Benha University

Faculty Of Engineering

Department of communication and computers

Course project

By:

Noran Nabil Ahmed

Supervisor:

Dr./ Ayman Mostafa

Department of communication and computers

Faculty Of Engineering

Benha University

May 2023

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- # Part one

1. Original signal

Comment: Signal amplitude is varying between (-1:1) volt in 10 seconds time long.

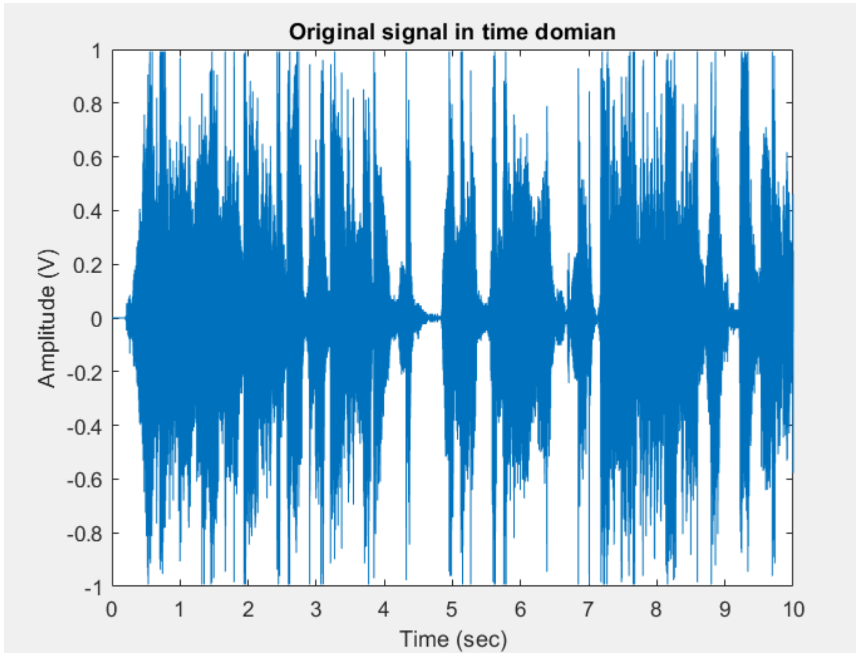

Figure 1:Original signal in time domain.

Comment: Signal bandwidth is almost 9KHZ with maximum amplitude of 0.006 V.

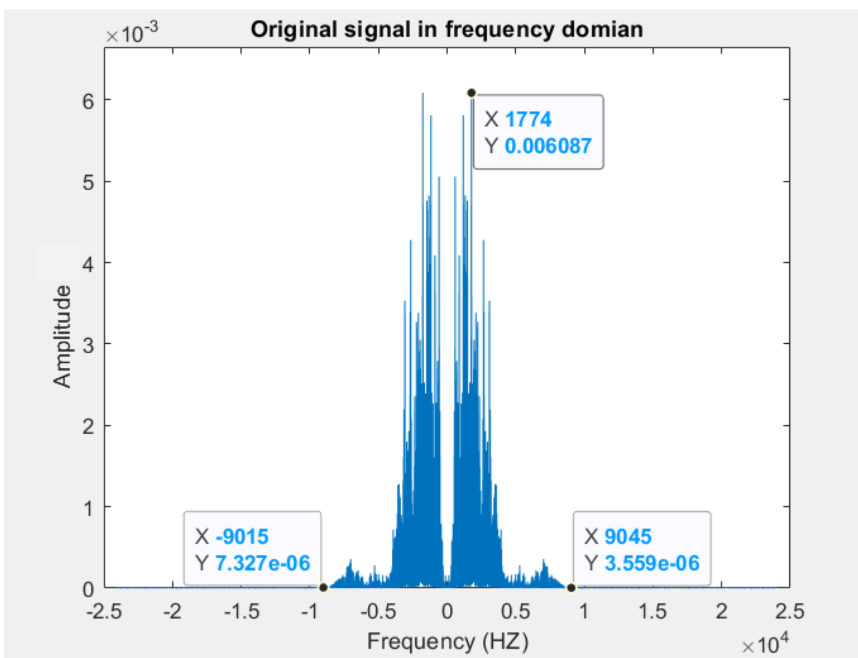

Figure 2:Original signal in frequency domain.

2. Filtered signal at F-cutoff=3400 HZ

No change from original signal is obvious by eye but Filtered signal bandwidth is almost 3.6 KHZ not as 3.4 KHZ as expected due to non-ideal filter with transmission band allows frequencies greater than 3.4KHZ to 3.6KHZ to pass though this filter.

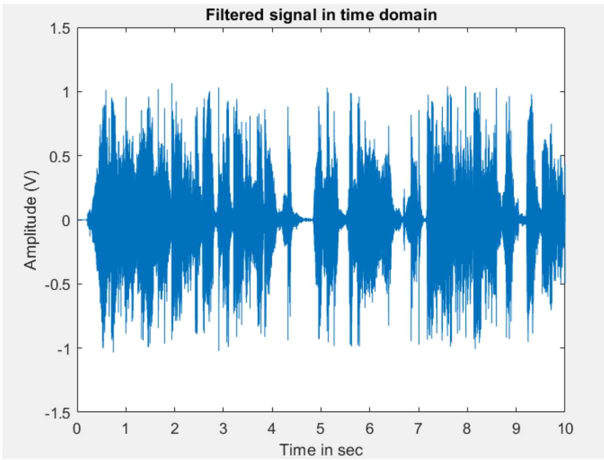

Figure 4:Filtered signal at 3.4KHZ in time domain.

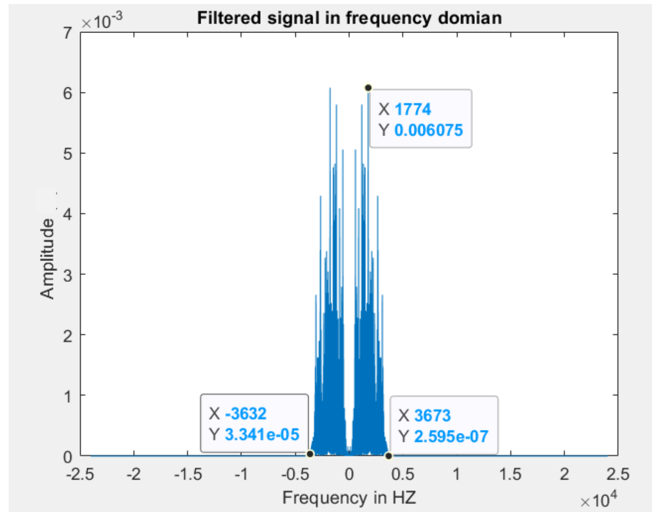

Figure 3:Filtered signal at 3.4KHZ in frequency

3. Filtered signal at F-cutoff=2.9KHZ

As signal filtered at lower cut off frequency more high frequency components are filtered and signal bandwidth is about 3KHZ due to transmission band.

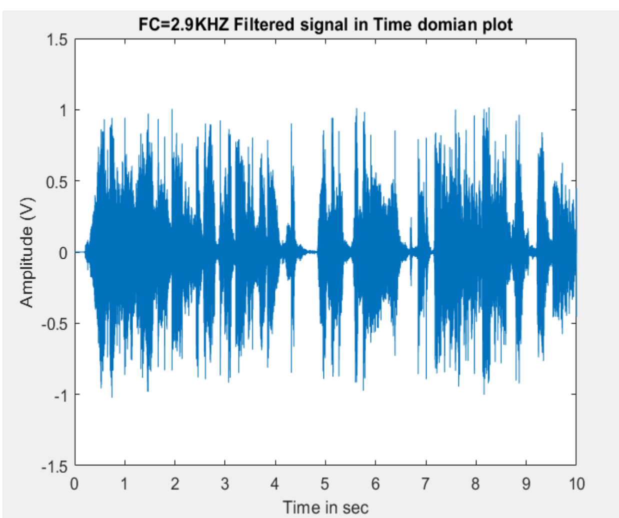

Figure 5:Filtered signal at 2.9KHZ in time domain

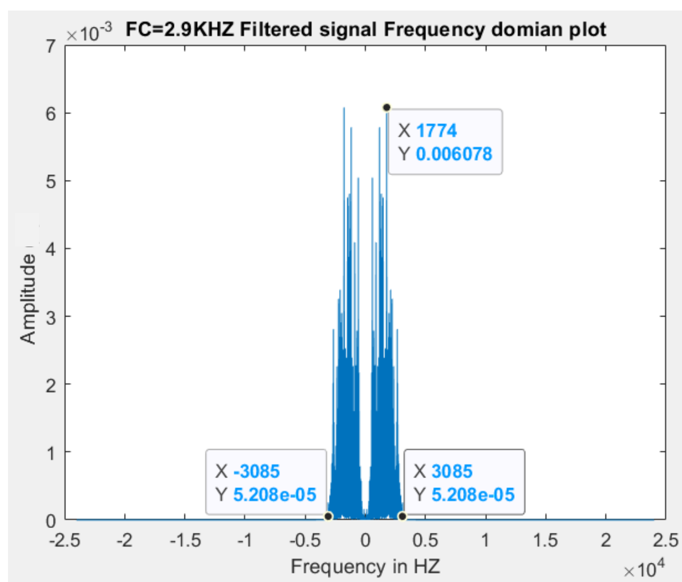

Figure 6:Filtered signal at 2.9KHZ in frequency domain

4. Filtered signal at F-cutoff=1.8KHZ

As signal filtered at lower cut off frequency more high frequency components are filtered and signal bandwidth is about 3KHZ due to transmission band.

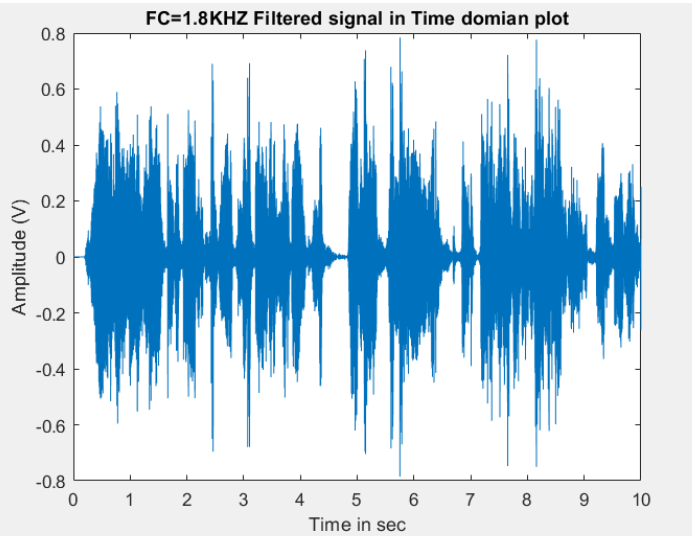

Figure 7:Filtered signal at 1.8KHZ in time domain.

