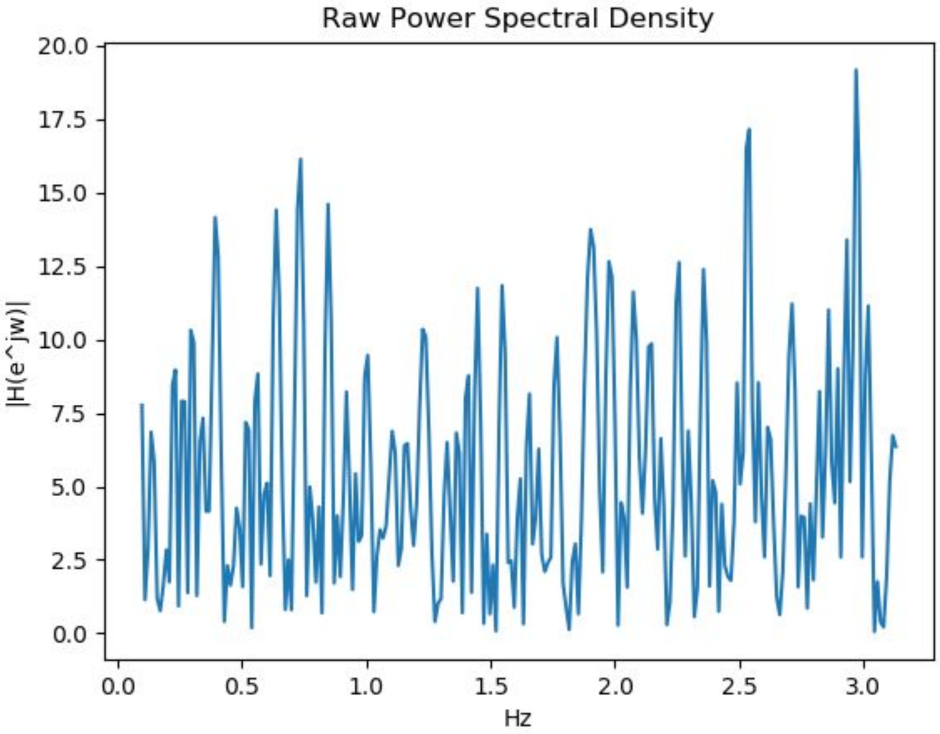
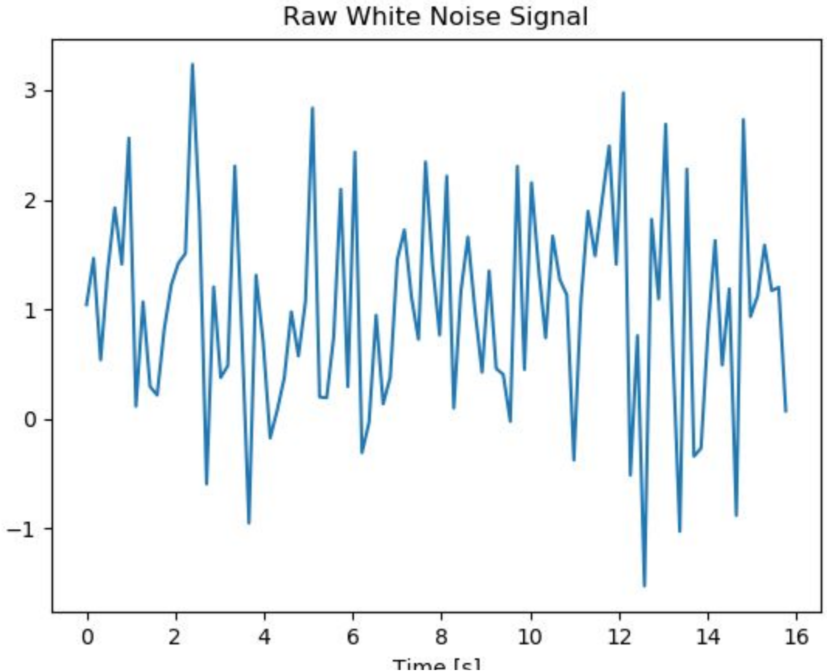
Non-negative FIR Filter Design

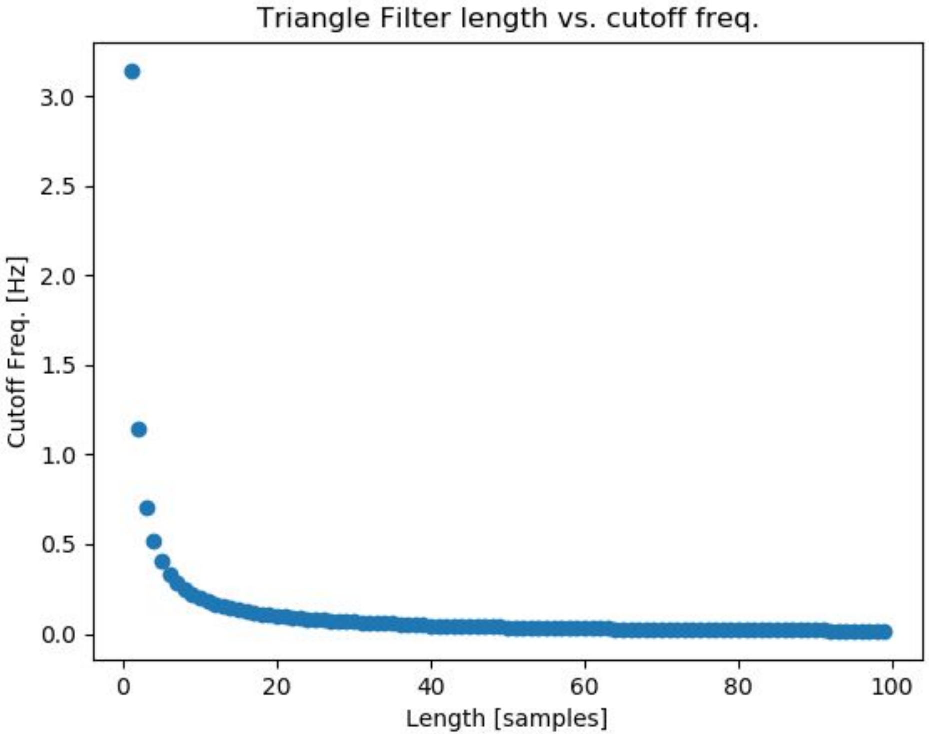
Philippe Proctor

White Noise and PSD

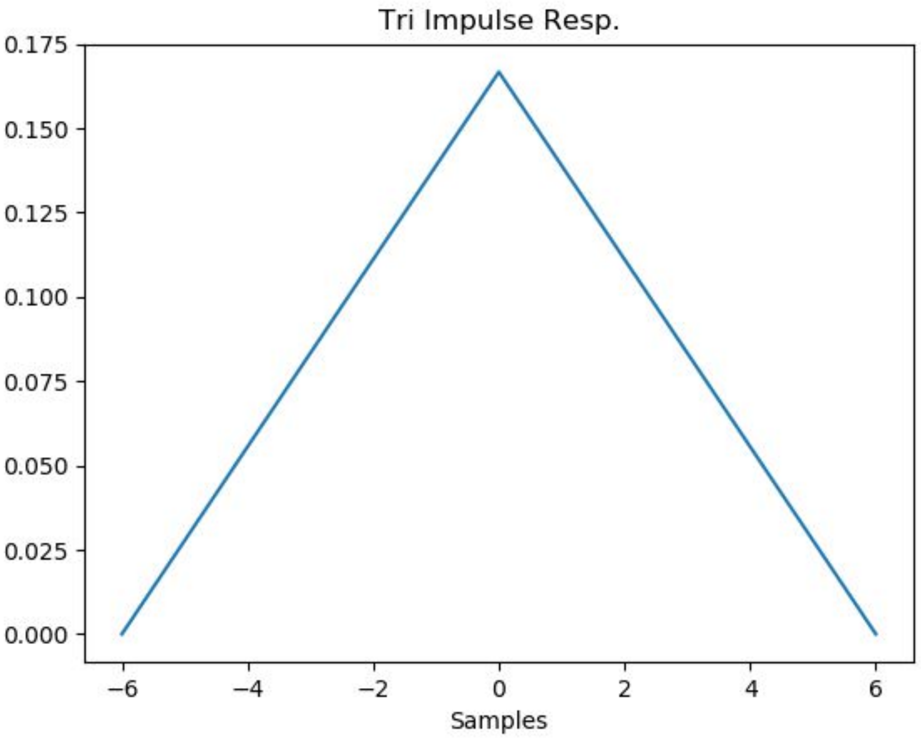


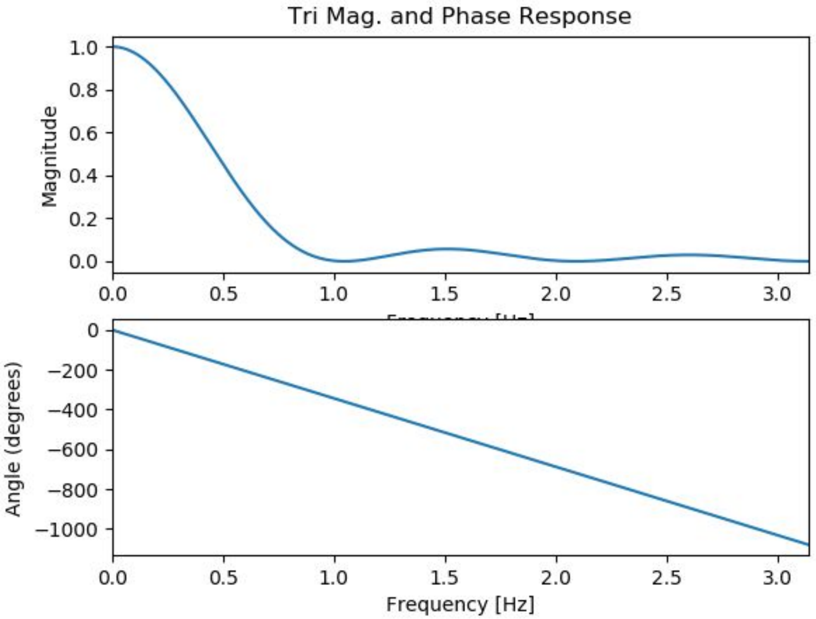


Filter #1 Triangle Filter

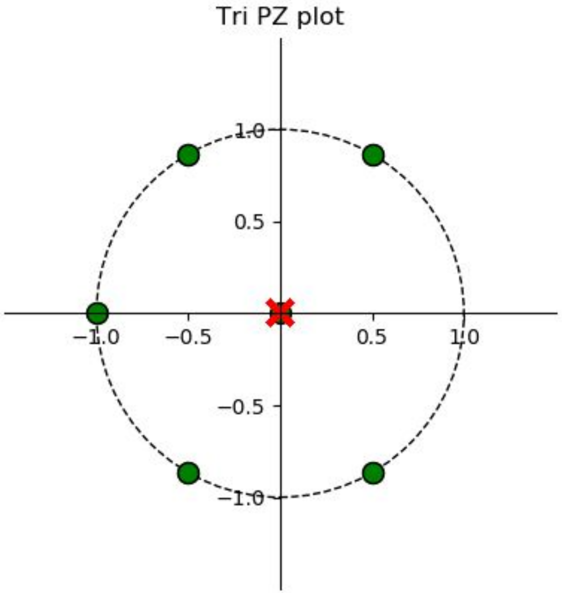


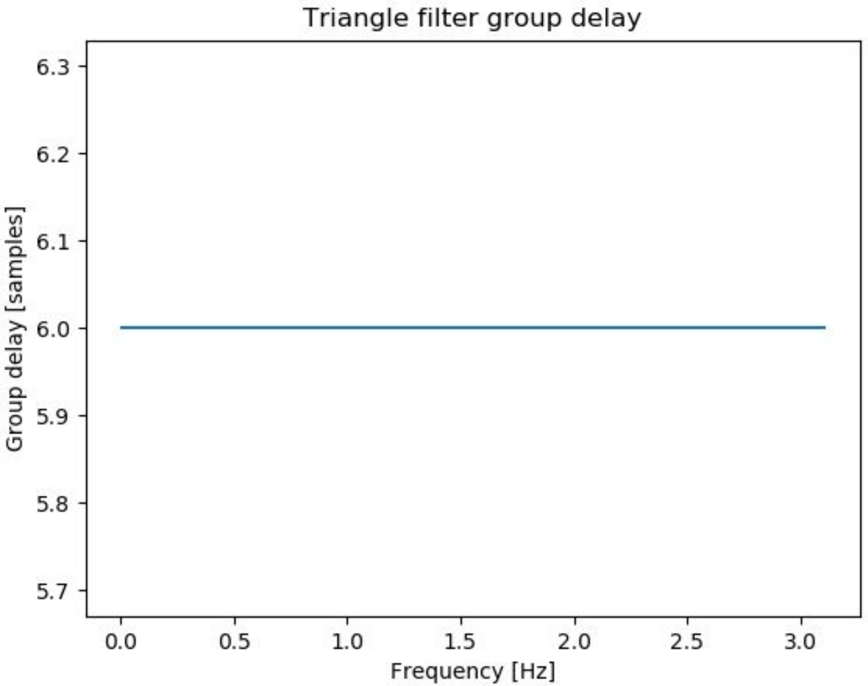
Filter #1 Triangle Filter(.1π cutoff)



