Experiment 4

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1 Aim of the experiment

To familiarise with the concept of spectral leakage and windowing.

2 Results/Graphs

2.1 Question 1

$x_a = 0.1\sin(30\pi t) + \cos(36\pi t) + 0.5\sin(14\pi t)$. The plots for this signal (discrete) are shown below. Sampling frequency = 100.

Code : task1.m

a) Graph

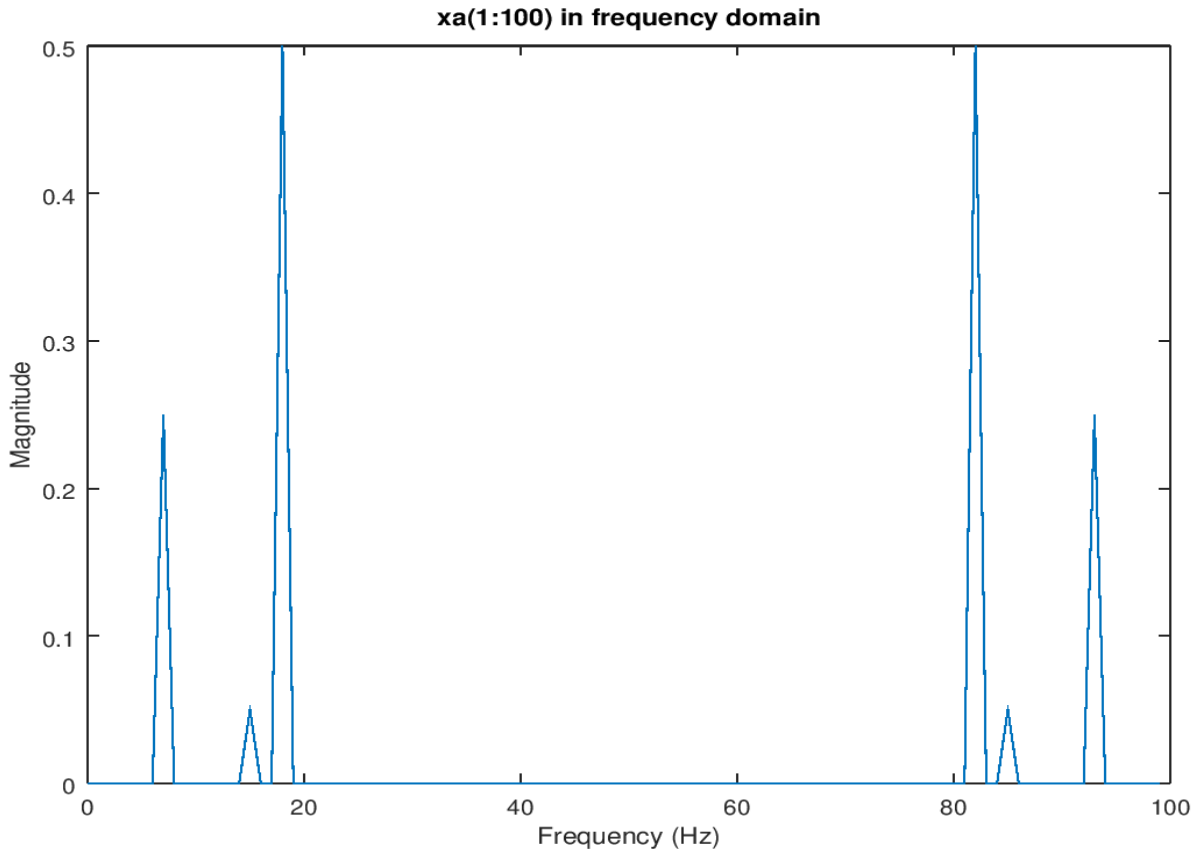

Figure 1: 100 samples FFT

b) Graph

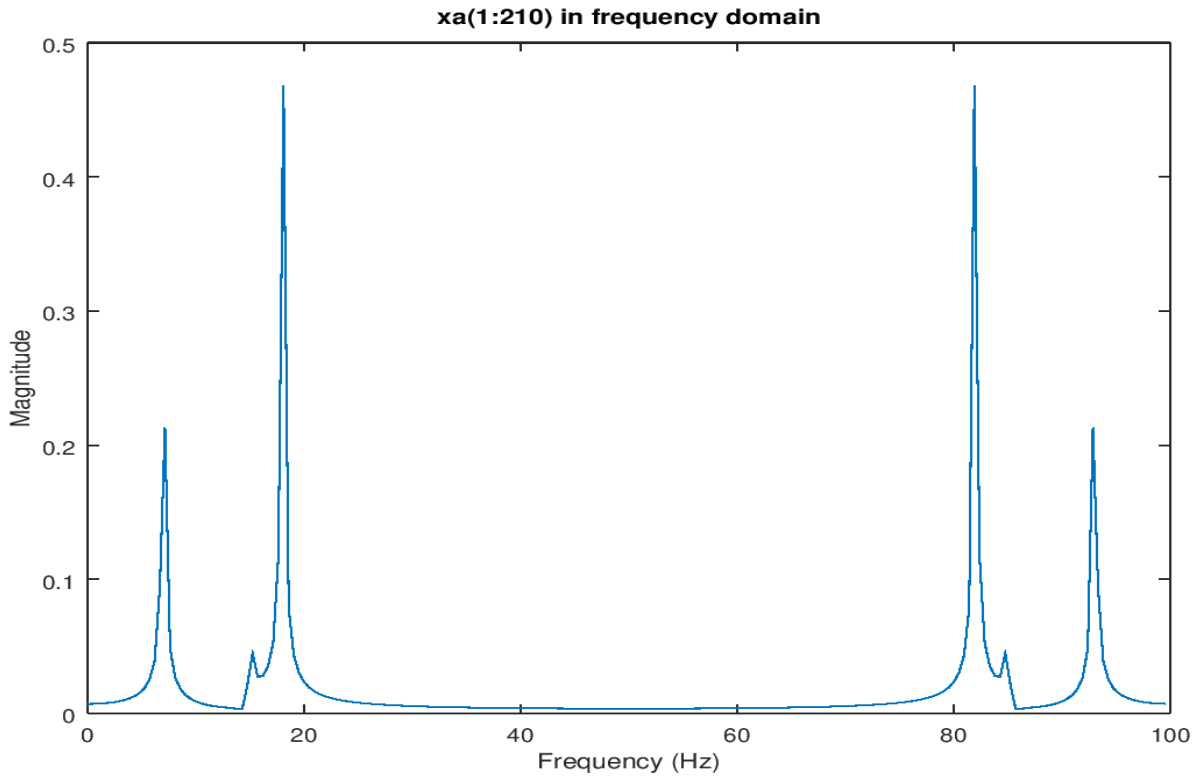

Figure 2: 210 samples FFT

Observations

- In xa(t) the three frequencies observed are 7, 15 and 18Hz with a sampling frequency of 100 samples/sec. So since F/Fs = k/N, the periodicity of the three components in xa(t) are 100, 20 and 50 whose LCM is 100.
- When we perform FFT on 100 samples the spectrum is more specific and shows the peaks at the right frequencies. When we take 210 samples which isn't a multiple of 100 the frequency spectrum gets distorted slightly and the peaks shift away and extra lobes are seen. This is called spectral leakage. Other frequency components are seen in the spectrum which actually dont exist.

Conclusion

- In this experiment spectral leakage is observed when 210 samples are considered and same is studied.
- To avoid spectral leakage we need to take samples in the multiples of the periodicity.

2.2 Question 2

Hamming window is applied to the signal xa(n) with 210 samples and the following graphs are obtained.

