QUES 4)

UNDERSTANDING THE PRACTICAL USE OF Z-TRANSFORMS.

- The practical use of z transforms is that we can make a different type of system by just varying its poles and zeros in the z domain.
- These changes affect the relationship between the input and output in the discrete-time domain and this can be easily computed in a computer. Thus proving the essence of DSP.
- For example, I implemented a low pass filter, which lowers the amplitude of high-frequency waveforms while barely affecting the low-frequency components.
- I came up with the filter's frequency response in the z domain just by knowing its zeros and poles.
- Here if we consider the normalized frequency which ranges between $[0, \pi]$ in the circular domain.
- Here 0 refers to the low-frequency components while π referring to high-frequency ones.
- Let z be the point moving along the unit circle $|z| = 1$, where frequency refer to the angle of a point .

- So we need to lower the strength of the components as we approach π i.e z = -1. Therefore z =-1 is the zero of the impulse response of the filter.
- While z = 0 can be the pole of it, since it does not contribute to the amplitude of the transfer function as the distance between the moving point and origin is always unity.
- Therefore the impulse response is $H(z) = (z+1) \div 2z$
- This gives us the relation of y[n] = (x[n] + x[n-1])/2
  Which is nothing but a moving average operation.
  The amplitude of the impulse is nothing but the euclidean distance between z on the unit circle and the poles and the zeros.

❖ AN INTUITIVE EXPLANATION OF WHY DOES A MOVING AVERAGE SYSTEM WOULD WORK?

ANS : let us take x[n] = [1,100,1,100,...]
This can be decomposed into [50,50,50,50...] ***(low freq component***)+[-49,50,-49,50...] ***(high freq component***) since its changing more frequently.
If we apply a moving average operation to it.
We see low freq = [50,50,50,50]

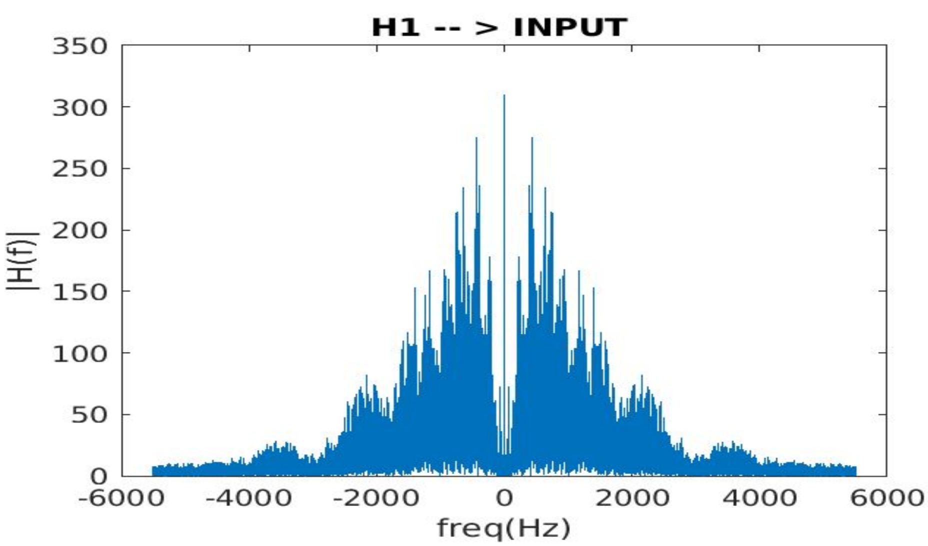
But high freq = [0.5,0.5,0.5,0.5]components are reduced in magnitude and now are barely changing .
Thus we can see that the moving average operation lowers the magnitude of the high-frequency components.