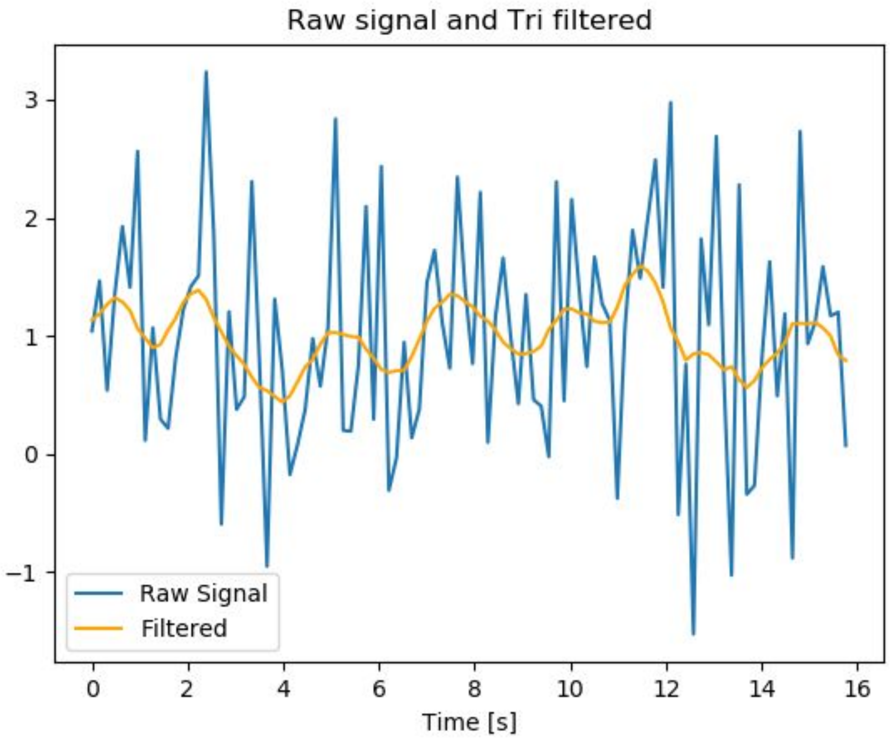


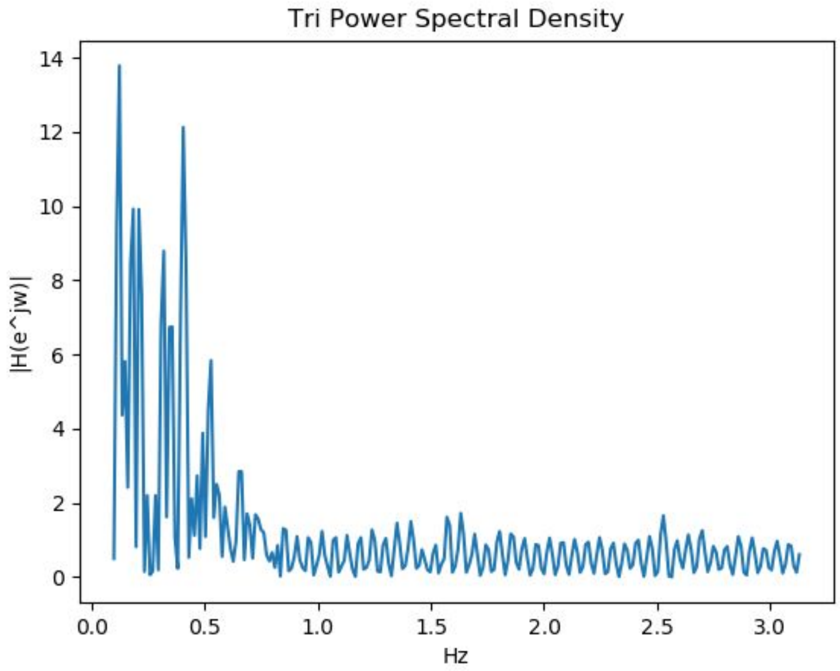
Filter #1 Triangle Filter(.1π cutoff)



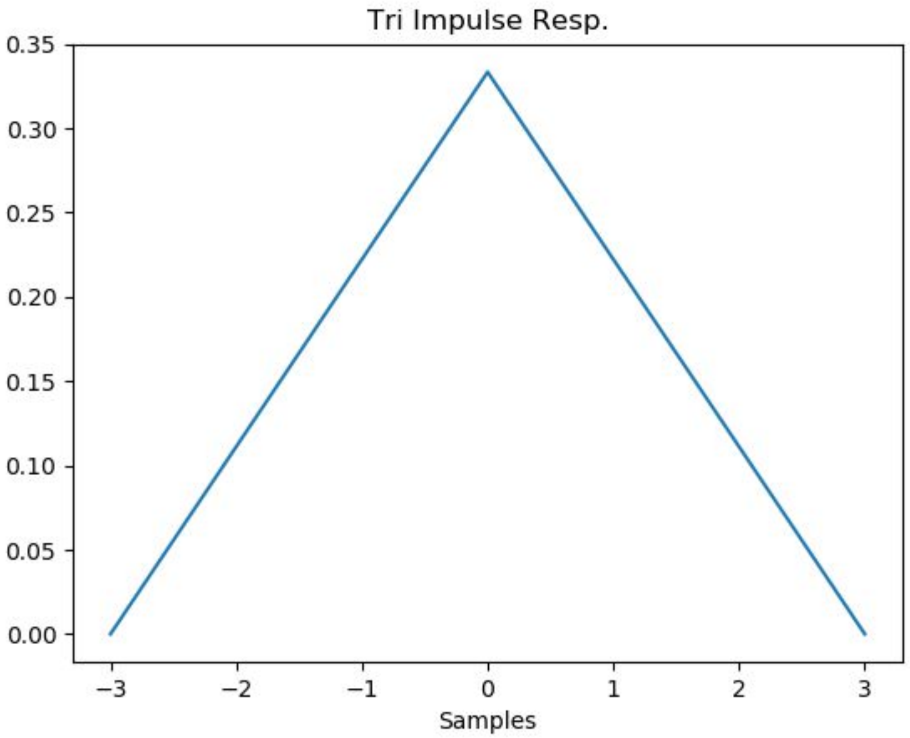


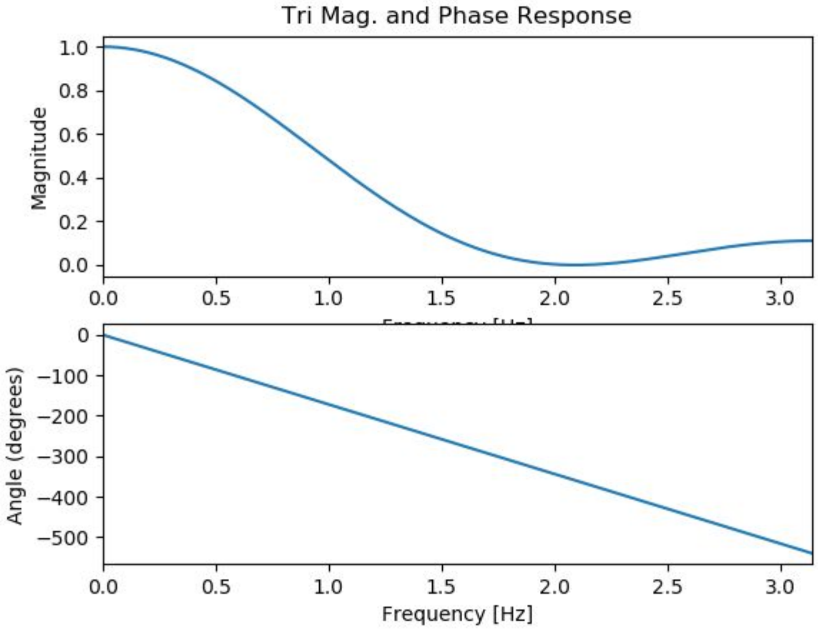
Filter #1 Triangle Filter(.1**π** cutoff)



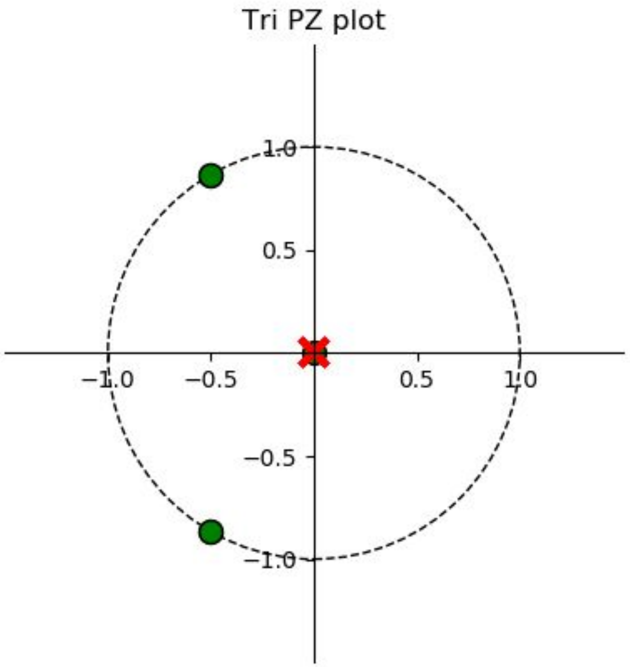


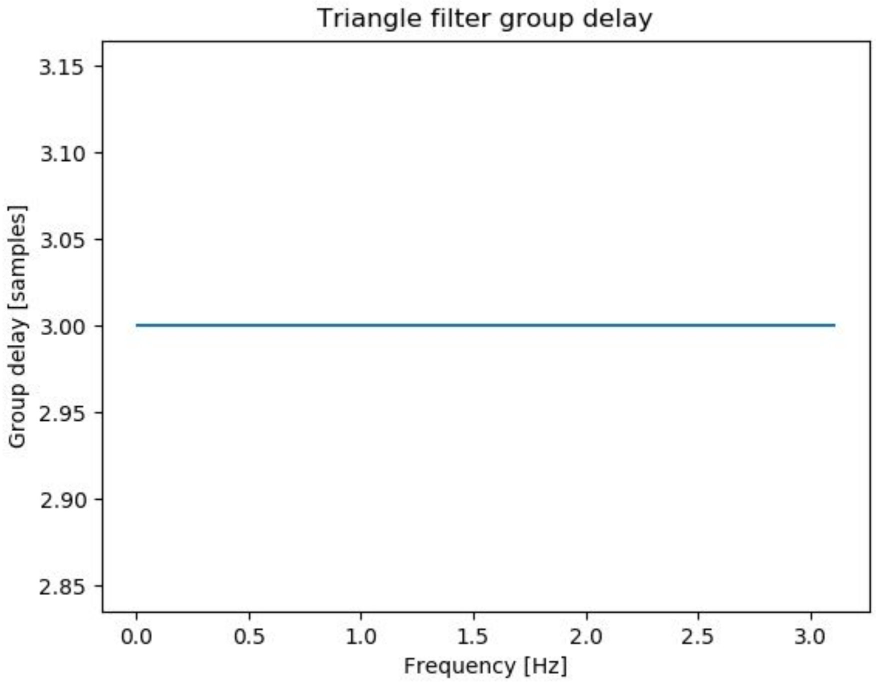
Filter #1 Triangle Filter(.2π cutoff)