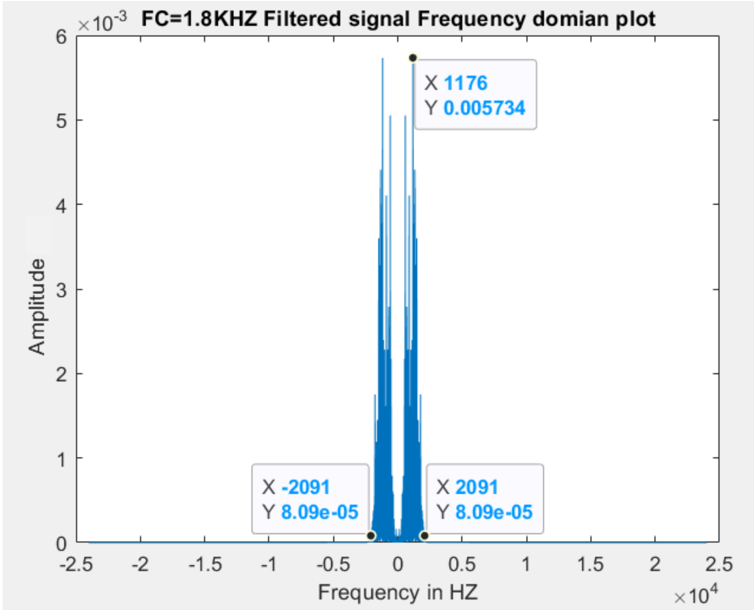

Figure 8:Filtered signal at 1.8KHZ in frequency domain.

5. Unintelligible filtered signal at F-cutoff=600HZ

Using lpf with f_c=600HZ the playback of the signal is unintelligible as its amplitude decreased from 1 to 0.04 in time domain and its bandwidth is about 785 HZ so it lost alot of its frequency component and its power.

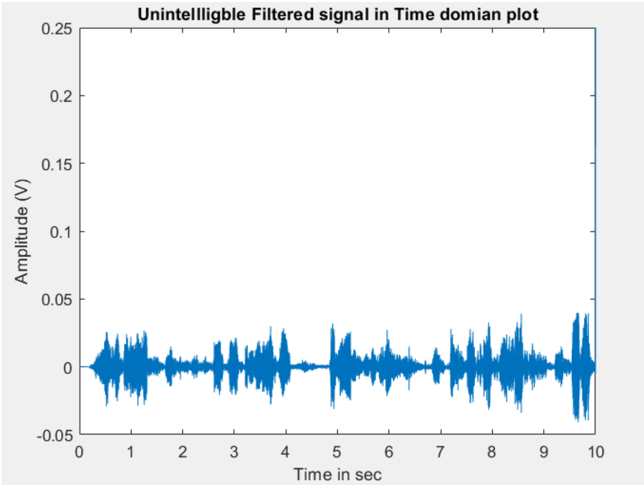

Figure 9:Unintelligible signal in time domain

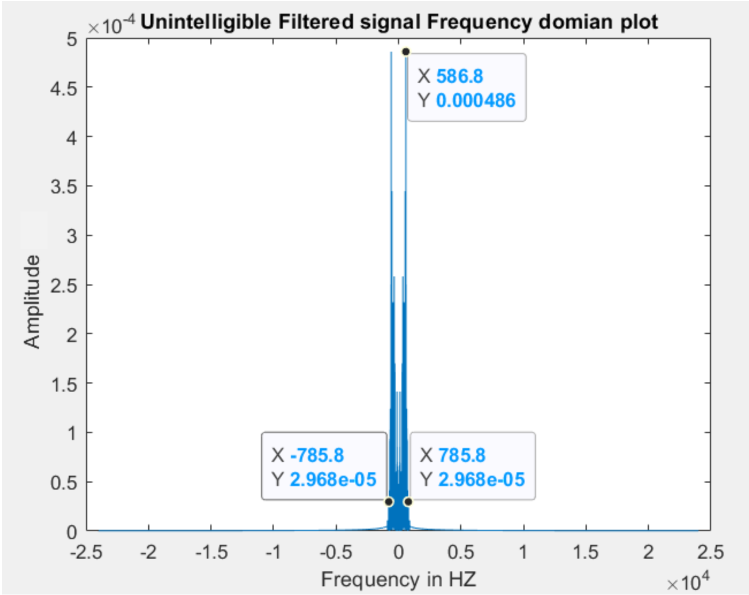

Figure 10:Unintelligible signal in frequency domain

6. Letter “F”

Letter F has a bandwidth of 8.4 KHZ.

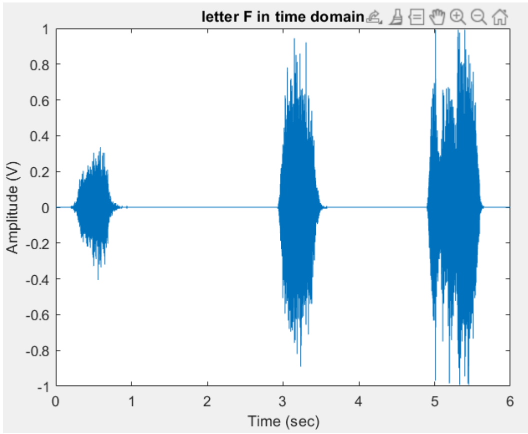

Figure 12:"F" in time domain.

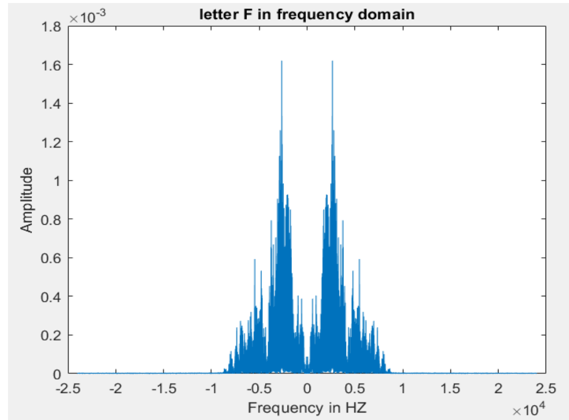

Figure 11:"F" in frequency domain.

Filtered “F” at 3.4KHZ has almost the same amplitude and lower bandwidth but it is still intelligent.

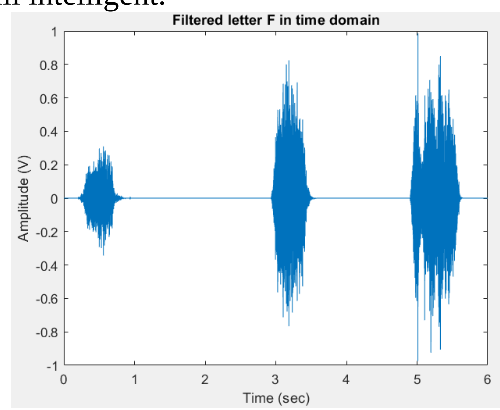

Figure 14:"F" filtered at 3.4KHZ in time domain

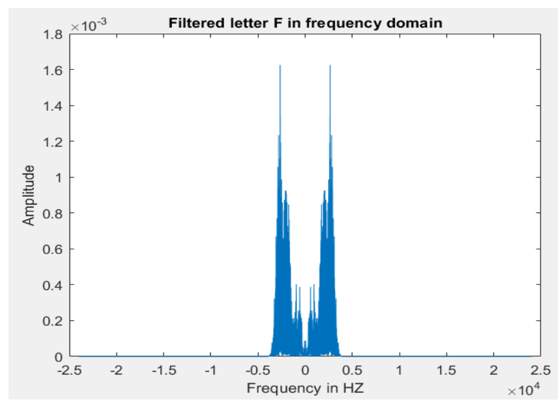

Figure 13:"F" filtered at 3.4KHZ in frequency domain.

At bandwidth of almost 1.97KHZ using a lpf with FC=1.8KHZ with small amplitude letter “F” becomes unintelligible

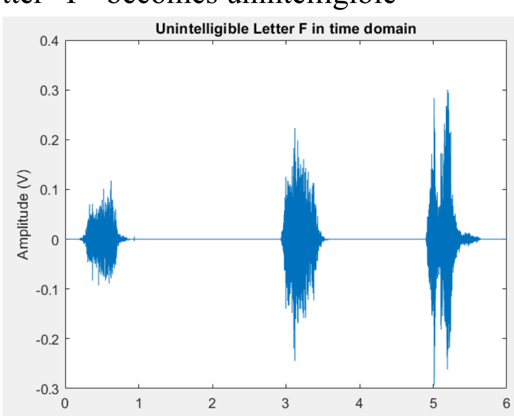

Figure 16:Unintelligible "F" in time domain

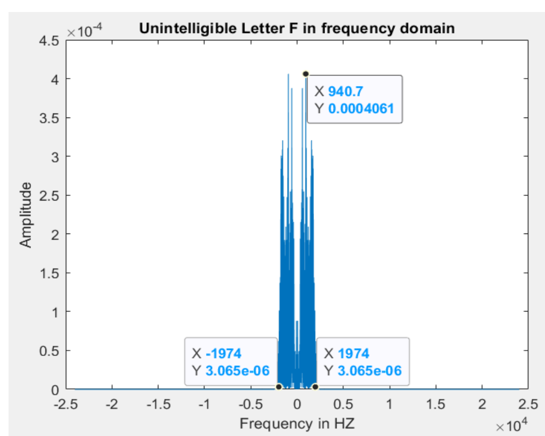

Figure 15:Unintelligible "F" in frequency domain.

7. Letter “S”

Letter S is of 8.9KHZ with more frequency components than F letter.

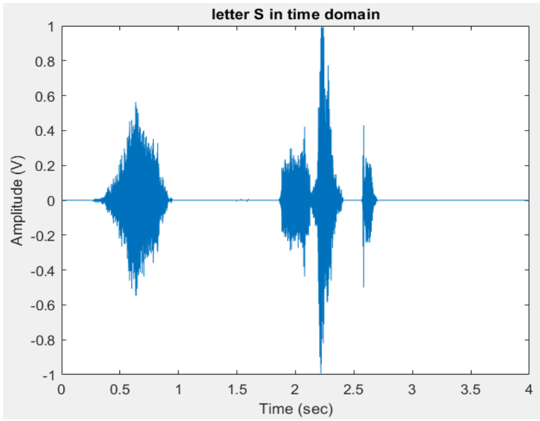

Figure 18:"S" in time domain

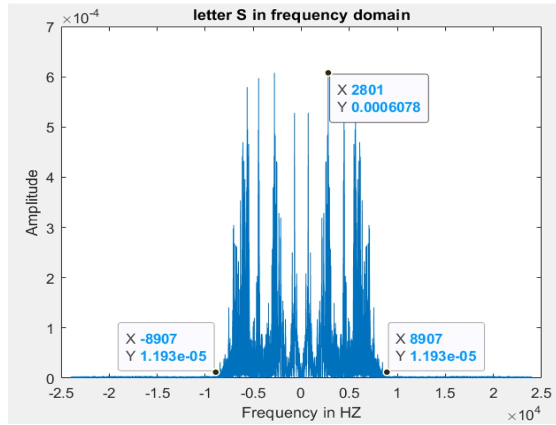

Figure 17:"S" in frequency domain.