- ❖ **SIMULATION RESULTS :**

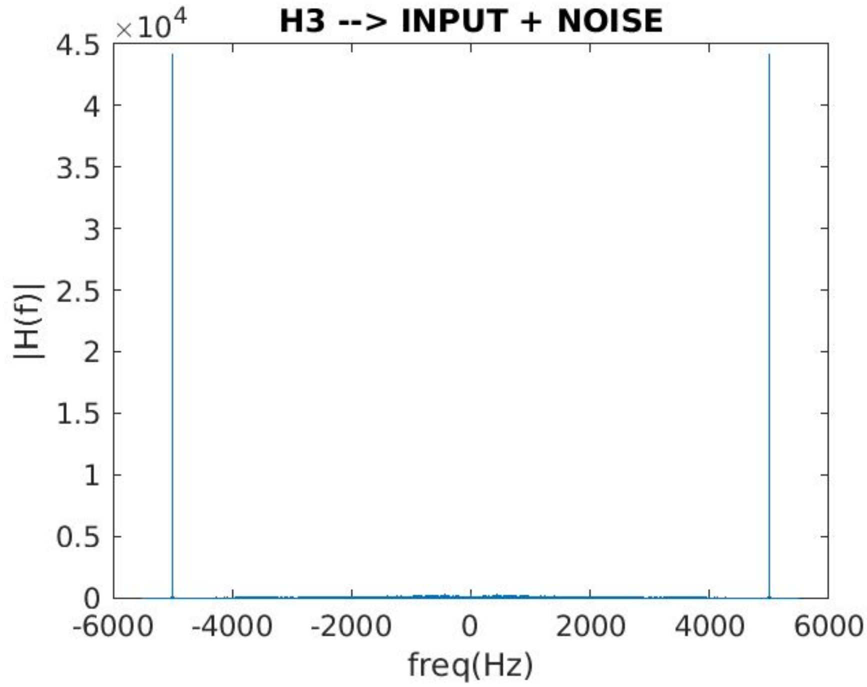
  I took a .wav file (sampled at Fs = 11025 Hz) from the internet, added a sinusoid noise $cos(2 * pi * 5000 * t)$ and tried to pass it through the moving average system and the notch filter. The below are the results .

- ➢ For notch filter :

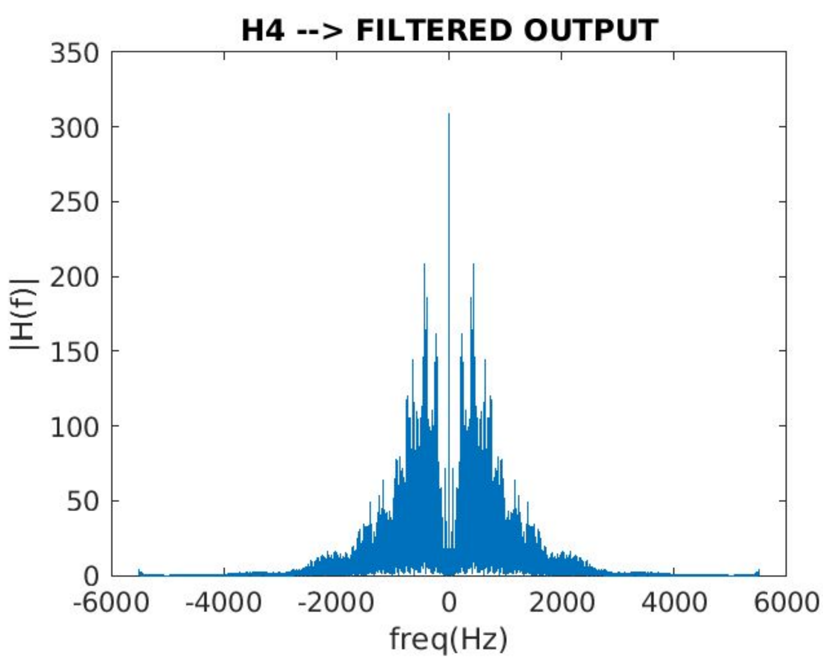
  1) Input frequency spectrum.



2) Input + noise frequency spectrum



Filtered outputs frequency spectrum.