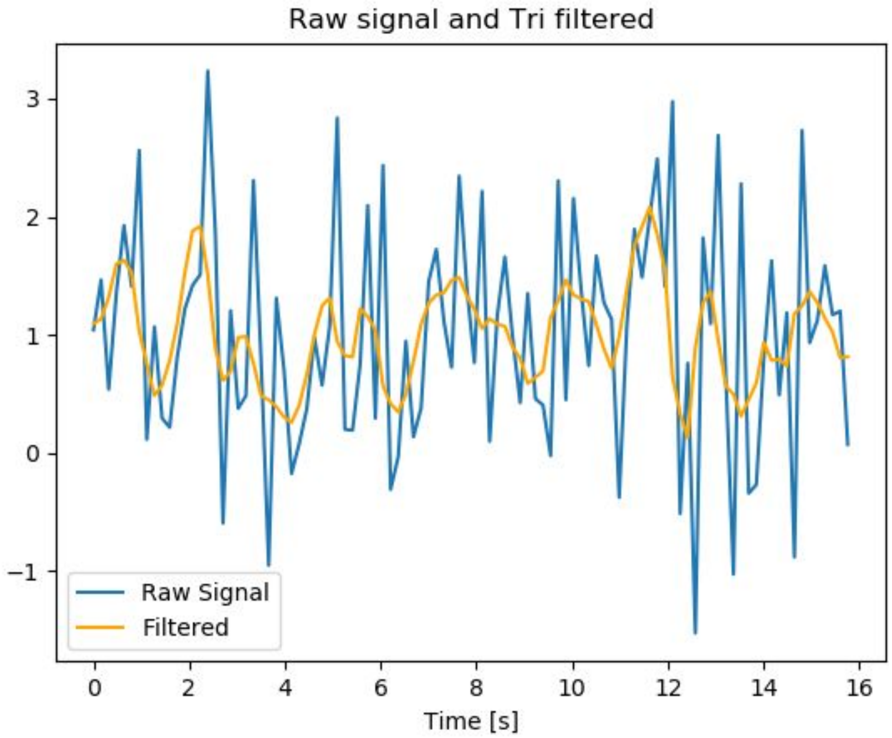


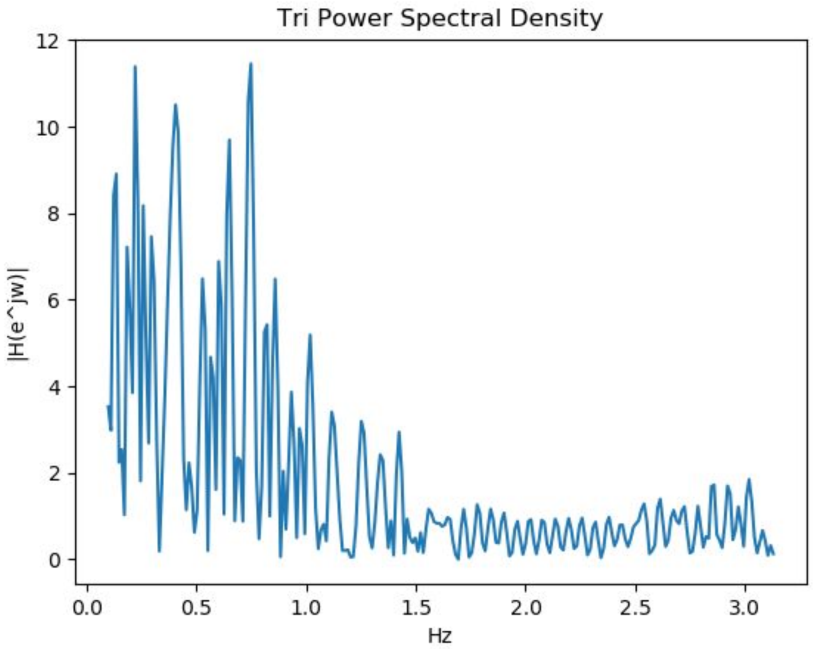
Filter #1 Triangle Filter(.2π cutoff)



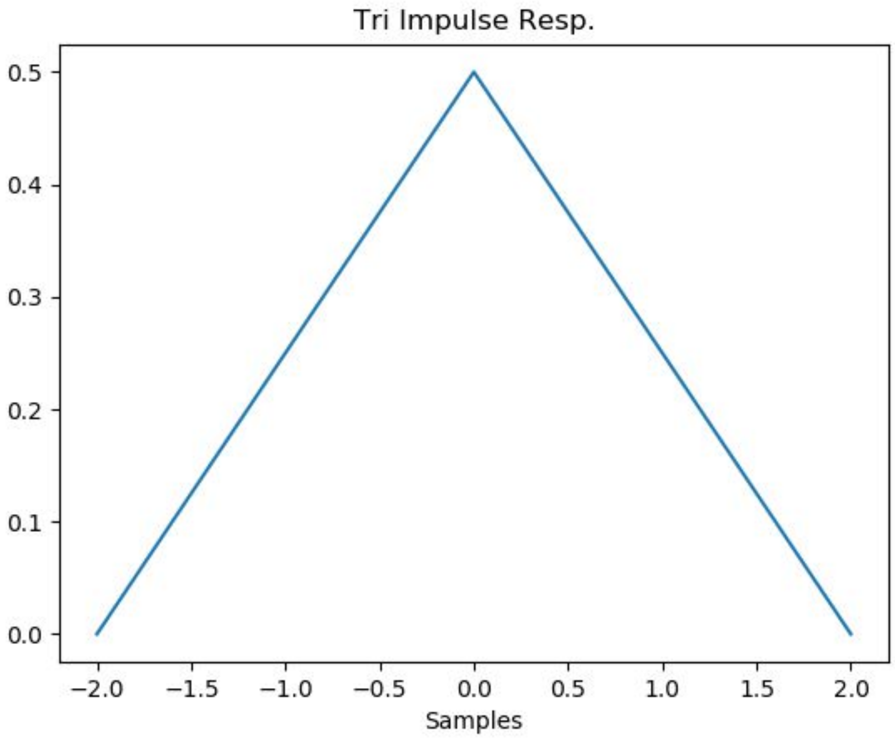


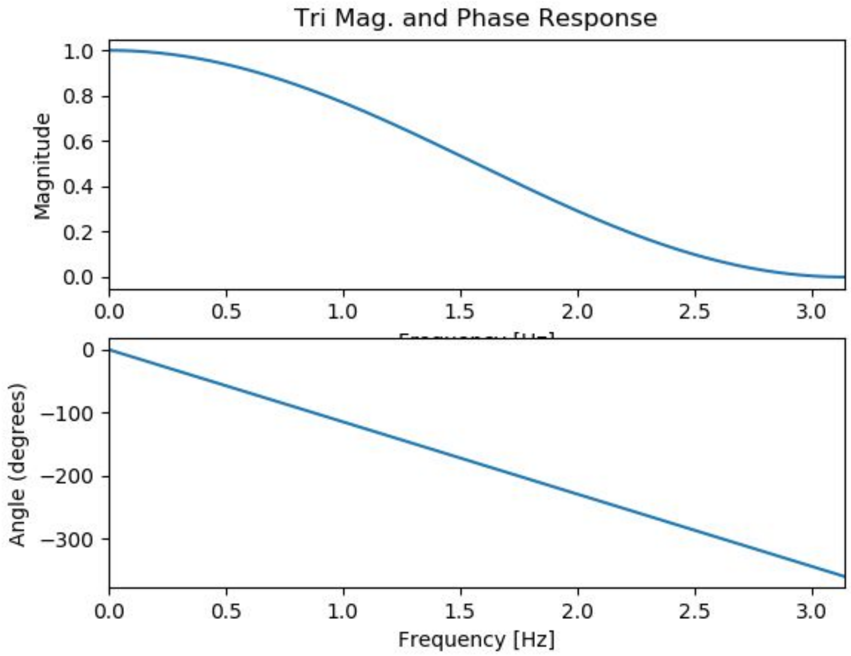
Filter #1 Triangle Filter(.2π cutoff)



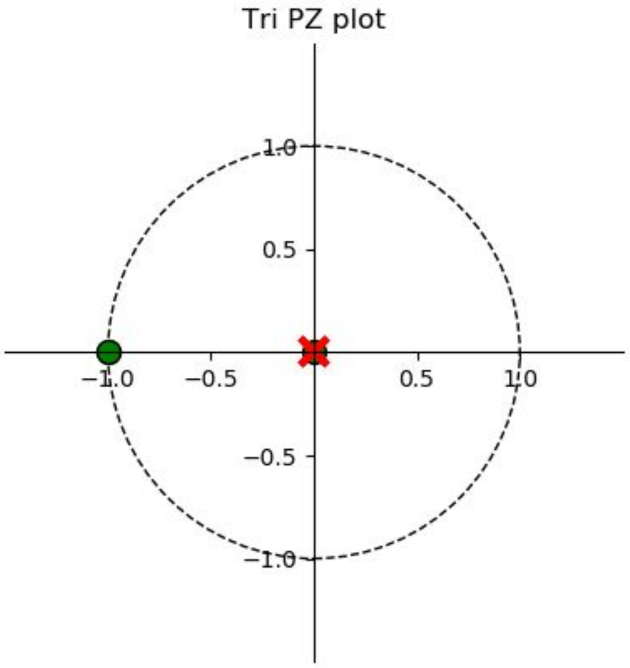


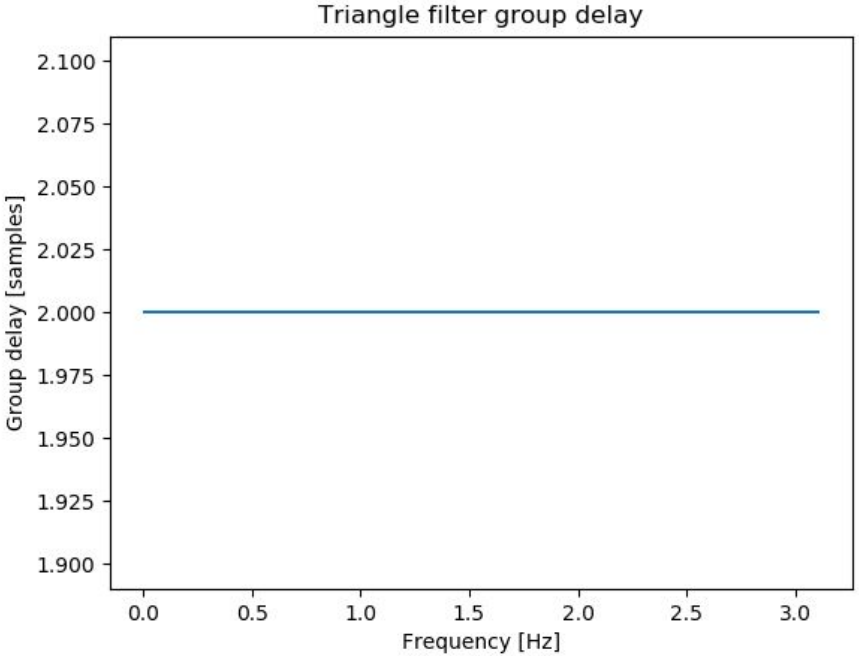
Filter #1 Triangle Filter(.3π cutoff)





Filter #1 Triangle Filter(.3π cutoff)