Filtered “S” at 3.4KHZ has a lower amplitude with lower bandwidth.

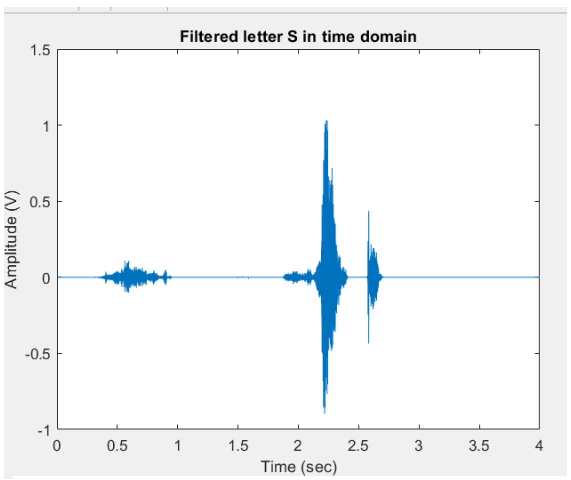

Figure 20:"S" filtered at 3.4KHZ in time domain

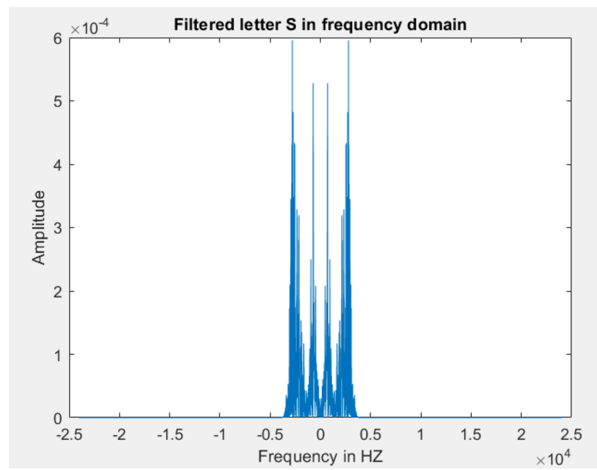

Figure 19:"S" filtered at 3.4KHZ in frequency domain.

At bandwidth of almost 1.2KHZ using a lpf with FC=1.1KHZ with small amplitude letter “S” becomes unintelligible.

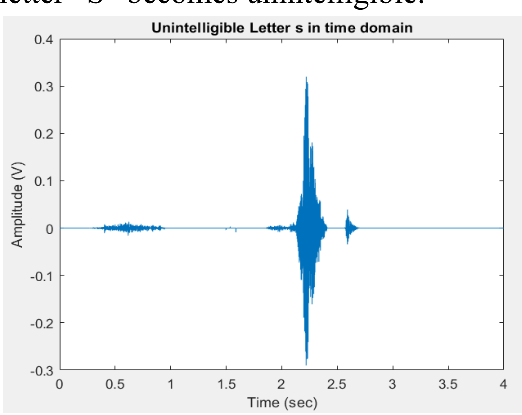

Figure 21:Unintelligible "S" in time domain.

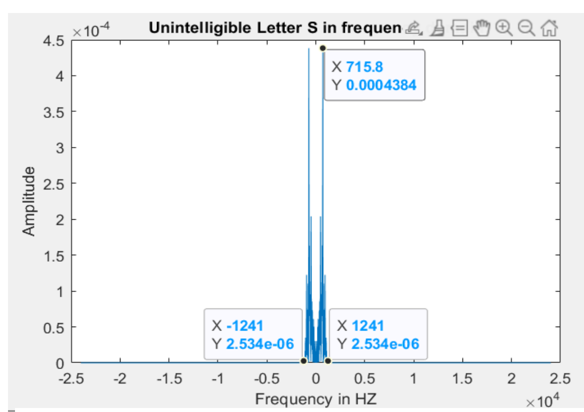

Figure 22:Unintelligible "S" in frequency domain.

8. Letter "B"

Letter B has a bandwidth of almost 7.5KHZ .

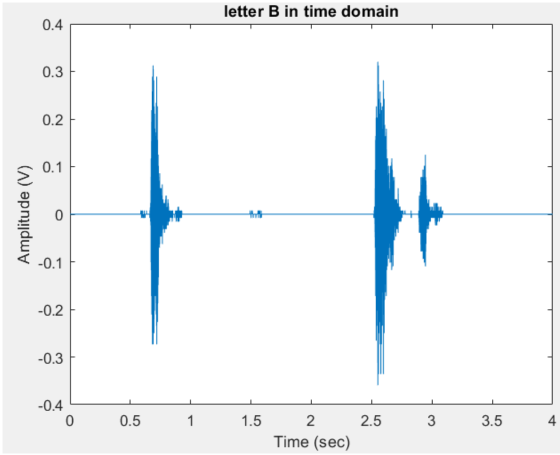

Figure 24:"B" in time domain

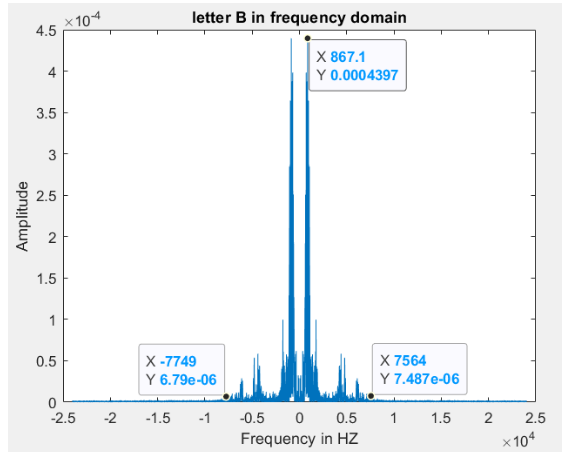

Figure 23:"B" in frequency domain

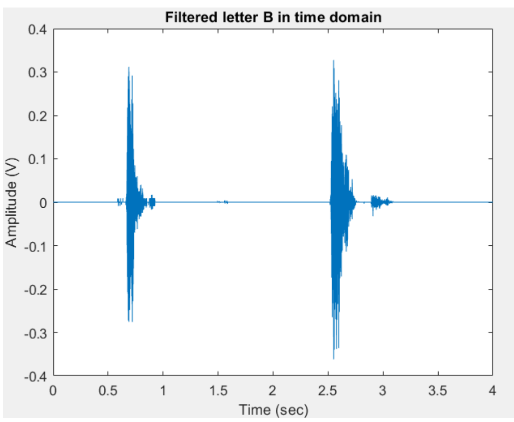

Figure 26:Filtered "B" in time domain.

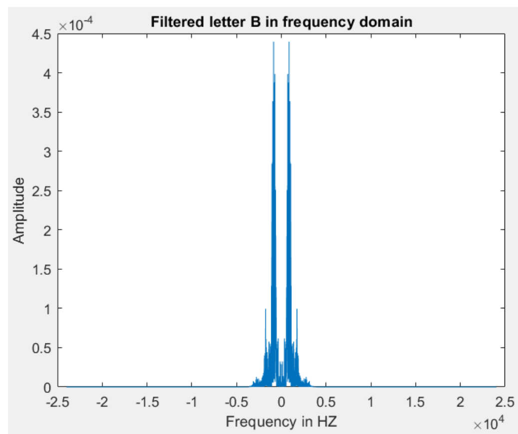

Figure 25:Filtered "B" in frequency domain.

At bandwidth of almost .7KHZ using a lpf with FC=.3KHZ with small amplitude letter "B" becomes unintelligible, here we find that result BW is higher than expected due to working in low frequency which affects negatively filters behavior.

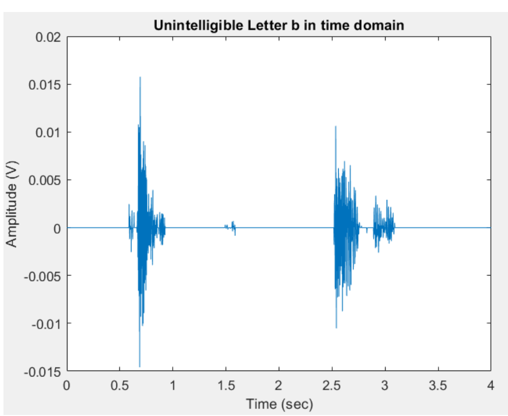

Figure 27:Unintelligible B in time domain

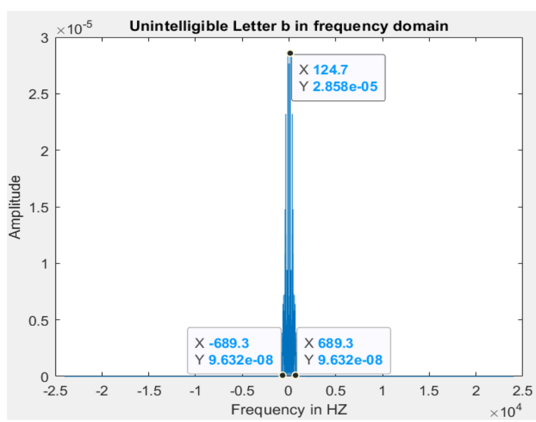

Figure 28:Unintelligible B in frequency domain.

9. Letter “D”

Letter “D” has a bandwidth of 4.3KHZ.

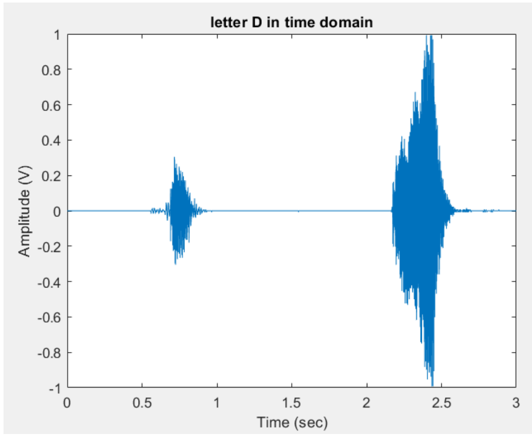

Figure 30:"D" in time domain

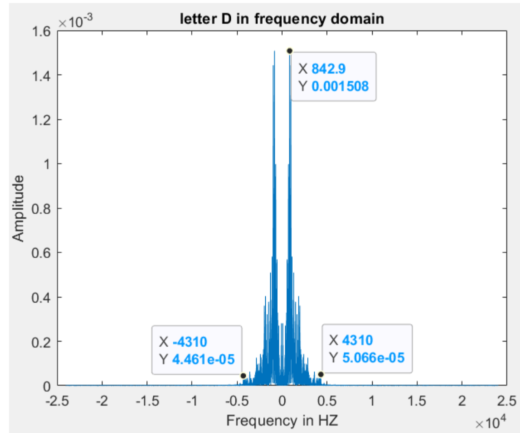

Figure 29:"D" in frequency domain

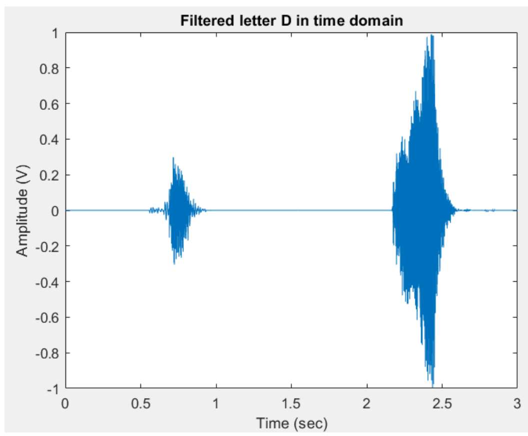

Figure 32:Filtered "D" in time domain.