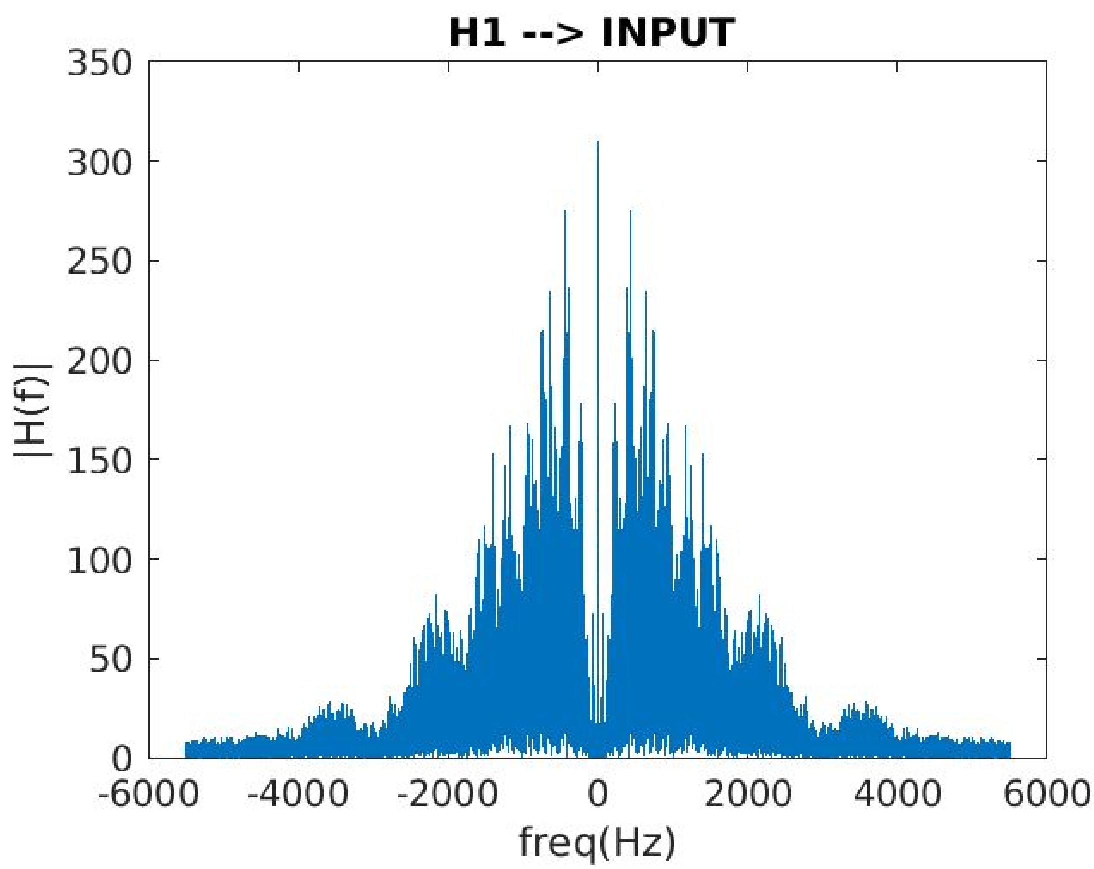


OBSERVATIONS :

We can see that when we use the notch filter we could remove the added noise at 5000Hz completely. We can observe the spike at 5000Hz in the input + noise fft completely vanish when passed through the filter.

- For Moving Average System :

1) Input frequency spectrum.



