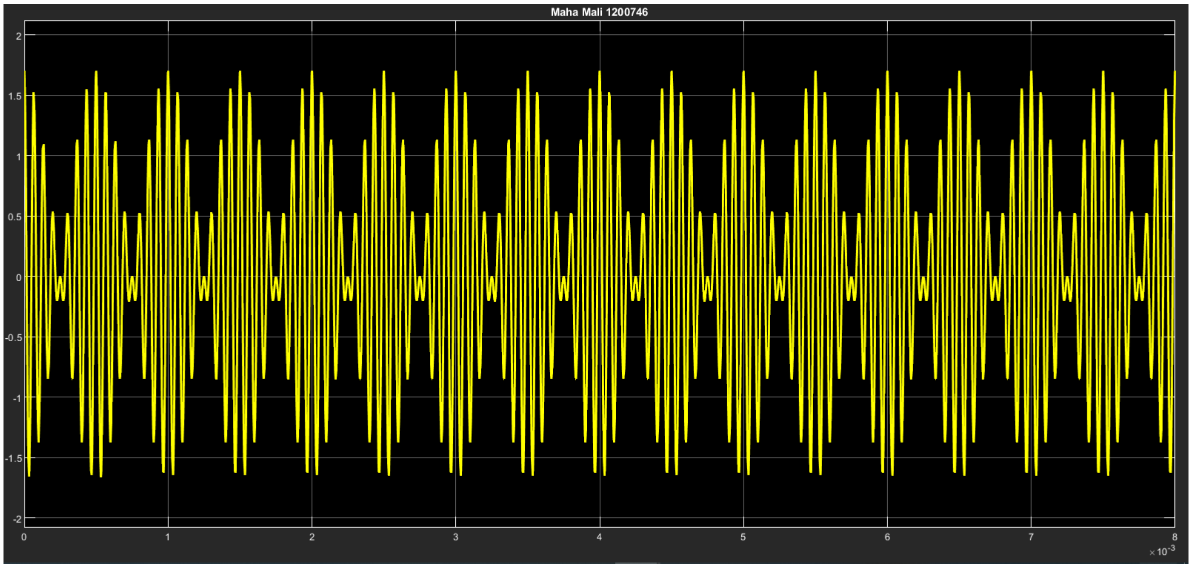

Figure 22: Modulated Signal in Time Domain

Modulated Signal in Frequency Domain

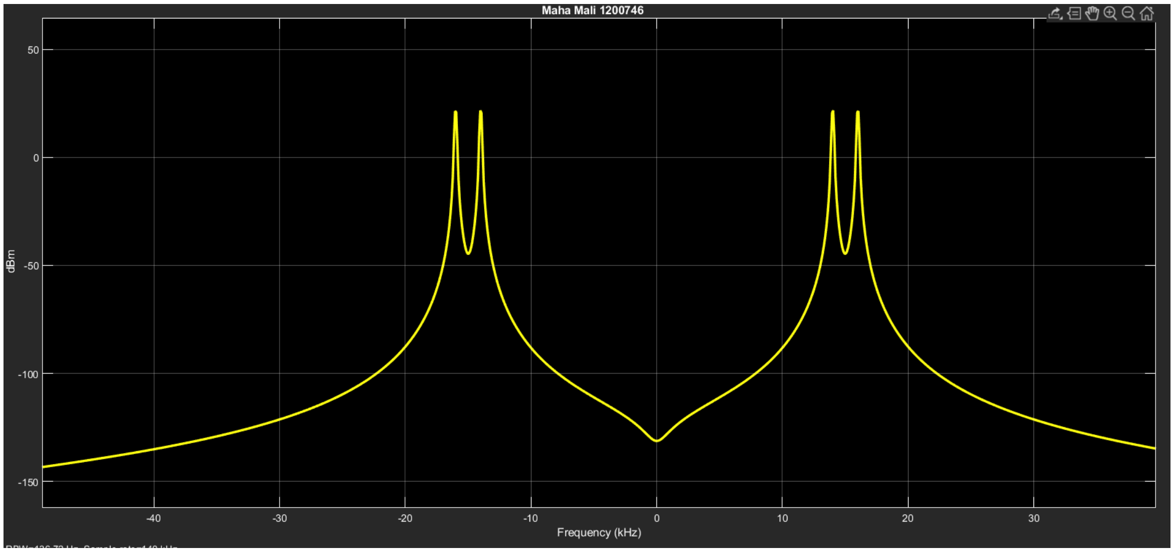

Figure 23: Modulated Signal in Frequency Domain

SSB-SC Demodulation

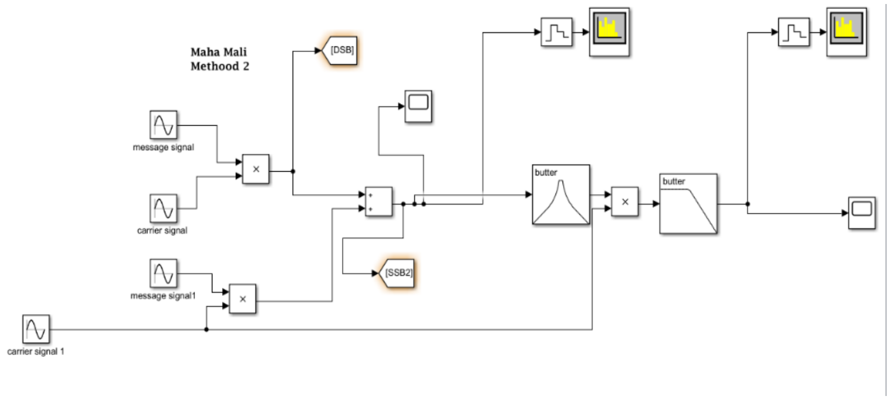

Figure 24: SSB-SC Demodulation

Demodulated Signal in Time Domain

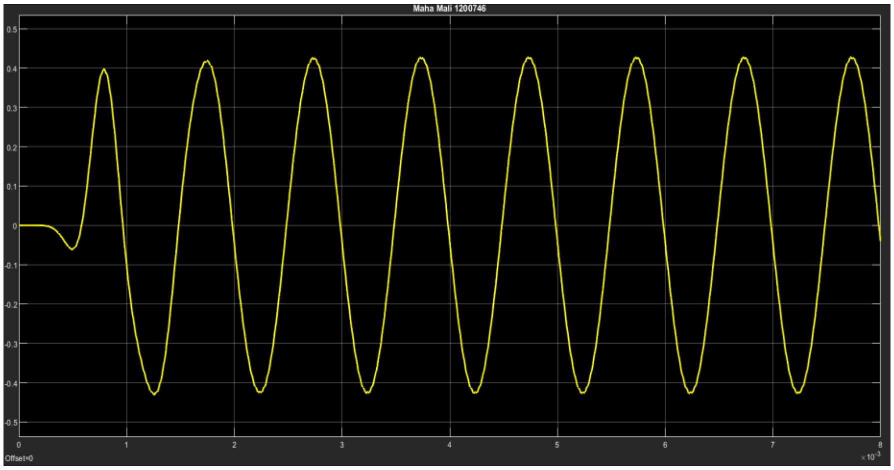