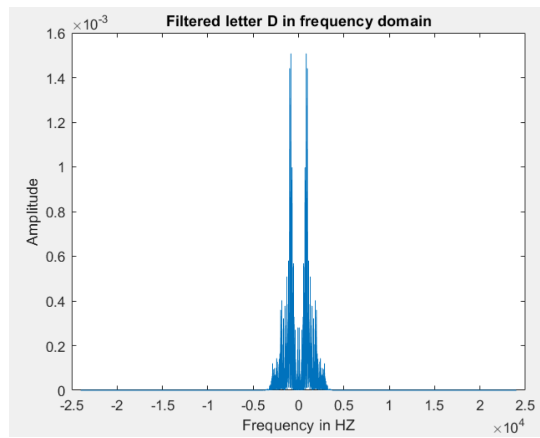

Figure 31:Filtered D in frequency domain

At bandwidth of almost .7KHZ using a lpf with FC=.3KHZ with very small amplitude letter “D” becomes unintelligible, here we find that result BW is higher than expected due to working in low frequency which affects negatively filters behavior.

Figure 33:Unintelligible D in time domain.

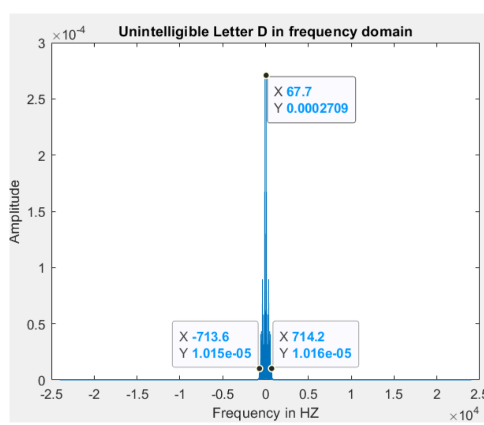

Figure 34:Unintelligible D in frequency domain

10.Letter “M”

Letter “M” has a bandwidth of 4.8KHZ.

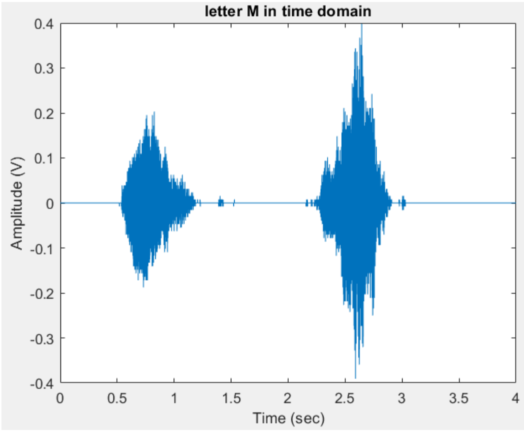

Figure 35:"M" in time domain.

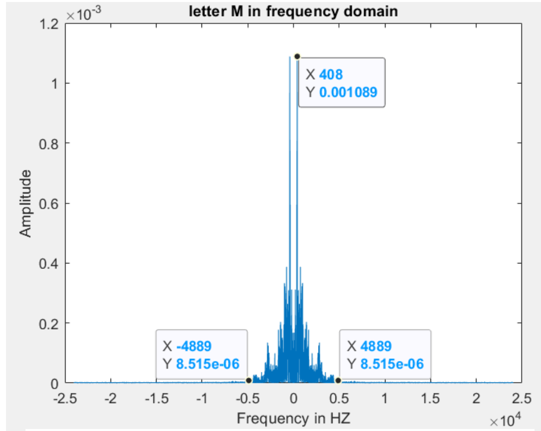

Figure 36:"M" in frequency domain

Filtered at 3.4KHZ.

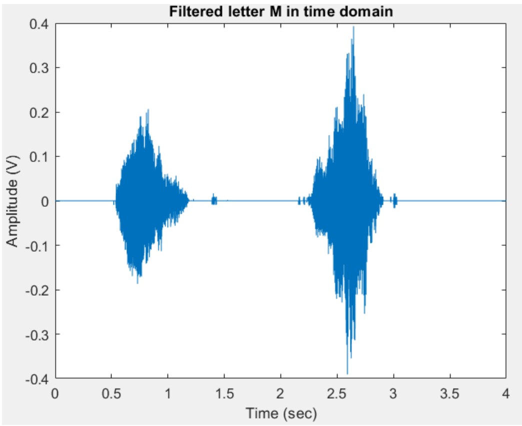

Figure 38:Filtered "M" in time domain.

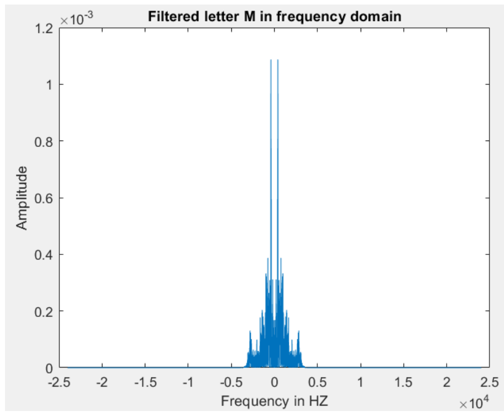

Figure 37:Filtered "M" in frequency domain.

At bandwidth of almost .7KHZ using a LPF with FC=.15KHZ with small amplitude letter “M” becomes unintelligible, here we find that result BW is higher than expected due to working in low frequency which affects negatively filters behavior.

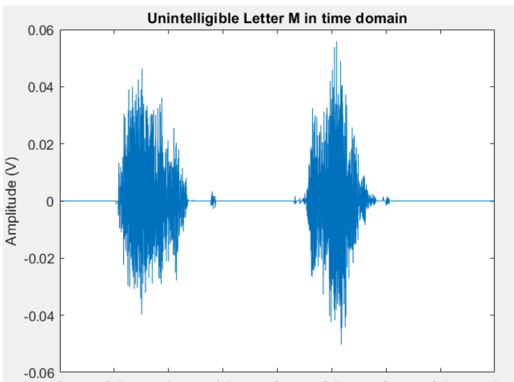

Figure 40:Unintelligible "M" in time domain.

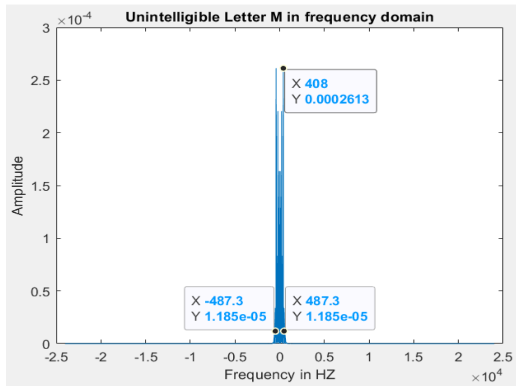

Figure 39:Unintelligible "M" in frequency domain.

11.Letter “N”

Letter N is of bandwidth 8.4KHZ

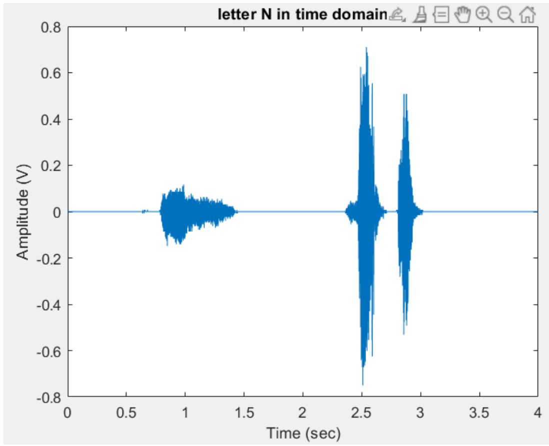

Figure 42:"N" in time domain.

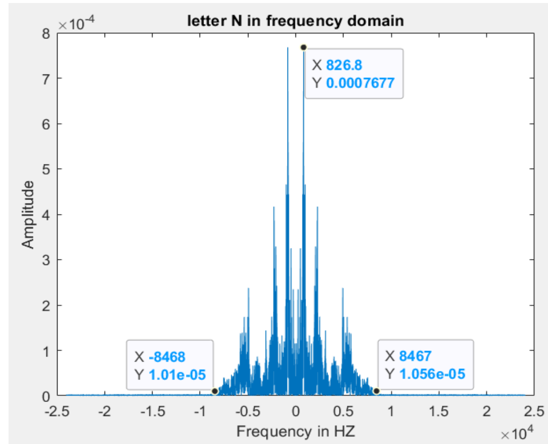

Figure 41:"N" in frequency domain.

Filtered at 3.4Khz.

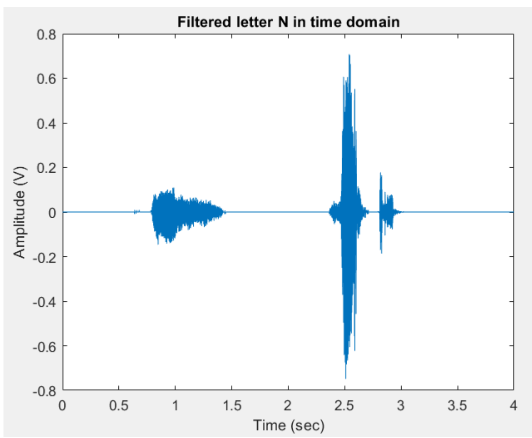

Figure 44:Filtered N in time domain.

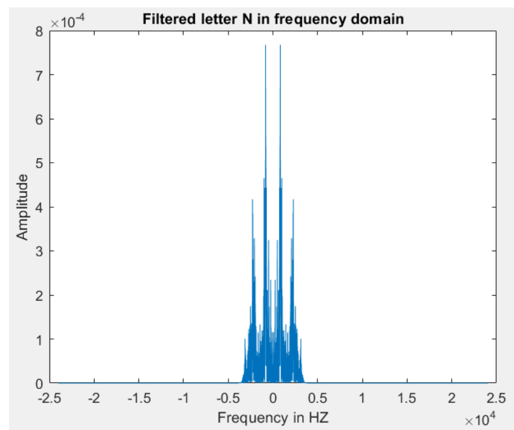

Figure 43:Filtered N in frequency domain.