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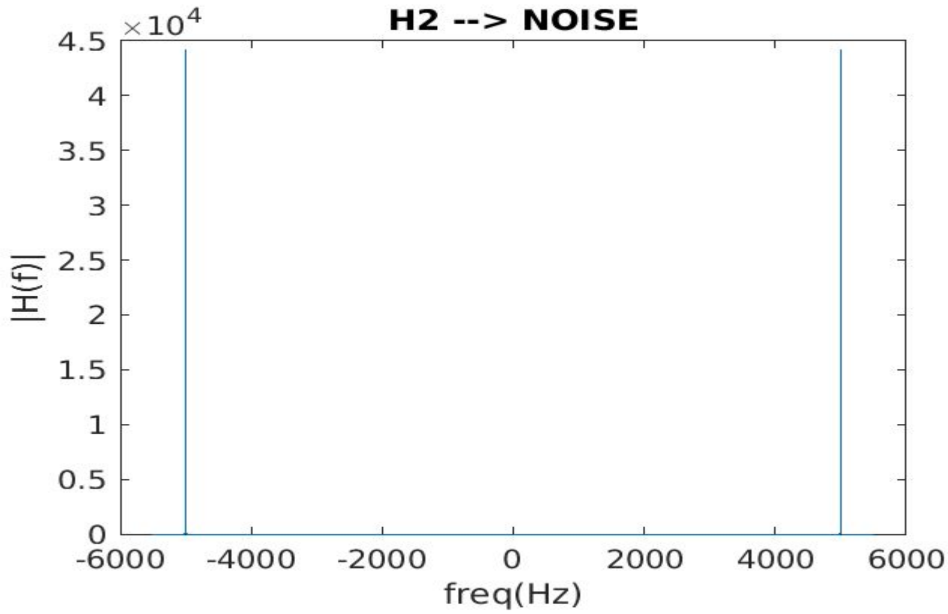
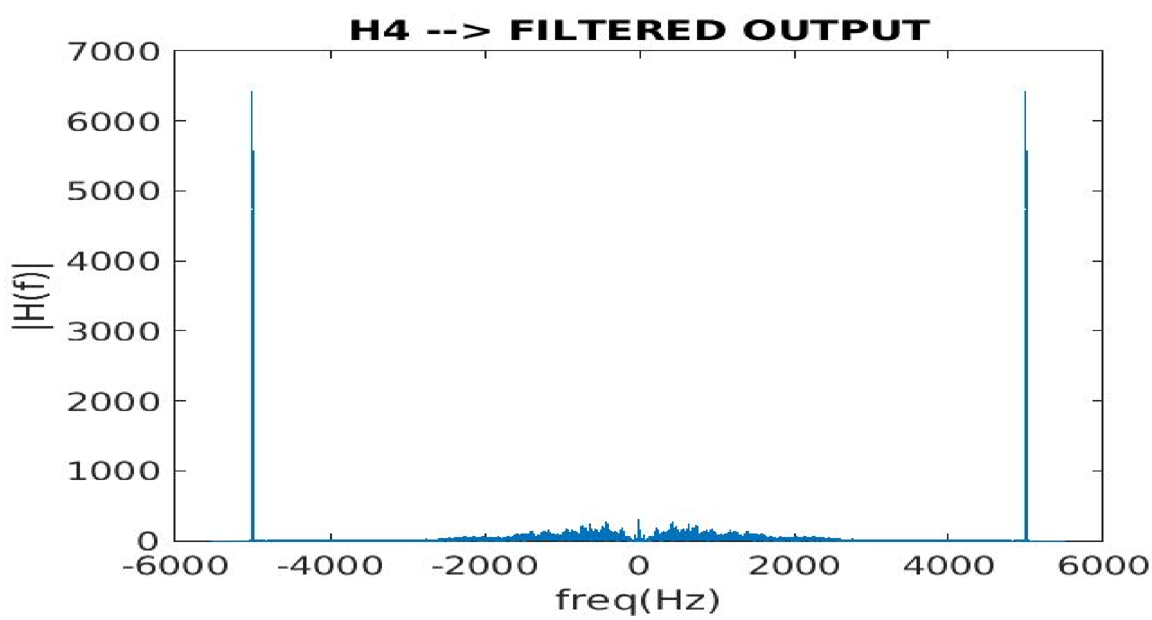
2) With input + noise (The input spectrum is not visible due to high magnitude of sinusoids fft)

➢ 

➢ 3) Output after applying the moving avereage operation over discrete time domain.



OBSERVATIONS :

Although the operation did not completely wipe out the noise, it lowered the amplitude of the noise from 450000 to 7000 which is great filtering in terms of frequency.