Code : task2.m

a) Graph

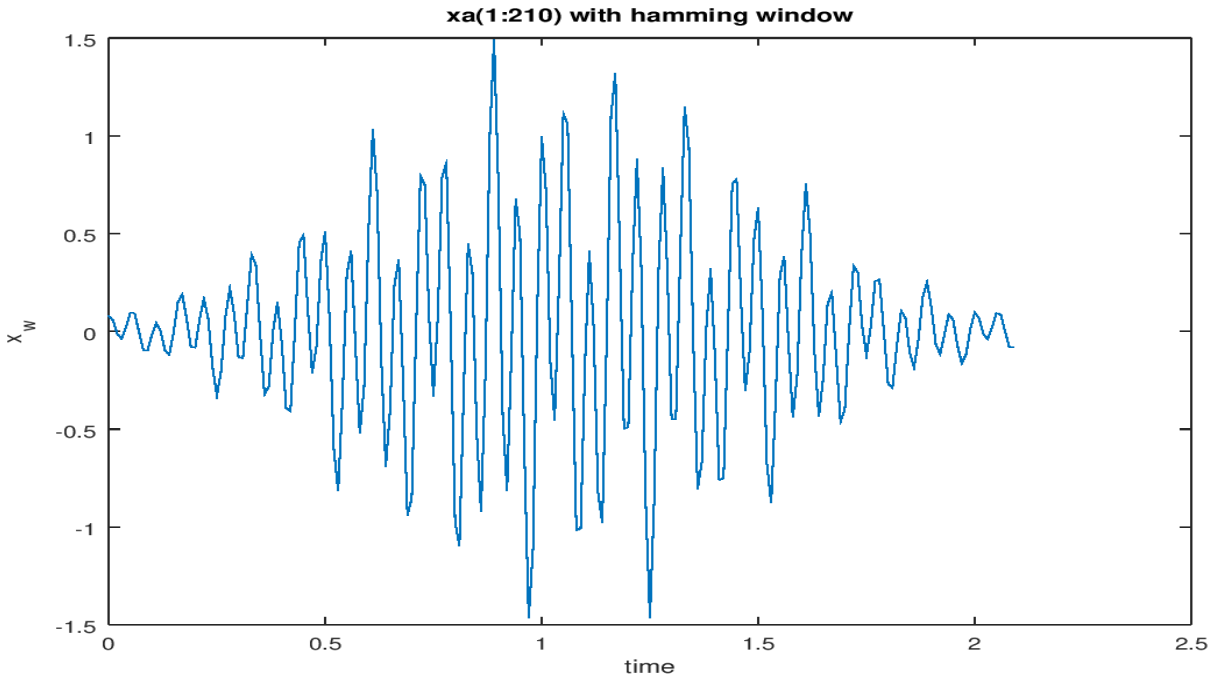

Figure 3: Signal after Hamming window is applied

b) Graph

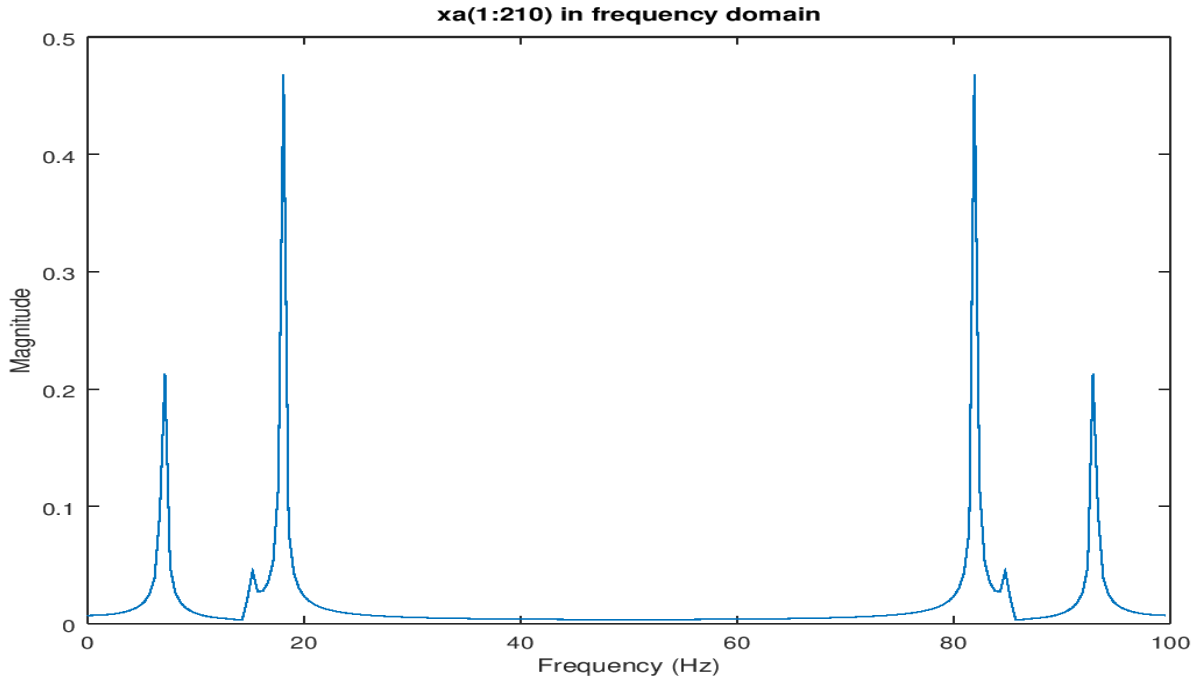

Figure 4: The frequency domain plot after hamming window is applied

Observations

- The FFT obtained looks smoother without leakage when compared to the graph without the windowing. The Windowing helps to minimize the transition edges of the sampled waveform. Applying the hamming window helps in smoothing out the edges on the sequence. This helps in getting a better frequency spectrum.
- In Hamming Window technique more weightage is given to the middle components. Its basically multiplying with a sinc function which multiplies the unwanted samples with zero in a way removing those frequencies.