With bandwidth of 0.54KHZ letter N becomes unintelligible using LPF with FC=0.2KHZ, here we find that result BW is higher than expected due to working in low frequency which affects negatively filters behavior

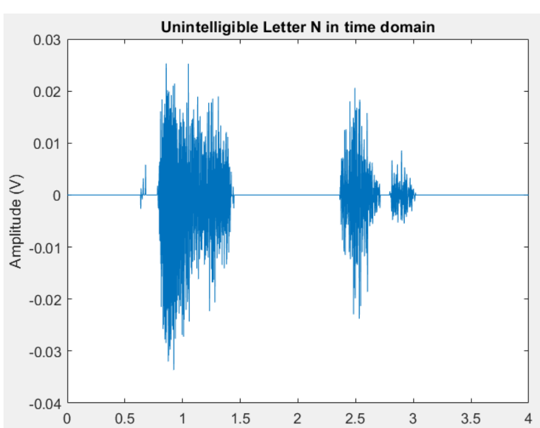

Figure 46:Unintelligible N in time domain.

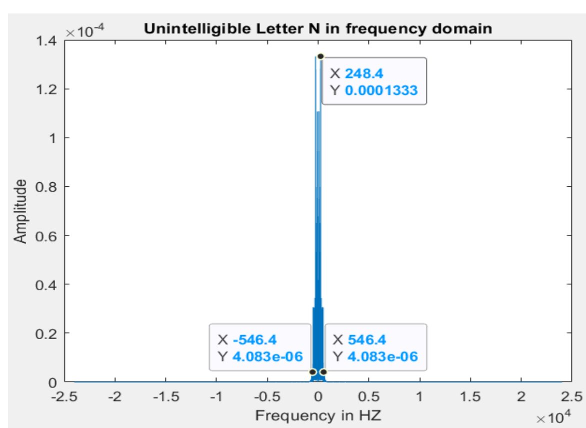

Figure 45:Unintelligible N in frequency domain.

12.DSB_LC modulation

Using filtered signal at 3.4KHZ with carrier of frequency 48KHZ, signal in modulated after up sampling it using this carrier which results in frequency domain with carrier components with very high amplitude compared to signal components so we noticed that DSB_LC modulation needs large power to be done without benefits on our signal. As modulation index is 0.8 we have undermodulated which can be detected using envelope detector at the receiver.

In time domain:

$$Am = 1.0233 \qquad Ac = Am/\mu$$

$$|\mathrm{Max}(modulated)| = Am + Ac = 2.3$$

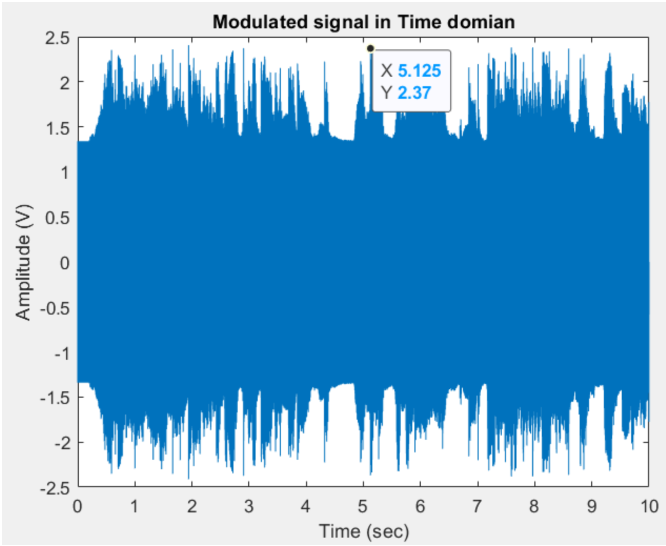

Figure 47:Modulated signal in time domain.

In frequency domain:

Here signal is found around carrier components but carrier amplitude is very high compared to signal components.

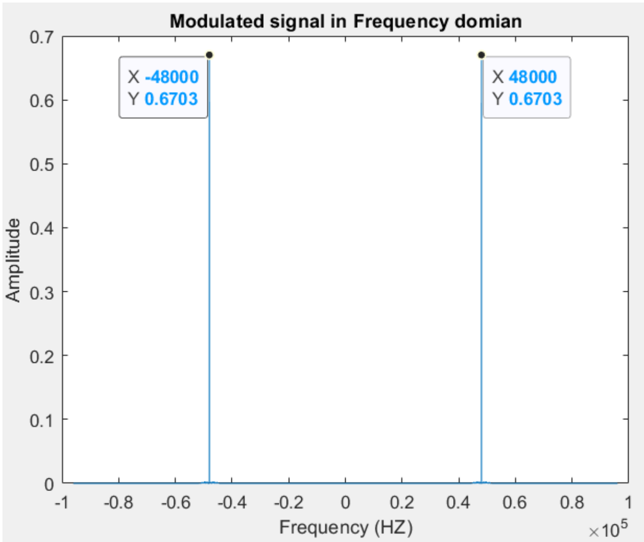

Figure 49:Carrier high amplitude in modulated signal.

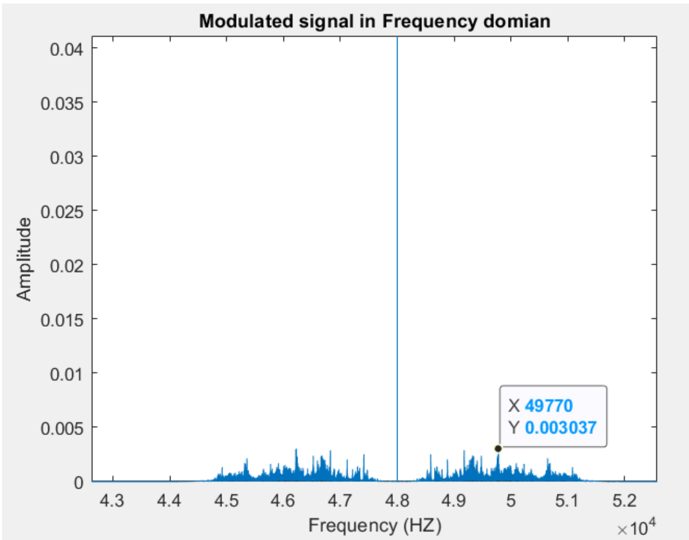

Figure 48:Signal components compared to carrier component

13.DSB_LC demodulation

An envelope detector is used for signal demodulation because of carrier existence in modulated signal so we can recover the signal after envelope detector and LPF but there is a dc component should be removed then it result a signal lower energy than that used in modulation so it is multiplicated by a factor which is related to relation between signal energy and recovered energy to get signal at receiver almost equal in amplitude the signal at the transmitter. In frequency domain we find the recovered signal is of bandwidth almost 3.6KHZ due to un-ideal filter used int the receiver.

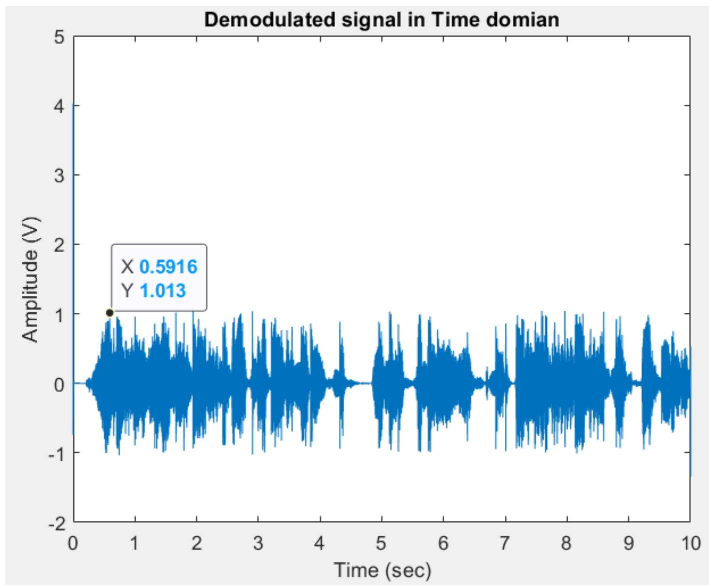

Figure 51:Demodulated signal at time domain.

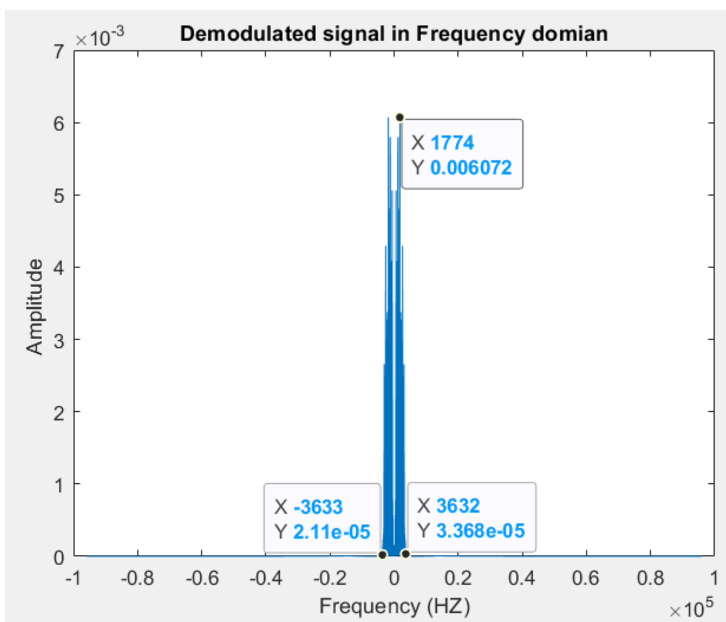

Figure 50:Demodulated signal at frequency domain.

- **Part two**

1. DSB_SC Modulation:

DSB_SC modulation causes signal to be shifted around carrier frequency as its center frequency in both sides negative and positive in frequency spectrum without carrier component which saves a lot of power used in DSB_LC. Change in signal in time domain is not illustrated as it is in frequency domain.