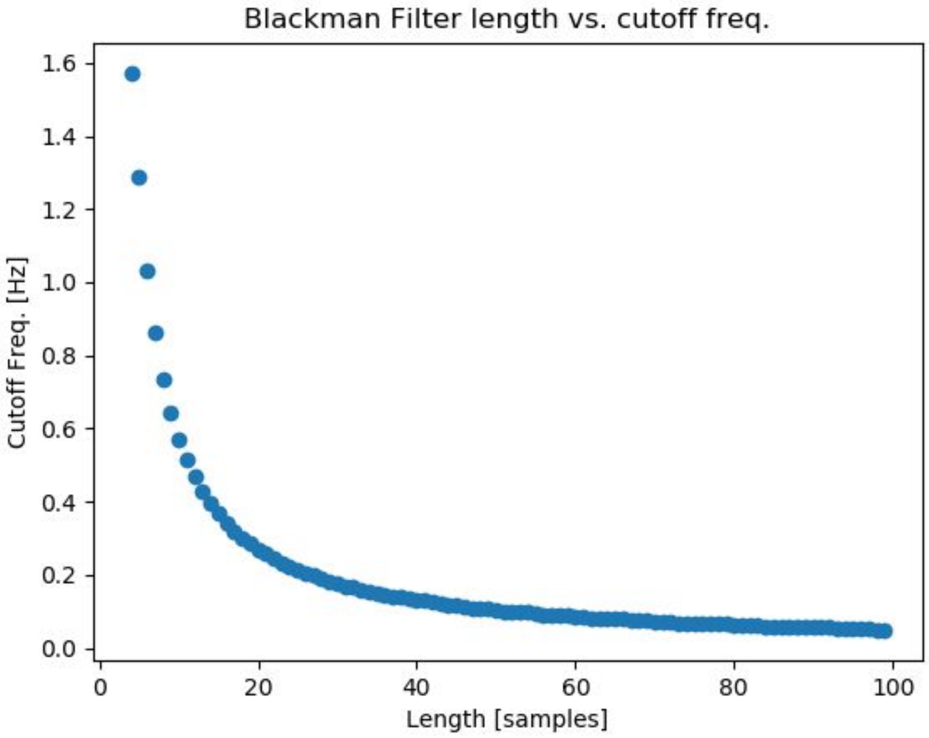




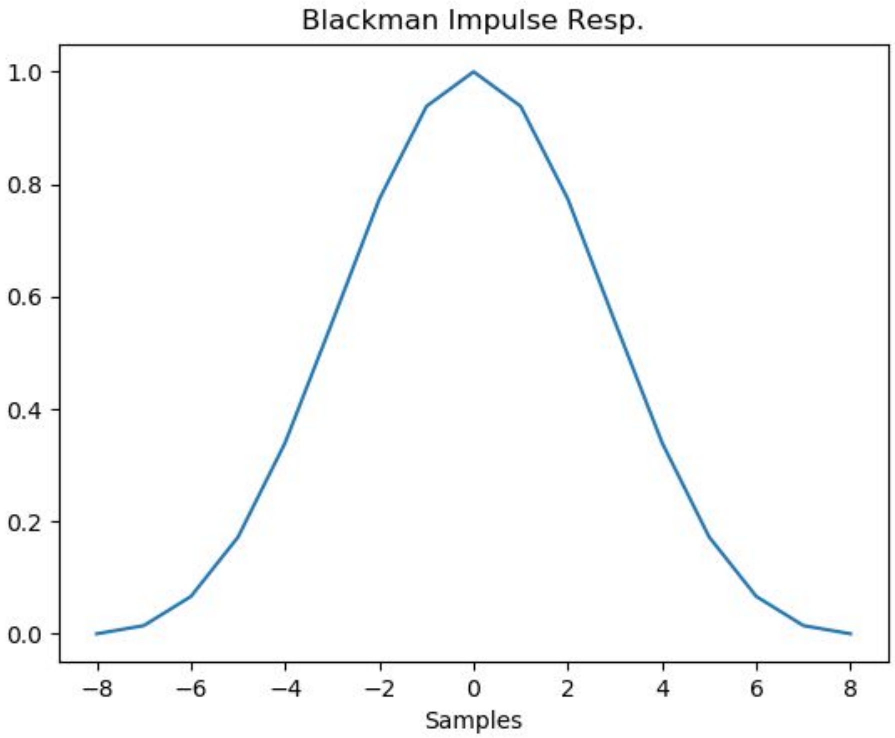
Triangle Filter explanation

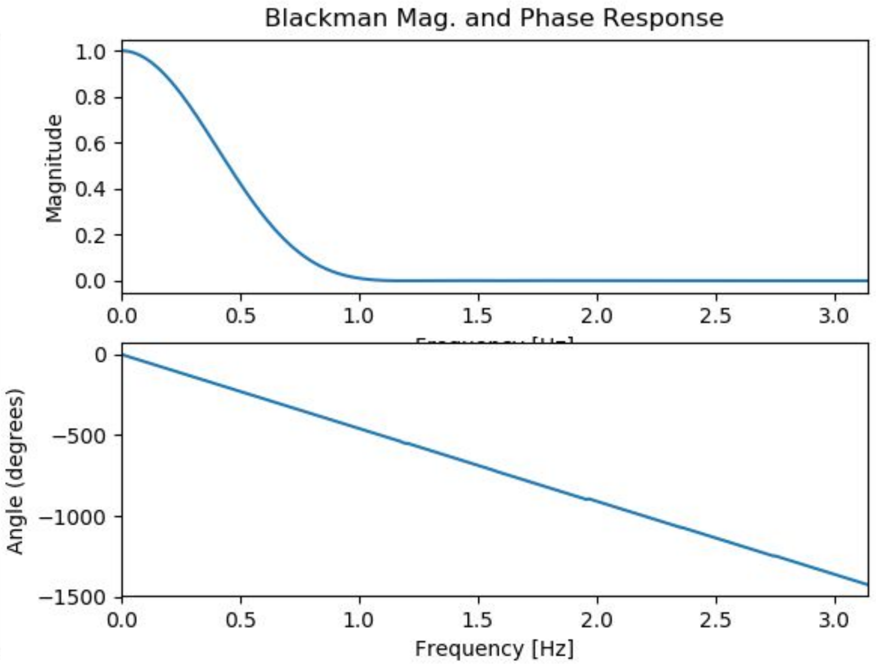
- b[n] = 1 - |n| if |n| < 1, 0 otherwise
- Fits the noncausal, symmetric, and positive
- Numerator coefficients were normalized by sum of the numerator coefficients

Filter #2 Blackman Filter

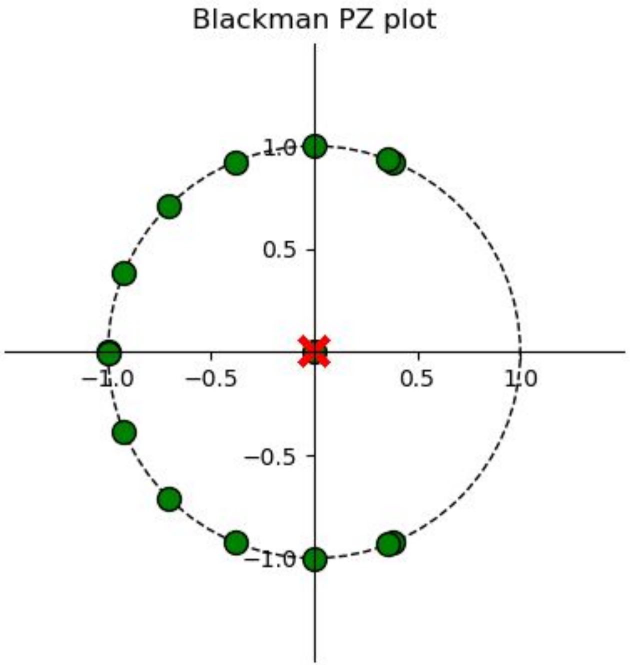


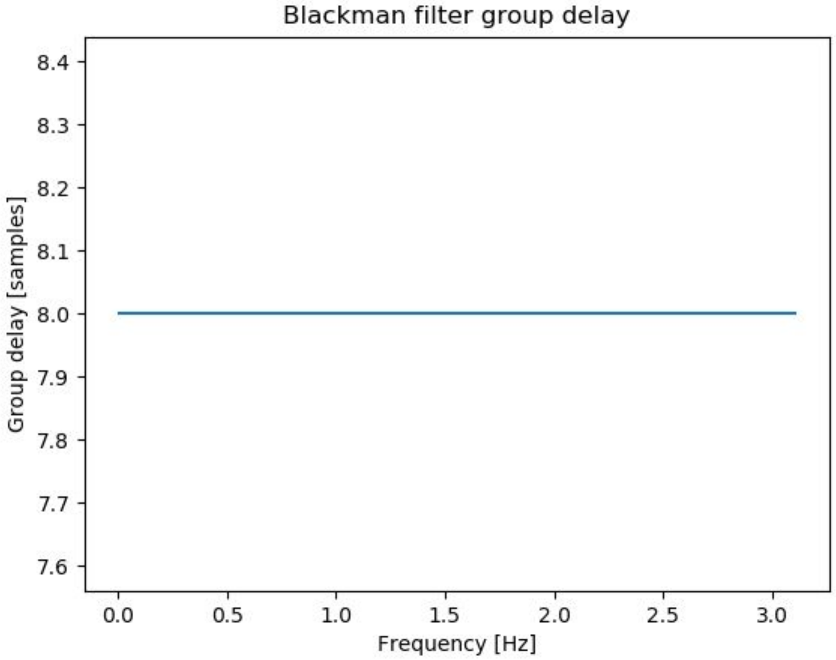
Filter #2 Blackman Filter(.1π cutoff)



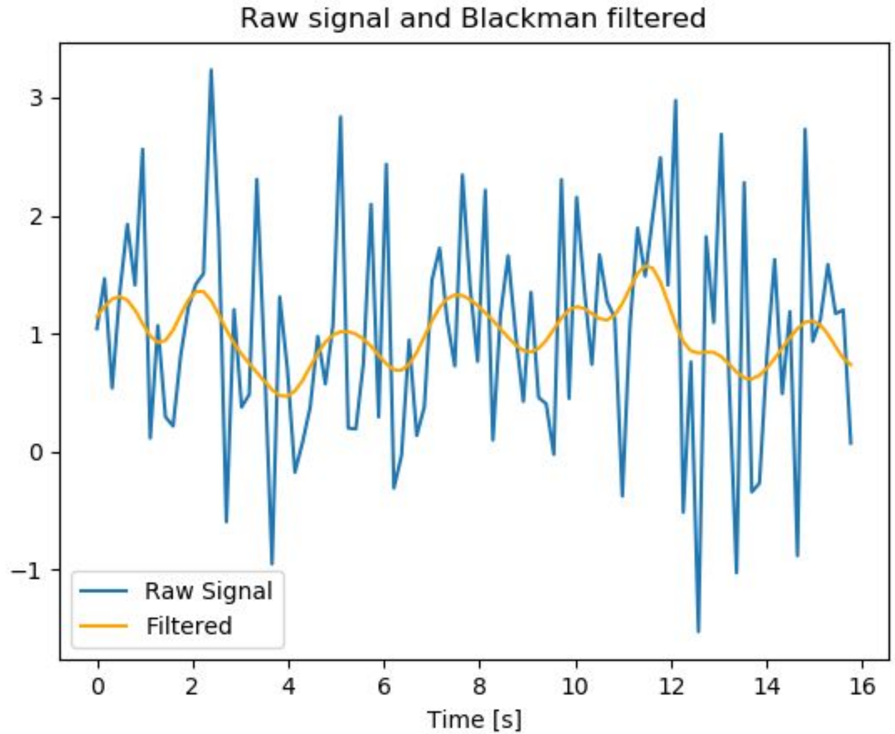


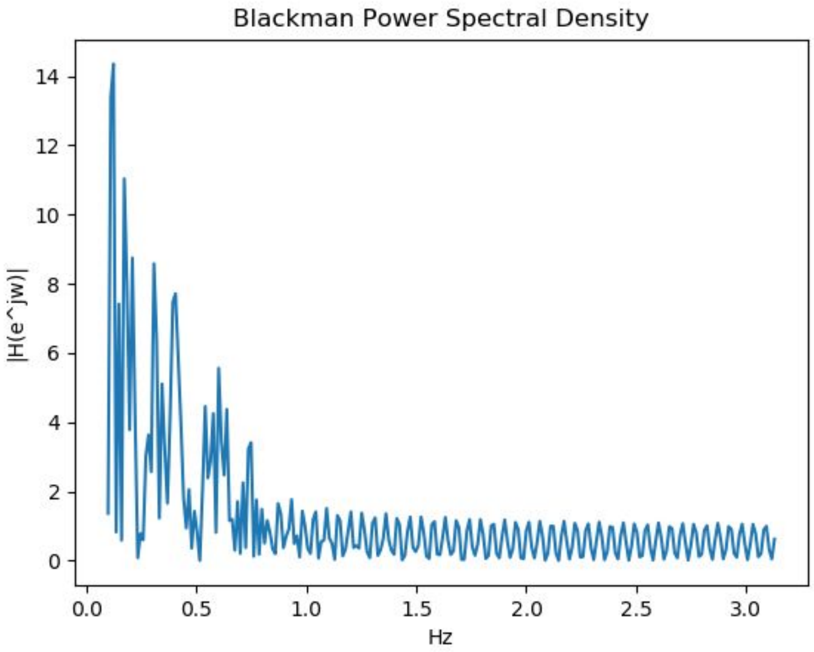
Filter #2 Blackman Filter(.1π cutoff)