Figure 25: Demodulated Signal in Time Domain

Demodulated Signal in Frequency Domain

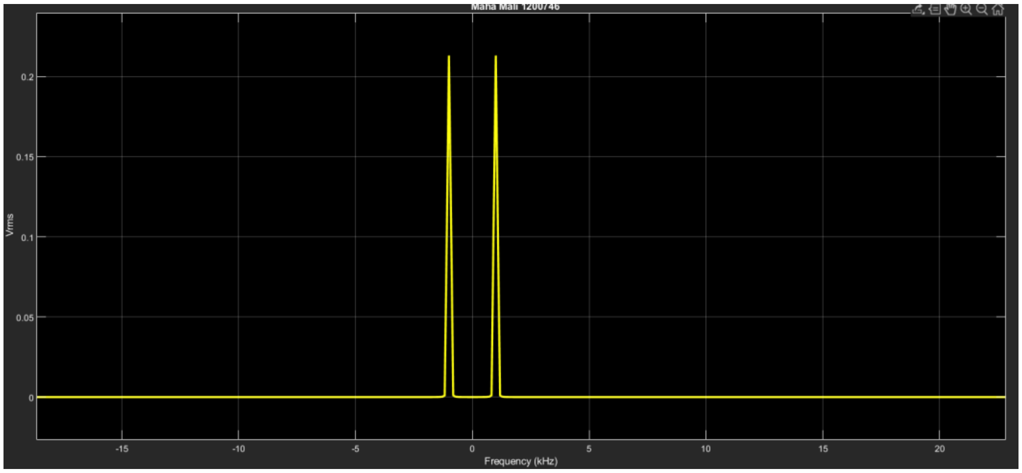

Figure 26: Demodulated Signal in Frequency Domain

References

[1] https://electronicscoach.com/double-sideband-suppressed-carrier-modulation.html

[2] https://en.wikipedia.org/wiki/Double-sideband_suppressed-carrier_transmission