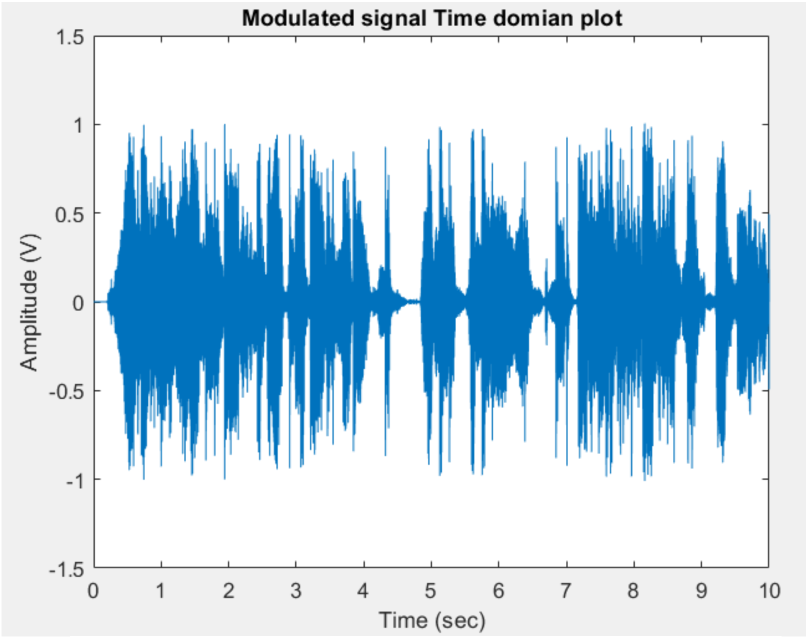

Figure 52:DSB_SC modulated signal in time domain

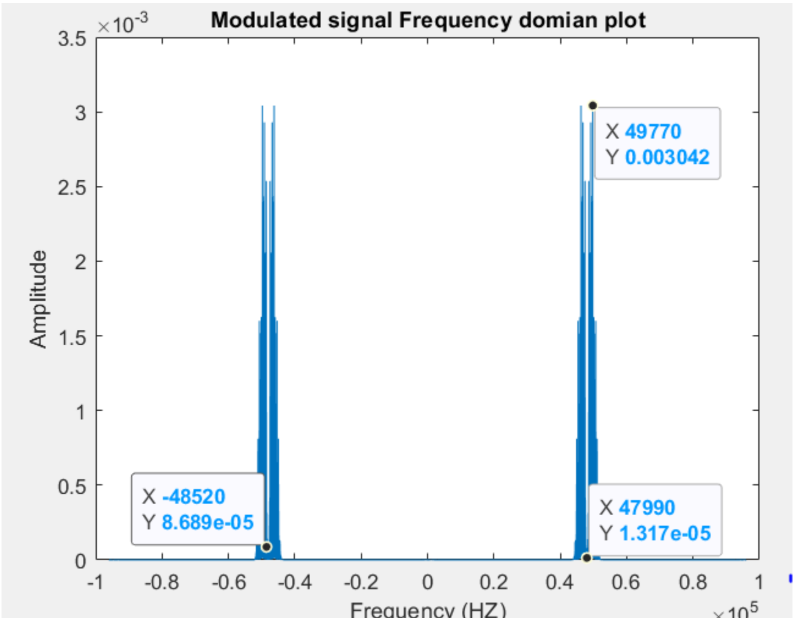

Figure 53:DSB_SC modulated signal in frequency domain

2. DSB-SC Demodulation using coherent detector

Recovered signal is half the original signal due to coherent detector effect which appears in both time domain, frequency domain and even in the play back of the signal. Demodulated signal is of bandwidth almost 3.7KHZ due effect of LPF used.

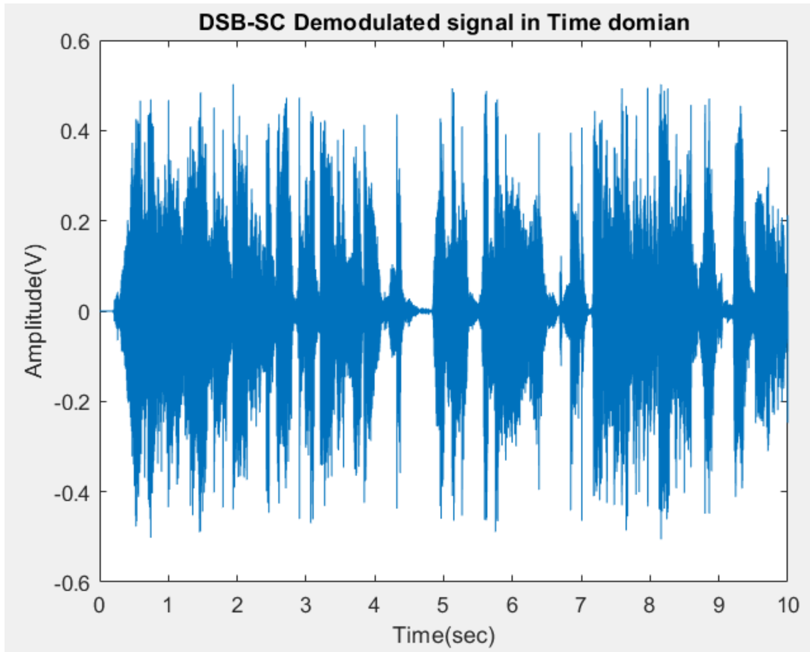

Figure 54:DSB-SC demodulated signal in time domain.

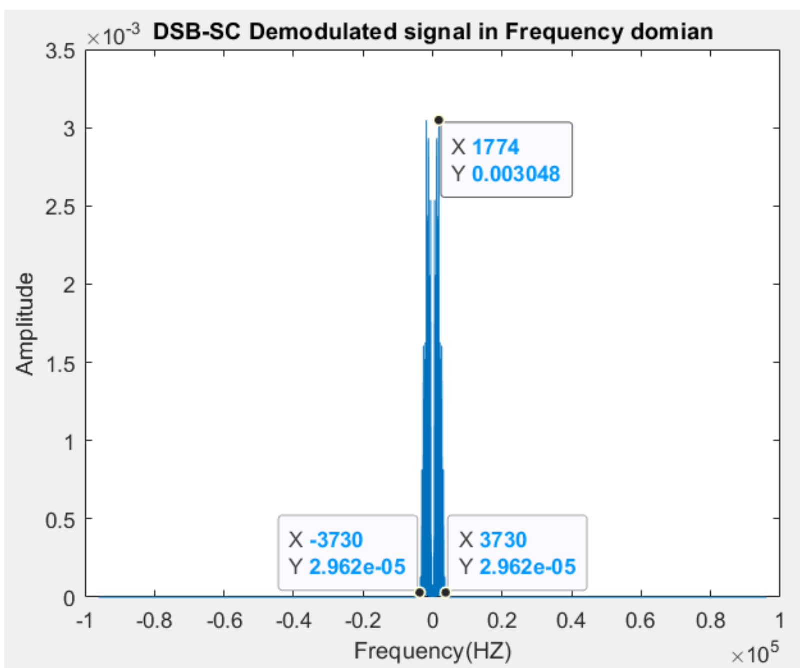

Figure 55:DSB-SC demodulated signal in frequency domain

3. Frequency shift effect in DSB-SC demodulation using coherent detector

Due to frequency shift in R-LO we get after LPF:

$v_o(t) = \frac{A_c}{2} * m(t) * \cos\left(W_{shift} * t\right)$ where cos is time varying so signal is distorted

Increasing the frequency shift increases the signal distortion until it is totally distorted. This occurs with low values of frequency shift compared to carrier frequency which is several KHZ where offset is of few hertz.

4. SSB Modulation

Here lower side of the signal only is modulated around carrier frequency taking bandwidth of only B which is better BW efficiency than DSB modulation which uses 2B for modulation of 50% BW efficiency.

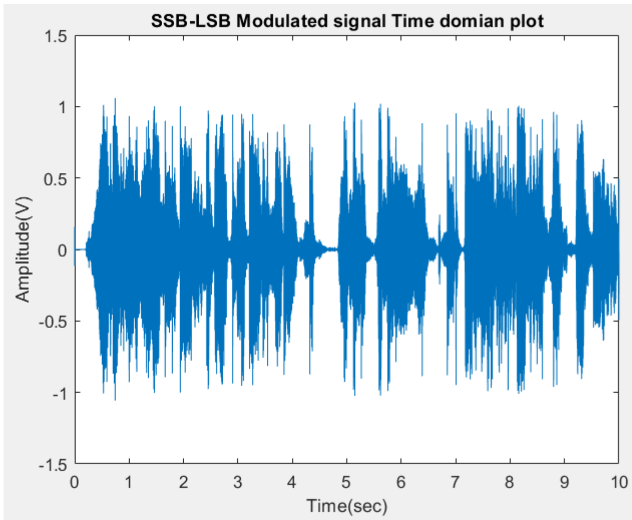

Figure 56: SSB modulated signal in time domain

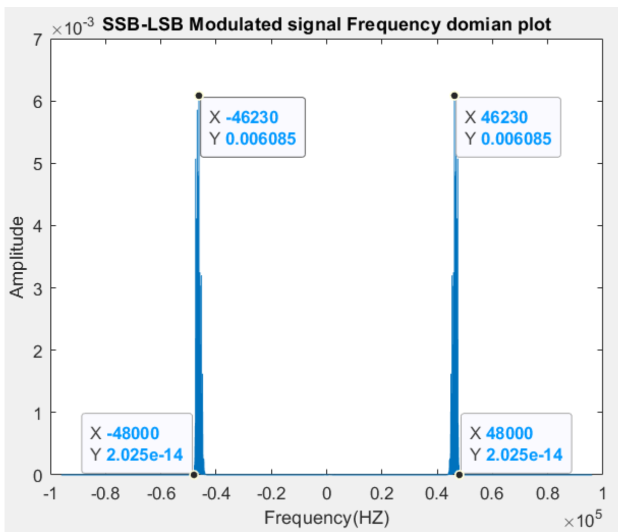

Figure 57:SSB modulated signal in frequency domain

5. SSB Demodulation using coherent detector

Recovered signal is half the original signal due to coherent detector effect which appears in both time domain, frequency domain and even in the play back of the signal. Demodulated signal is of bandwidth almost 3.8KHZ due effect of LPF used