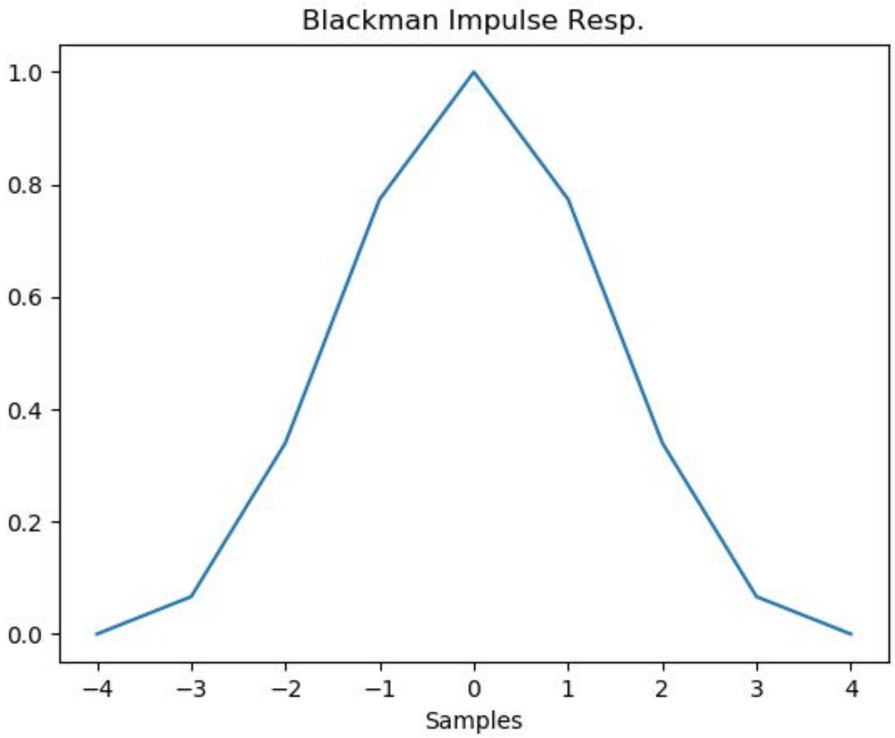


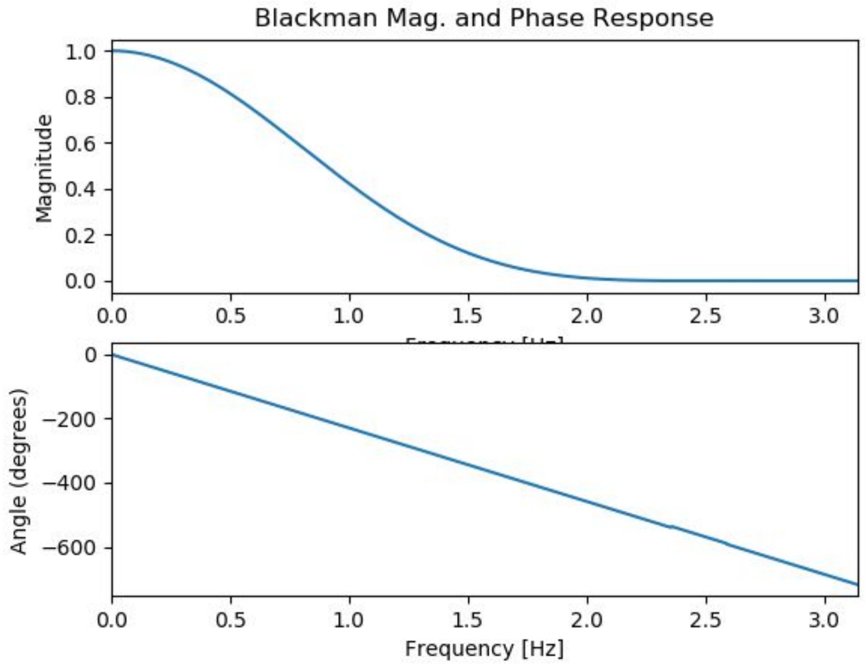
Filter #2 Blackman Filter(.1π cutoff)



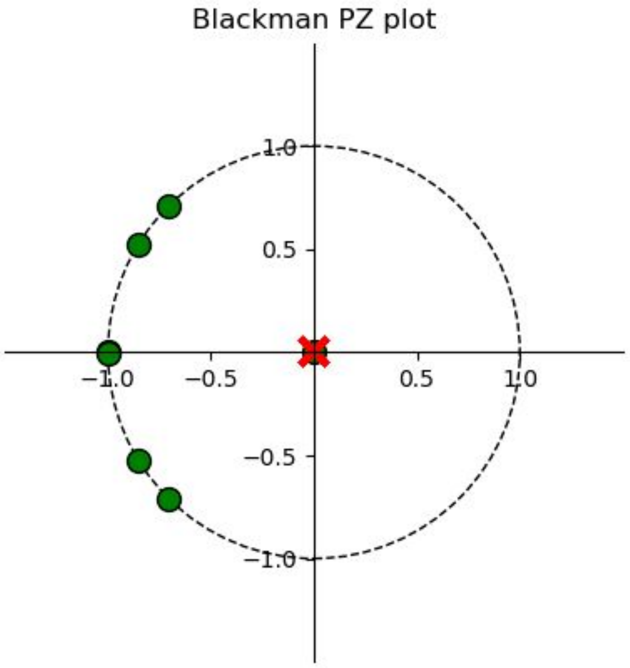


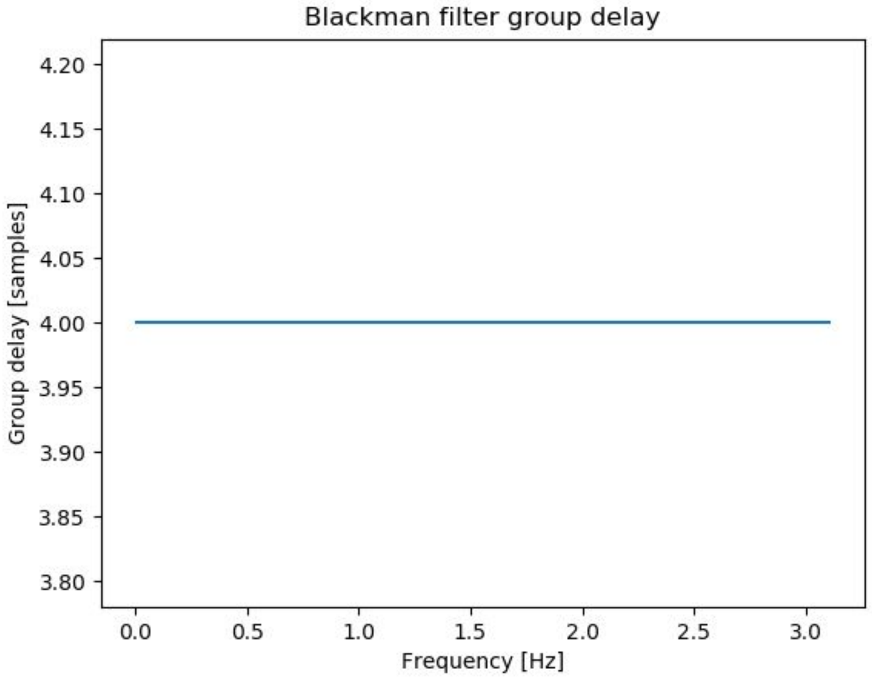
Filter #2 Blackman Filter(.2π cutoff)



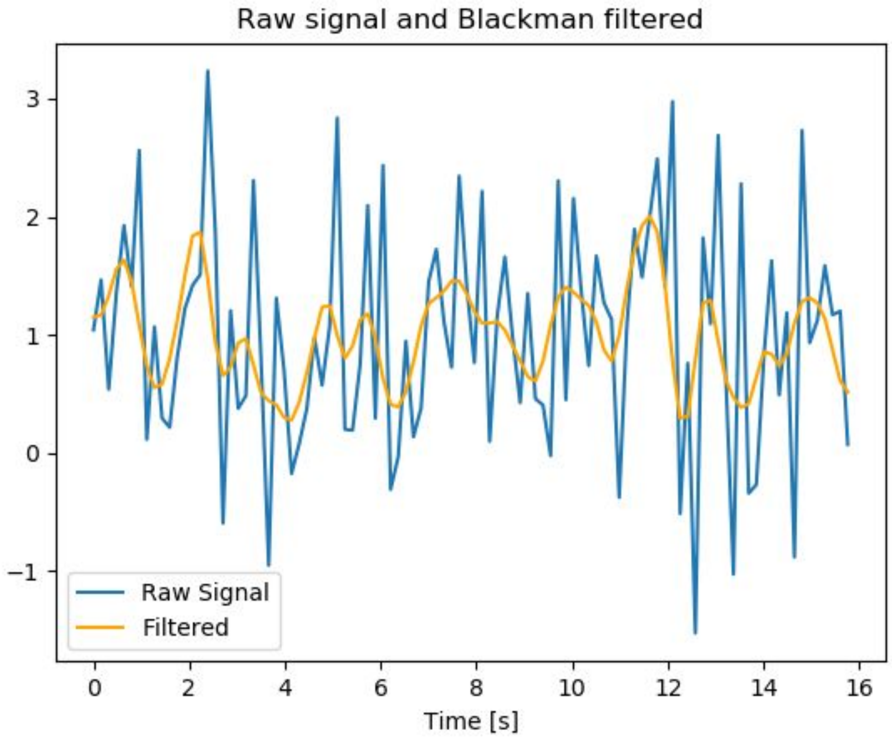


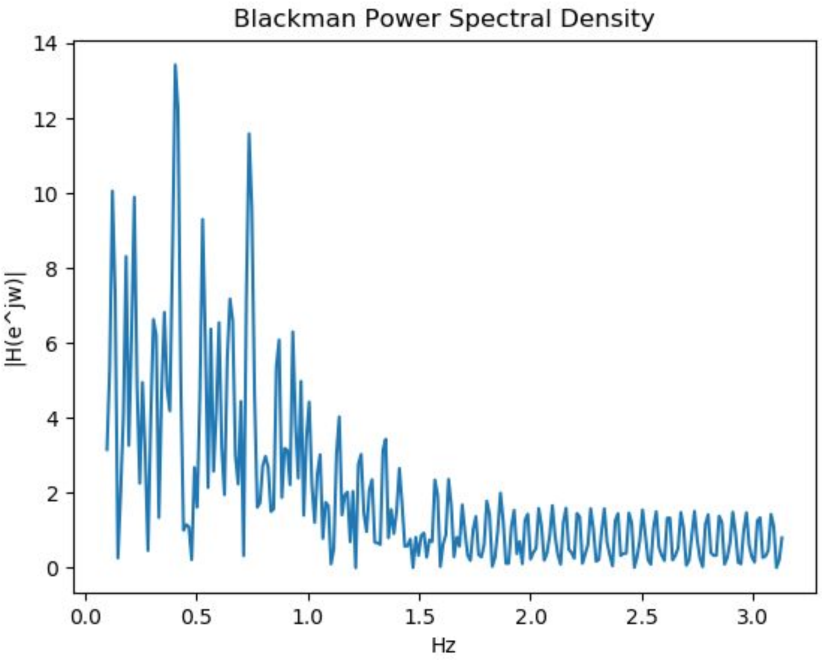
Filter #2 Blackman Filter(.2π cutoff)



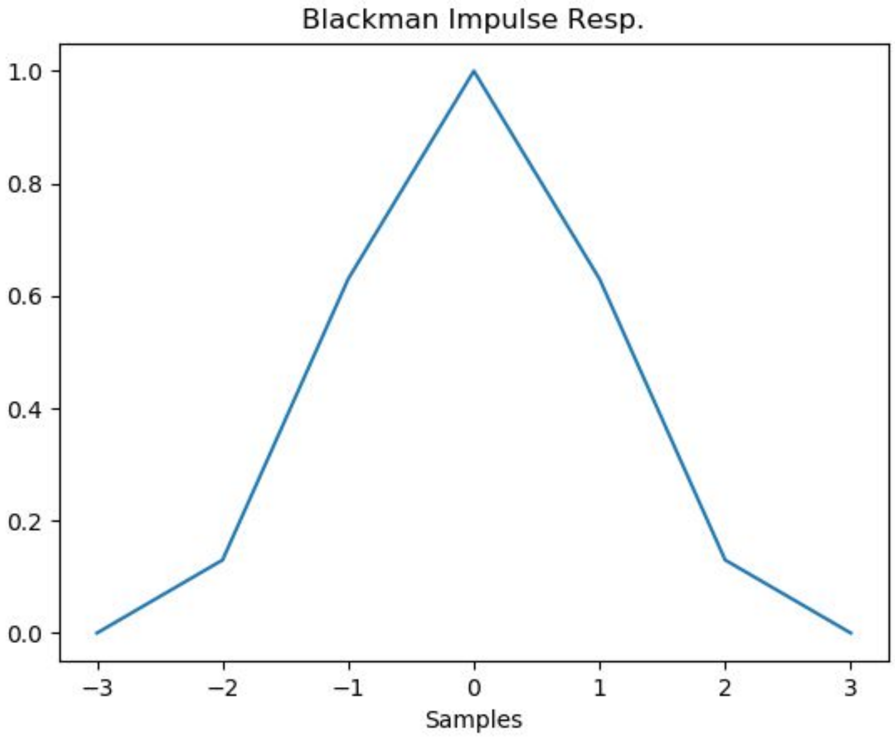


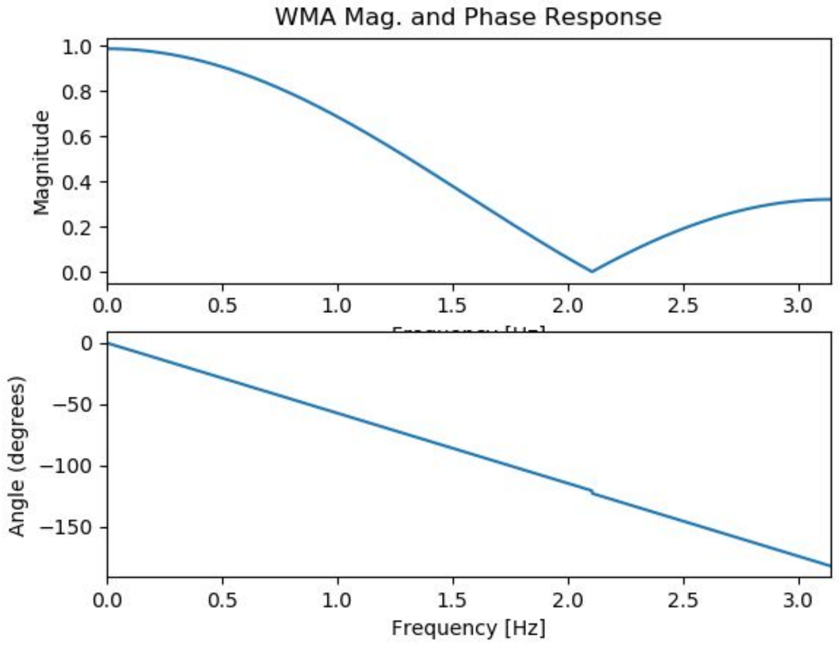
Filter #2 Blackman Filter(.2π cutoff)