Conclusion

- Windowing helps to minimise the transition edges of the sample waveform.
- Windowing reduces the amplitude of the signal since the window's maximum value is 1 and ¡1 elsewhere.

2.3 Question 3

Code : task3.m

a) Graph

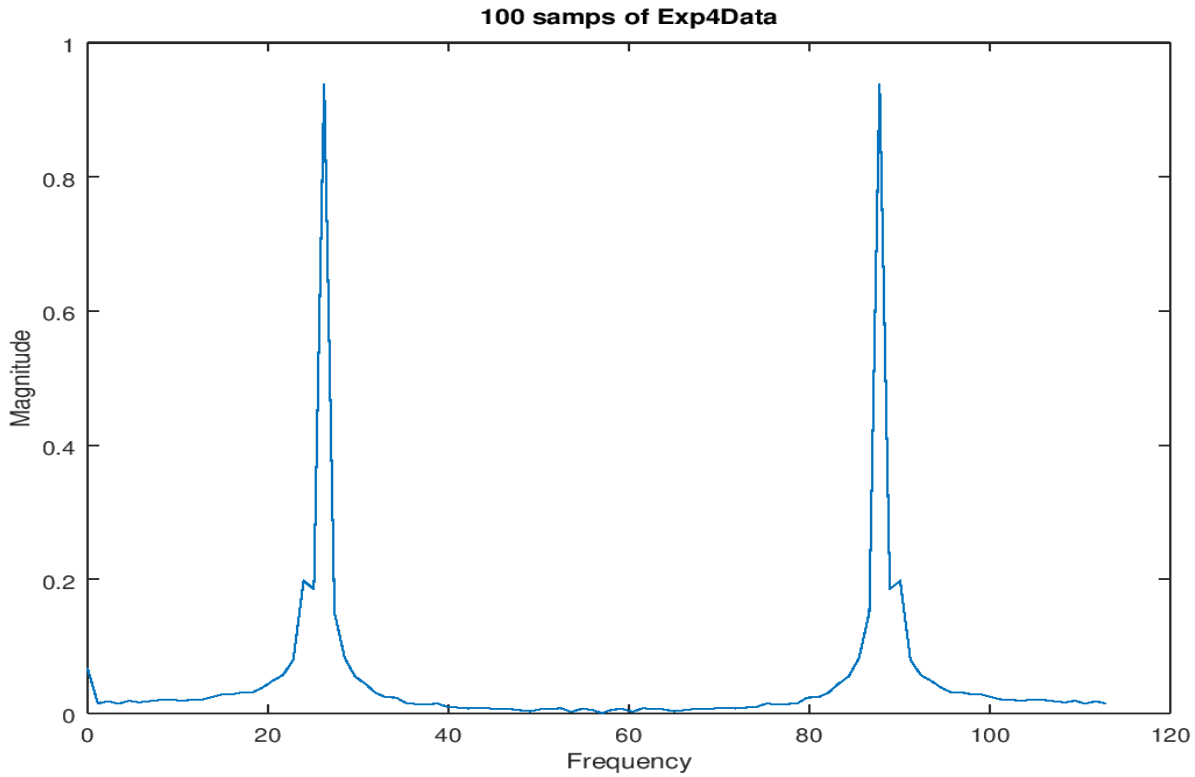

Figure 5: 100 samples FFT

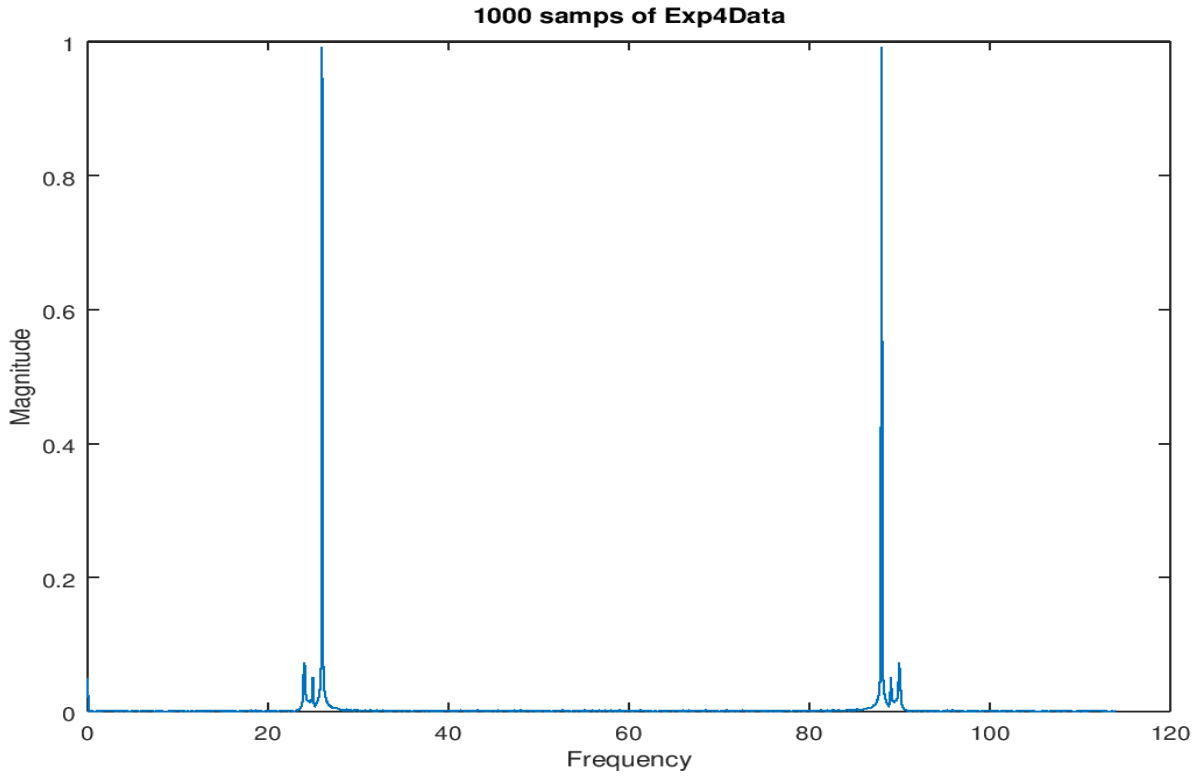

Figure 6: 1000 samples FFT

b) Graph

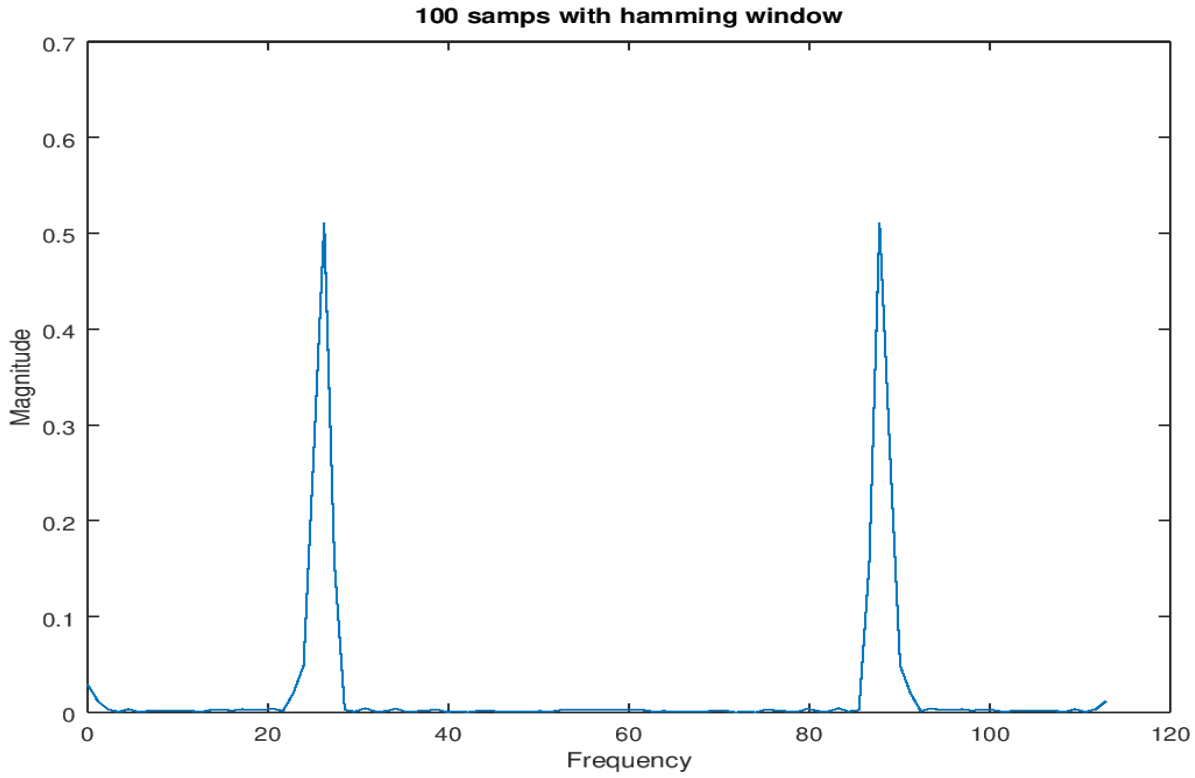

Figure 7: 100 samples FFT after applying hamming window