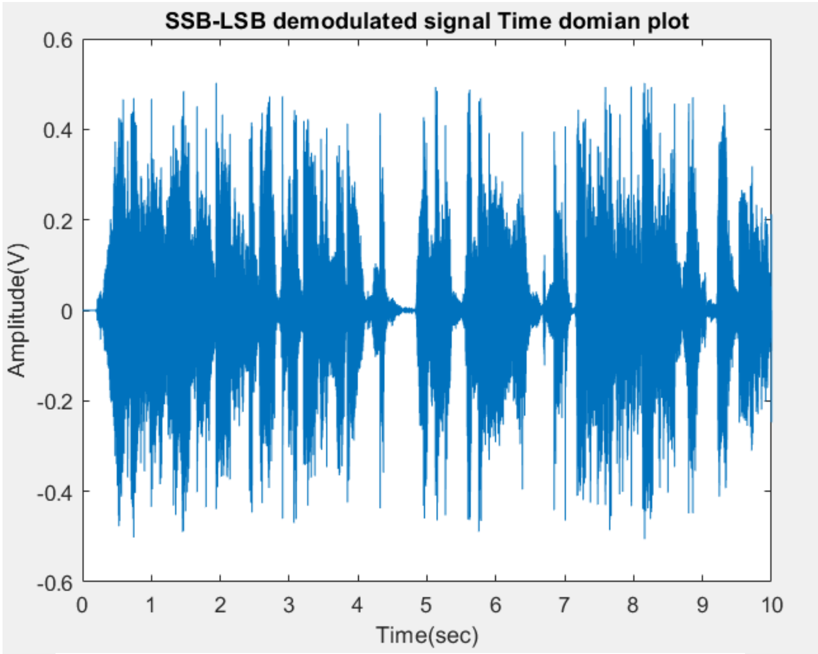

Figure 58:SSB demodulated signal in time domain

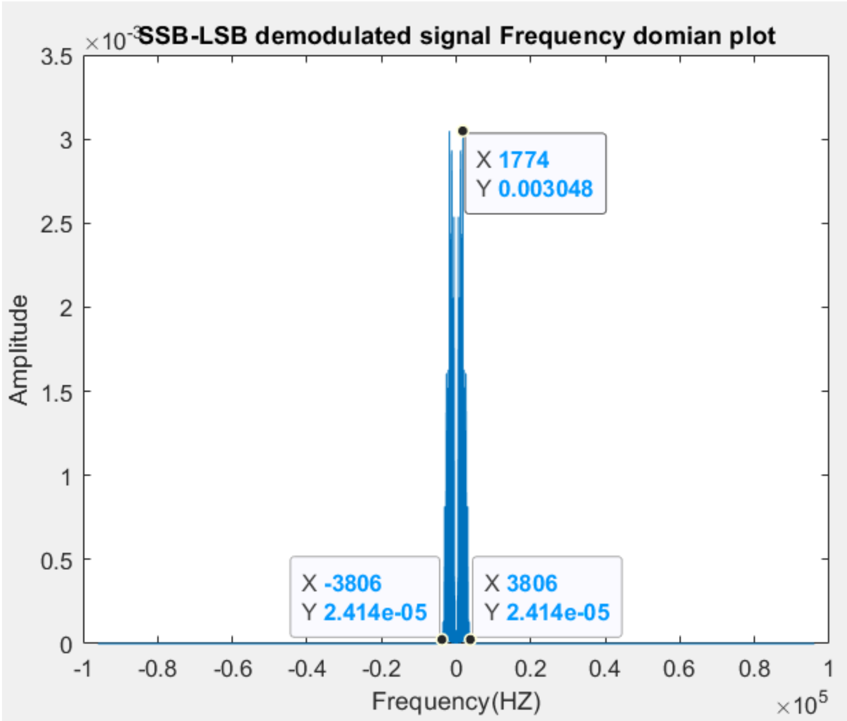

Figure 59:SSB demodulated signal in frequency domain.

6. **Frequency shift effect in SSB demodulation using coherent detector**
   Same as frequency shift effect in DSB-SC, frequency shift causes signal distortion which increases by increasing f shift which appears in signal playback.

- # Part Three

1. Signal FM Modulation with deviation ration=3

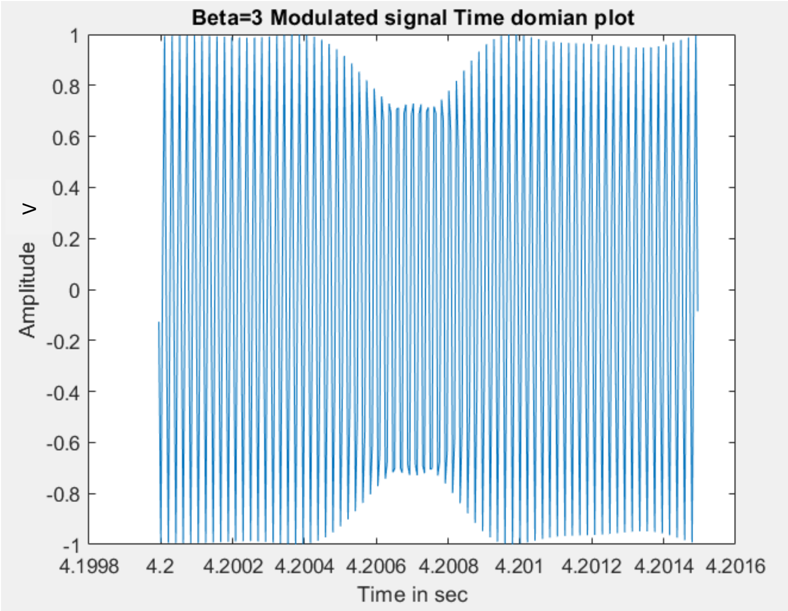

Figure 60:Segment of FM modulated signal with B=3 in time domain

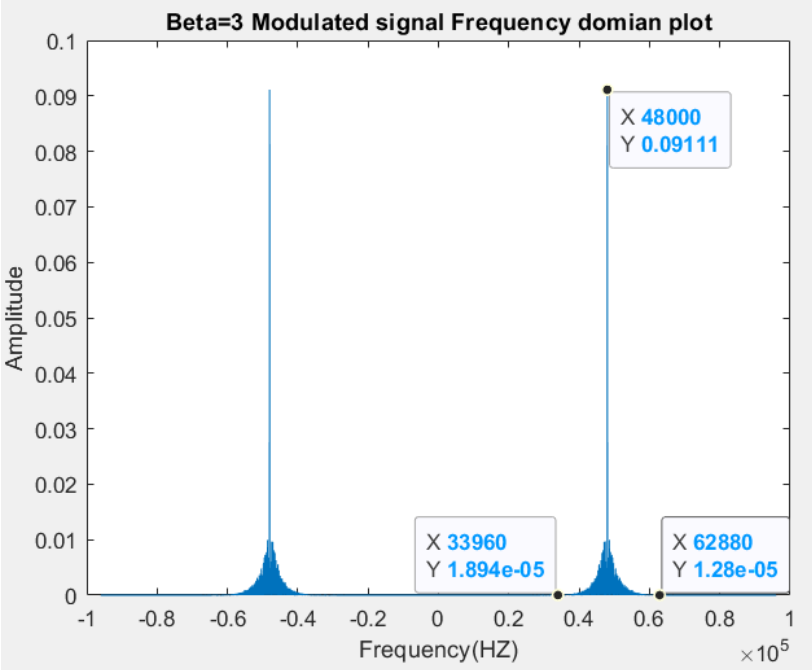

Figure 61:FM modulated signal with B=3 in frequency domain

Bt=62.88-33.96=28.92 KHZ which is almost equal to Carson's law which results with value 27.2KHZ

2. Signal FM Modulation with deviation ration=5

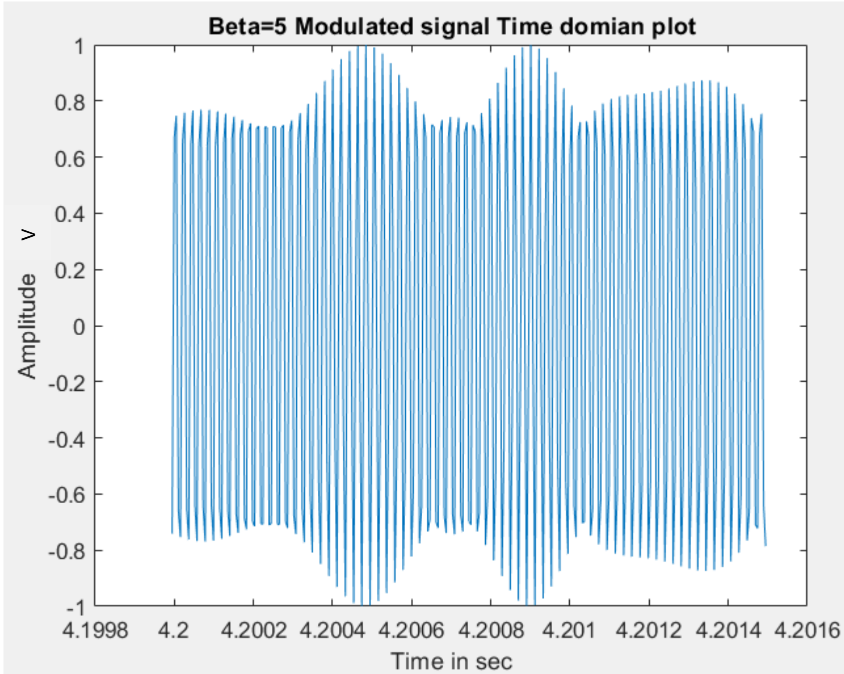

Figure 62:FM modulated signal with B=5 in time domain

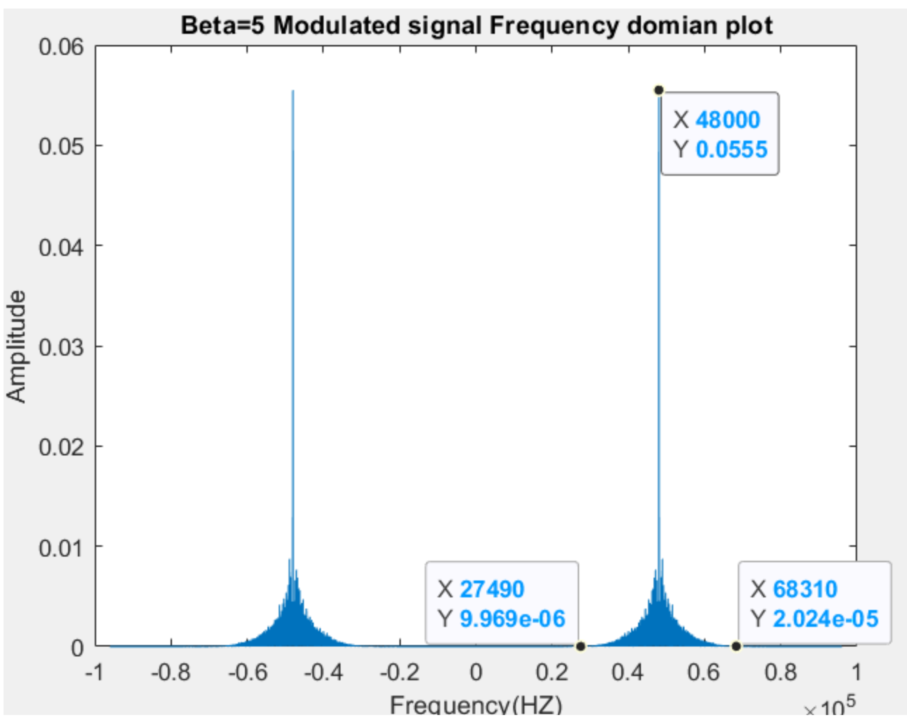

Figure 63:FM modulated signal with B=5 in frequency domain

Signal is modulated around carrier frequency with BT almost equals 68.31-27.49=40.82KHZ where Carson's law sets that it is 40KHZ which is higher than BT of modulation using B=3.