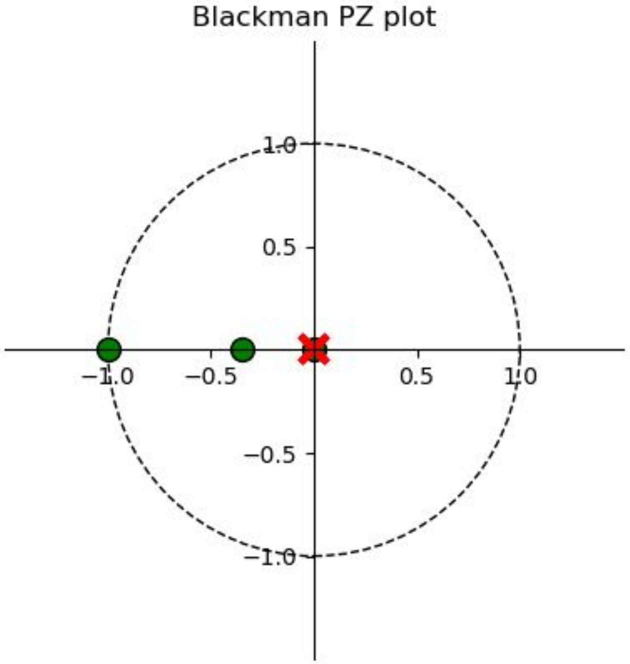


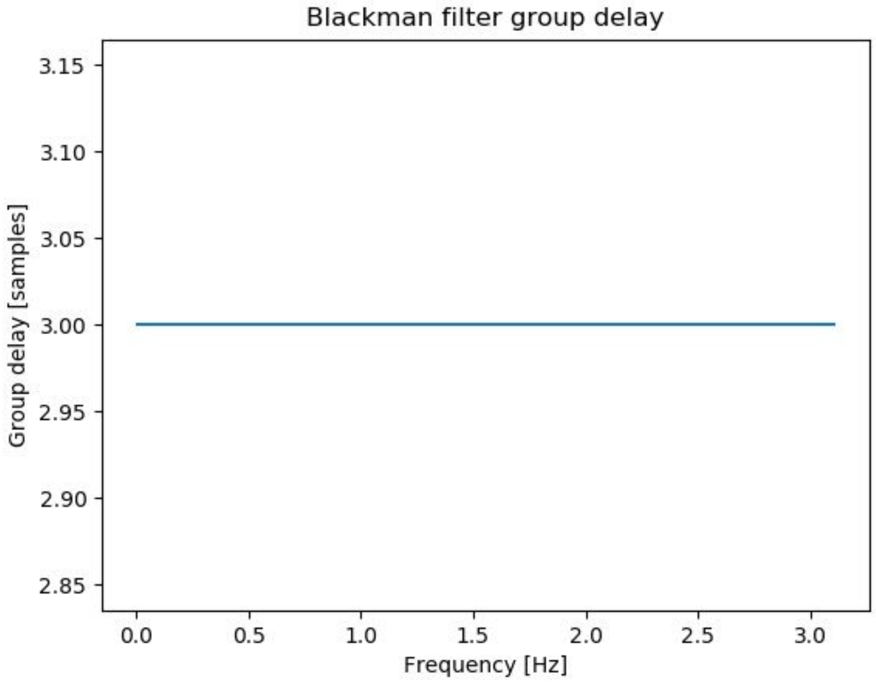
Filter #2 Blackman Filter(.3π cutoff)



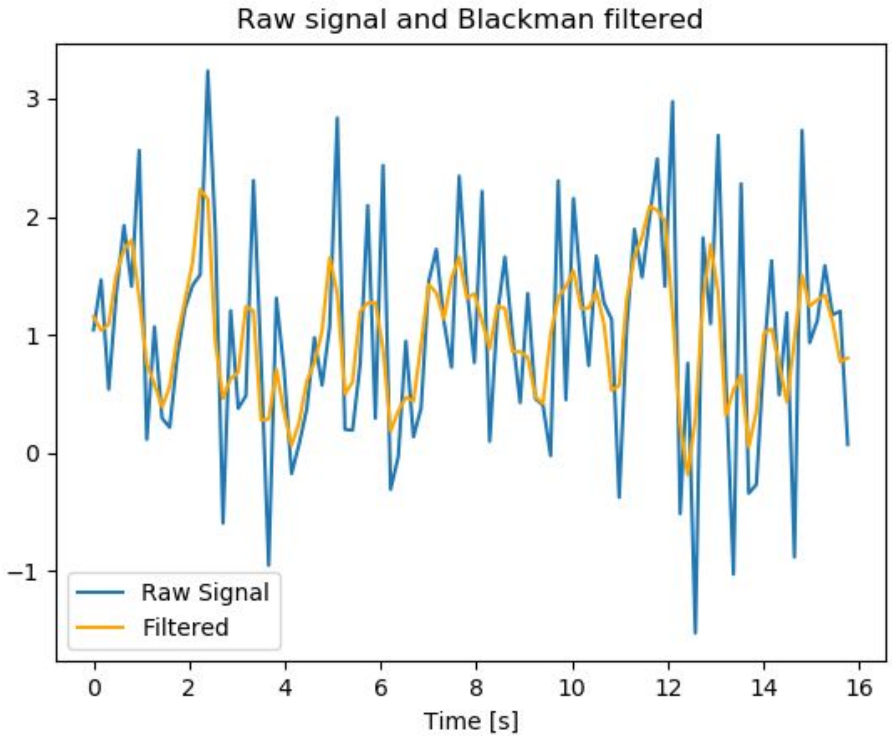


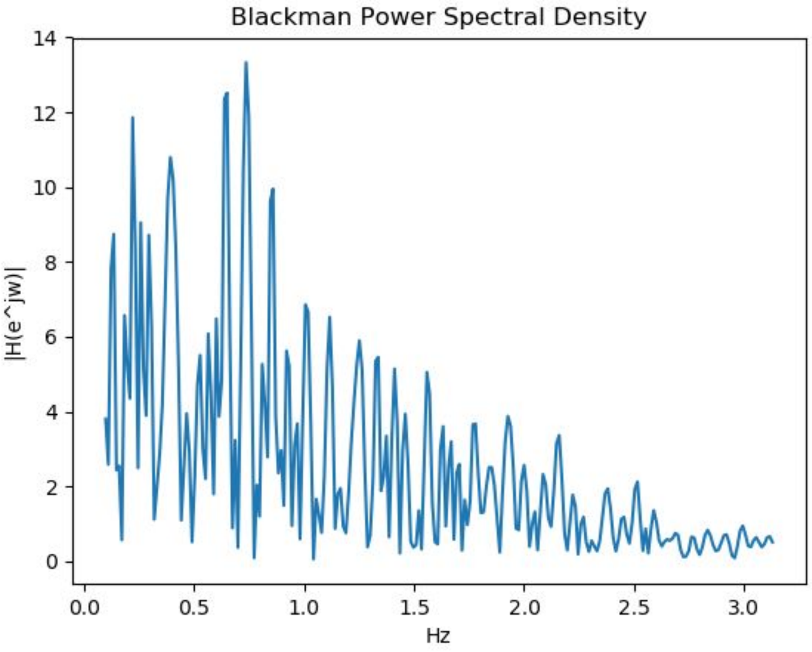
Filter #2 Blackman Filter(.3**π** cutoff)





Filter #2 Blackman Filter(.3π cutoff)

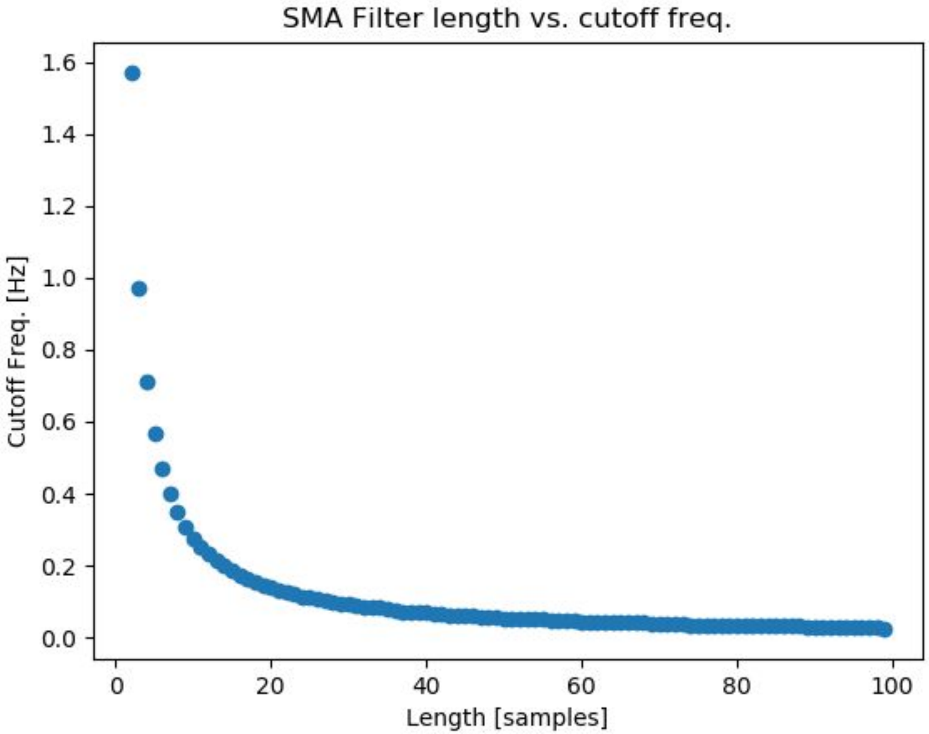




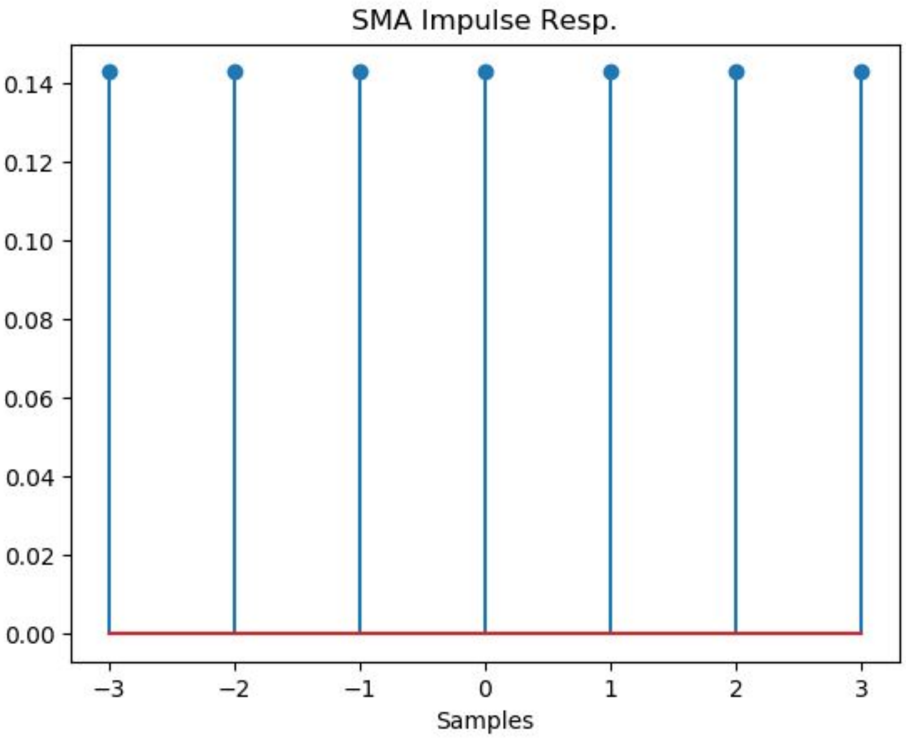
Blackman Filter explanation

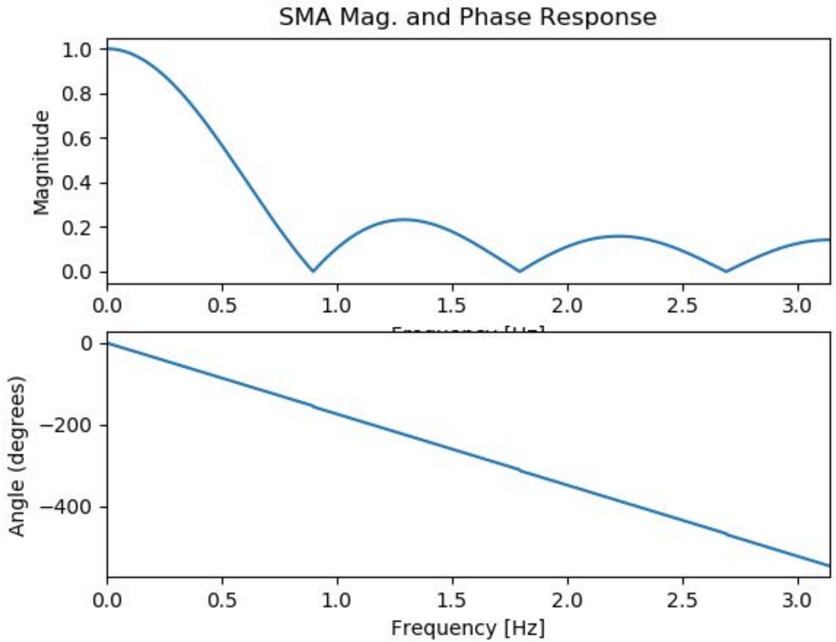
- $b[n] = .42 - .5\cos(2\pi n/N) + .08\cos(2\pi n/N)$
- Fits the noncausal, symmetric, and positive
- Numerator coefficients were normalized by sum of the numerator coefficients