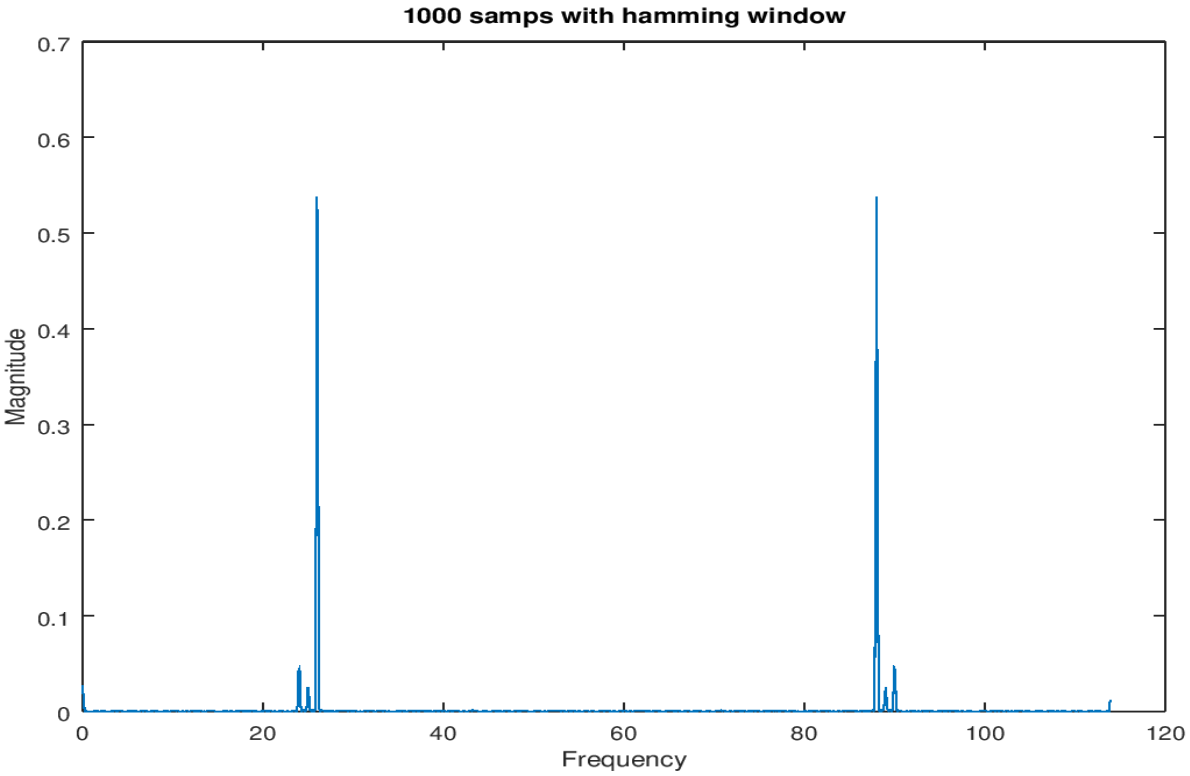

Figure 8: 1000 samples FFT after applying hamming window

Observations

- As seen in the graphs, FFT on a windowed sequence is more specific in frequency and the peaks are sharper and localized at certain points. The FFT of the non-windowed sequence has extra lobes and is distributed over a larger area. The windowed FFT gives a clearer idea of the frequency components present in the signal.
- More number of samples leads to better frequency resolution. Its sharp and similar to an impulse at the frequencies present in the signal.

Conclusion

- The frequency observed is 25 Hz.
- The peaks appeared sharp in windowed fft of 1000 samples.
- Windowing sequence helps in getting a clearer FFT of the signal by smoothing out the transition edges of the sampled waveform.
- More number of samples leads to better frequency resolution of the signal