3. Single-tone FM Modulation with deviation ration=3

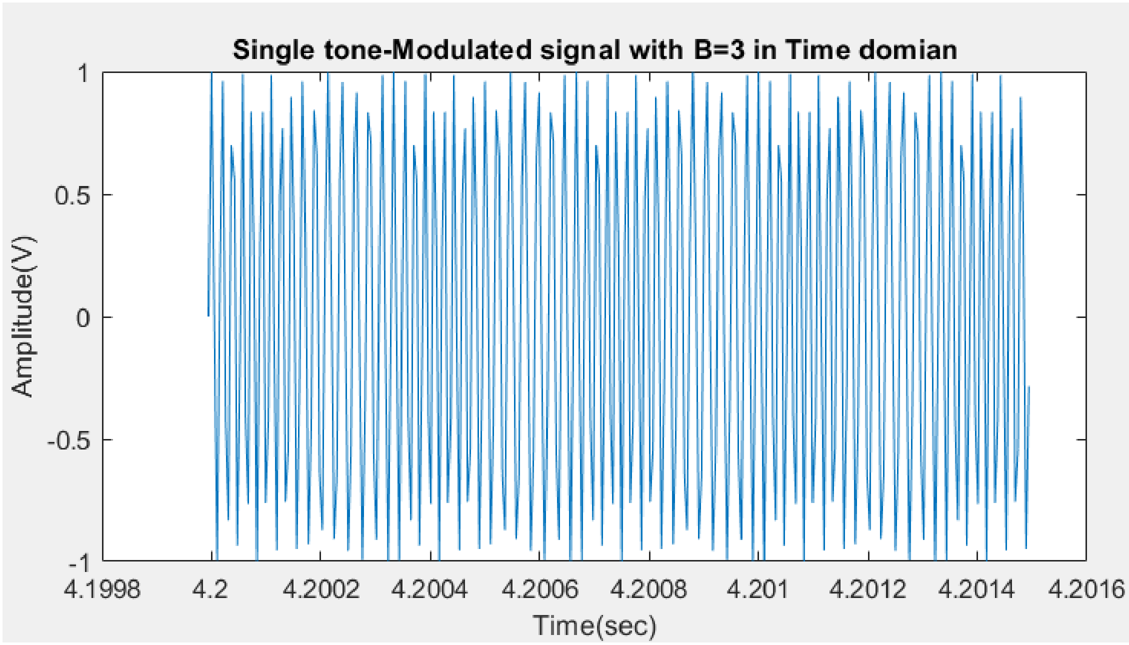

Figure 65:part of single-tone modulated signal with B=3 in time domain

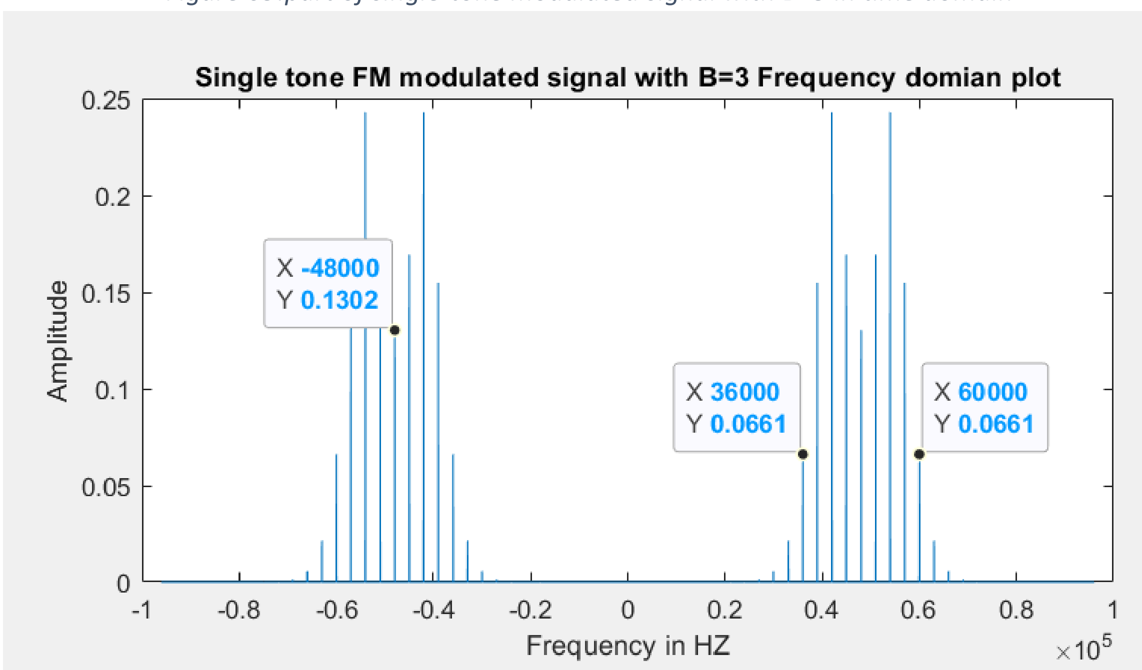

Figure 64:single-tone modulated signal with B=3 in frequency domain

Signal is modulated around carrier frequency with BT of 24KHZ of significant Bessel component (n=1+B=) which are 4 components. This agrees with Carson's law.

4. Single-tone FM Modulation with deviation ratio=5

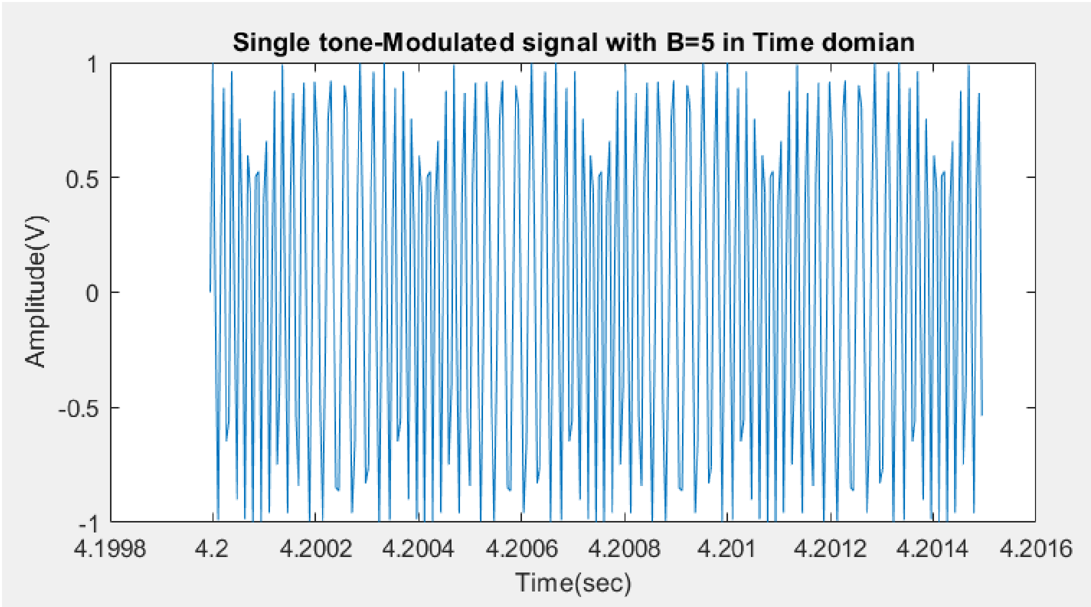

Figure 66:Part of single-tone modulated signal with B=5 in time domain

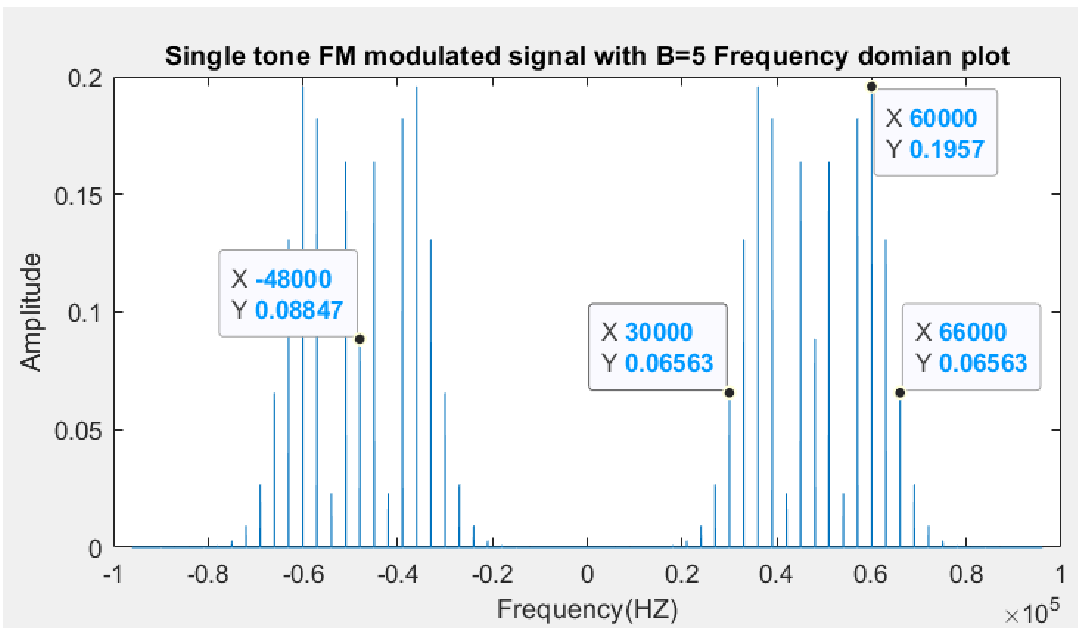

Figure 67:Single-tone modulated signal with B=5 in frequency domain

Signal is modulated around carrier frequency with BT of 36KHZ of significant Bessel component (n=1+B) which are 6 components. This agrees with Carson's law

- **Part Four**

1. **Experience different noise levels**

   Effect of white gaussian noise added increases at lower SNRi which means higher noise power which results unclear signal after demodulation, which appears in SNRo that decreases with increasing noise value getting lower quality signal.

$$SNR_0 = \frac{3A_c^2 k_f^2 P_m}{(2\pi)^2 2N_0 B^3}$$

   At higher deviation ratio with same SNRi (same noise) noise effect decreases which results with a higher SNRo that means clearer signal

$$SNR_0 = 3\left(\frac{\Delta f}{B}\right)^2 \frac{P_m}{m_p^2} \cdot SNR_0]_{Baseband}$$

$$= 3\beta^2 \frac{P_m}{m_p^2} SNR_0]_{Baseband}$$

2. **Threshold effect**

   Occurred at deviation ratio =1 and SNRbb=25 db where SNRo=15.671 db which is smaller than SNRth which is 16.0206.