Filter #3 SMA Filter

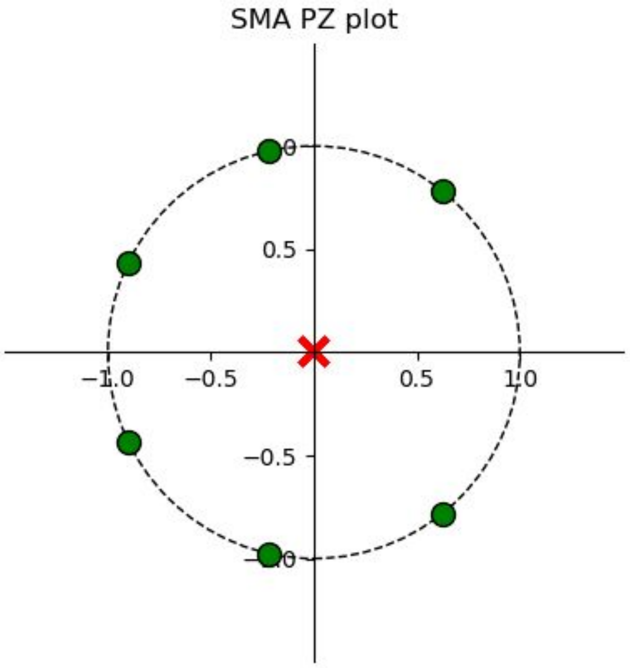


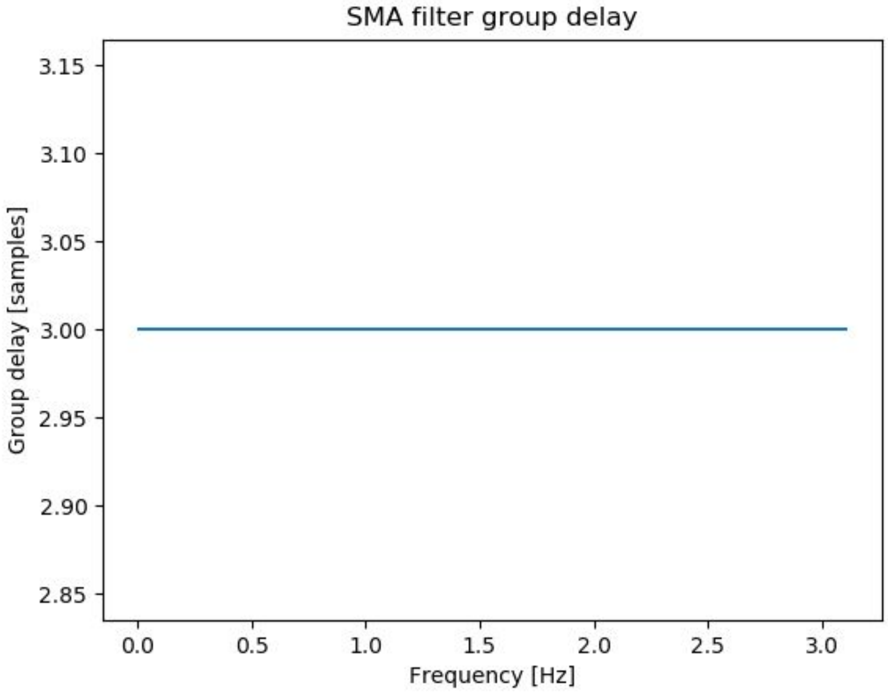
Filter #3 SMA Filter(.1**π** cutoff)



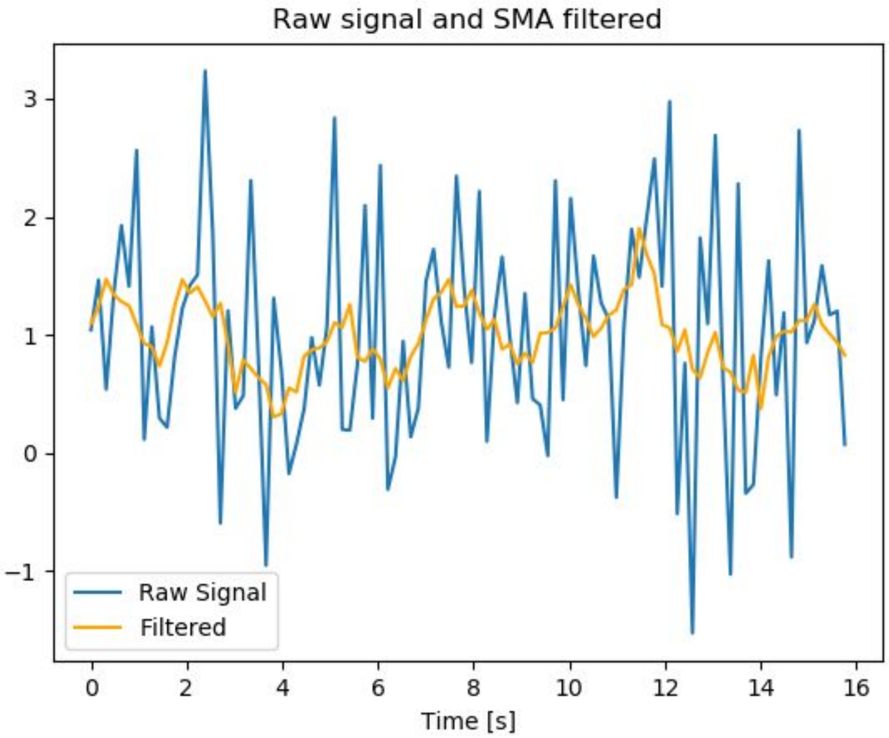


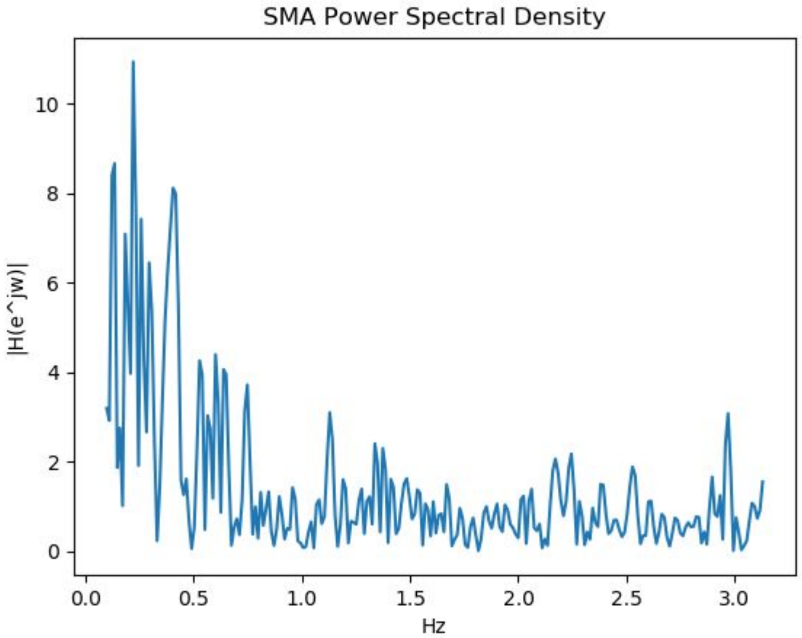
Filter #3 SMA Filter(.1π cutoff)



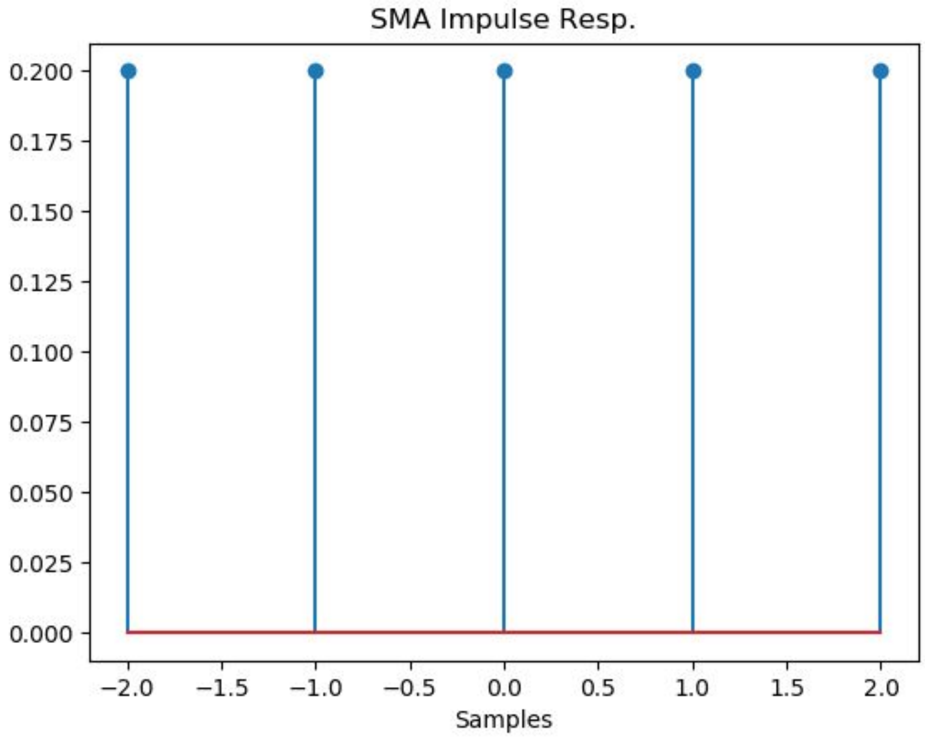


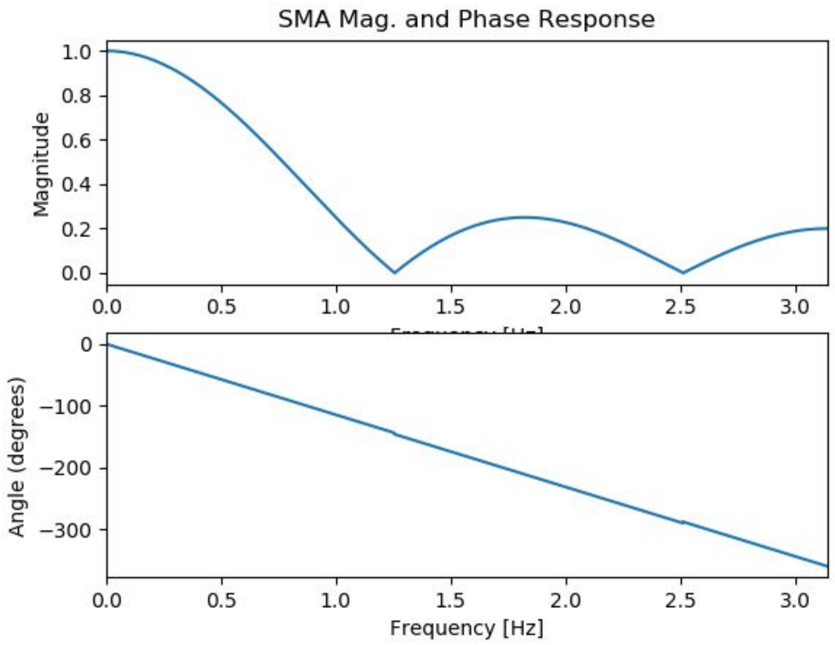
Filter #3 SMA Filter(.1π cutoff)



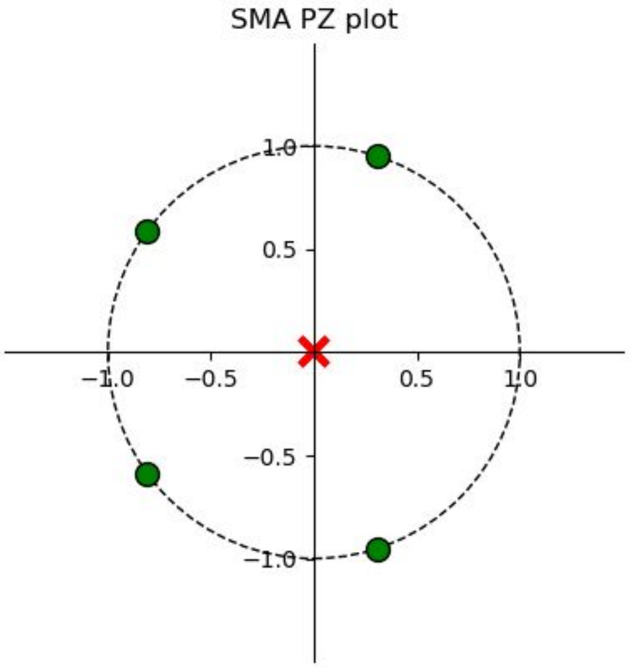


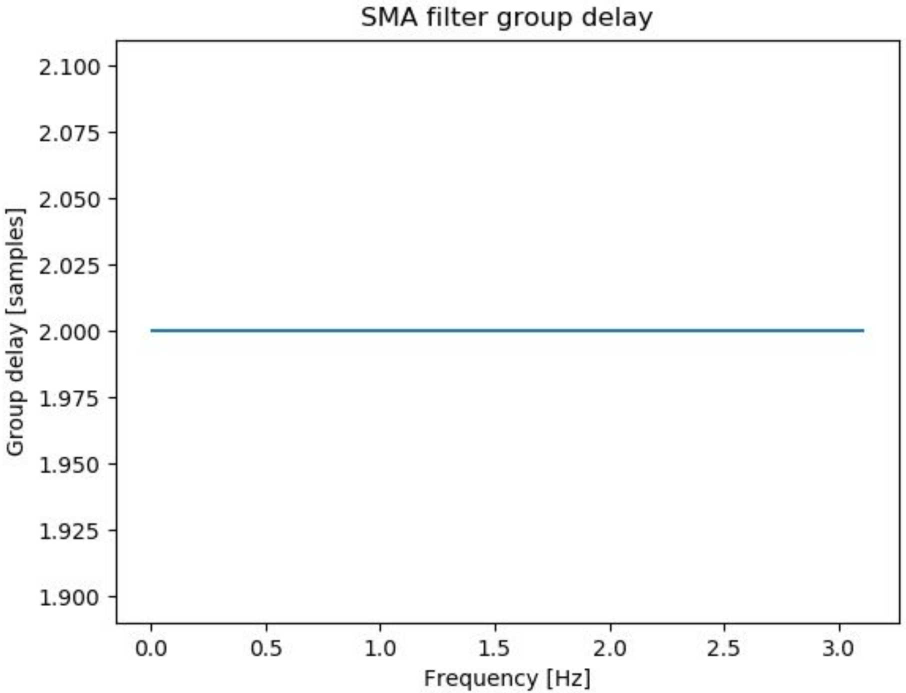
Filter #3 SMA Filter(.2π cutoff)



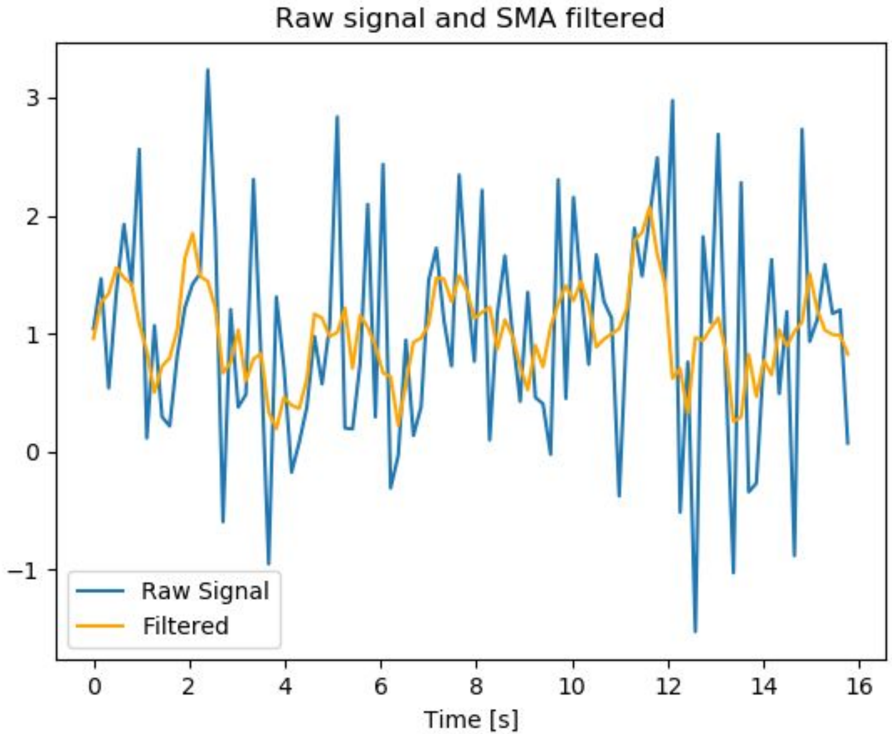


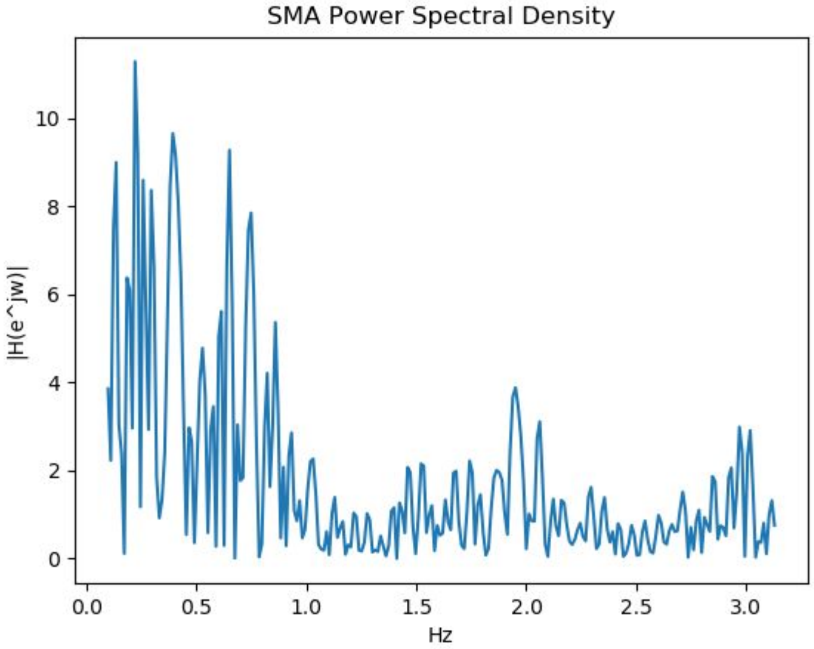
Filter #3 SMA Filter(.2π cutoff)



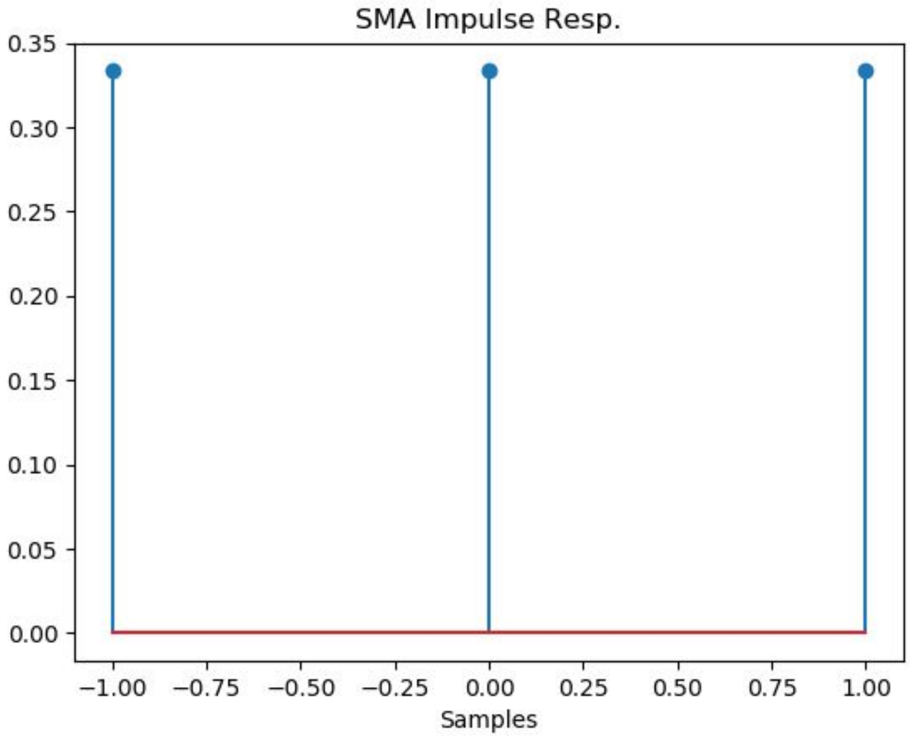


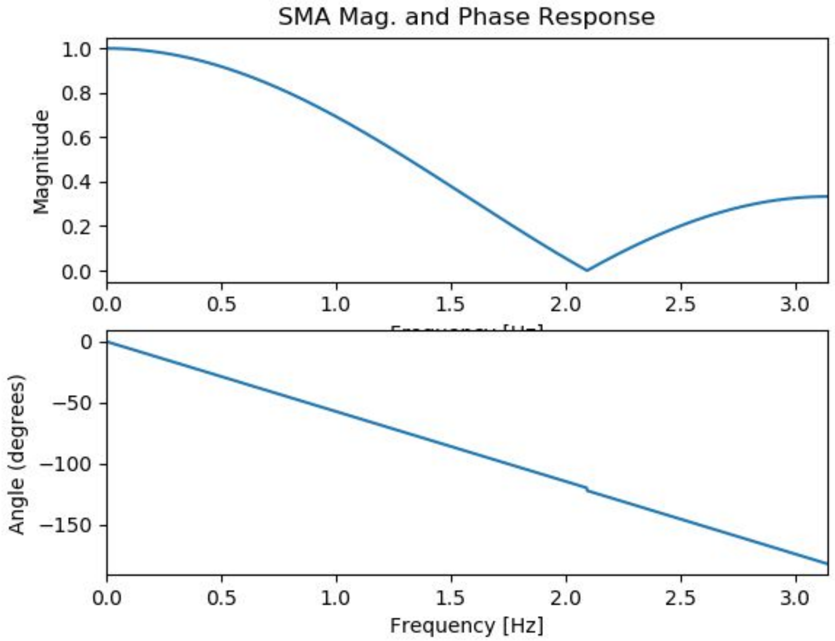
Filter #3 SMA Filter(.2π cutoff)



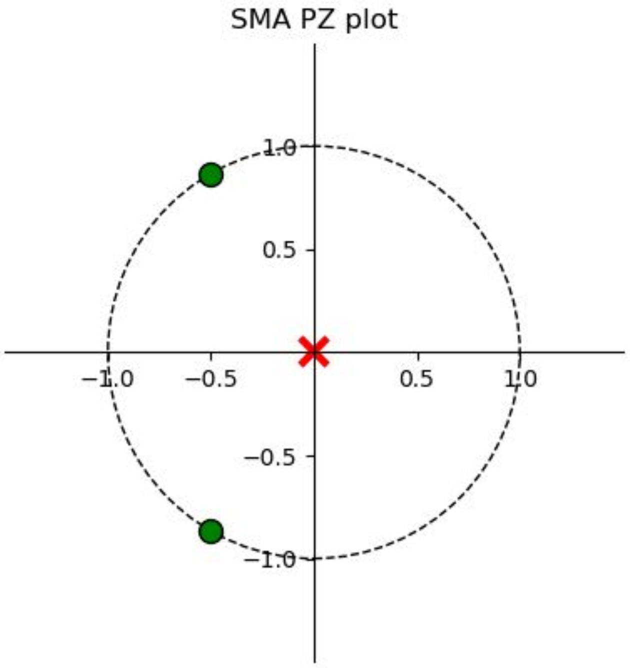


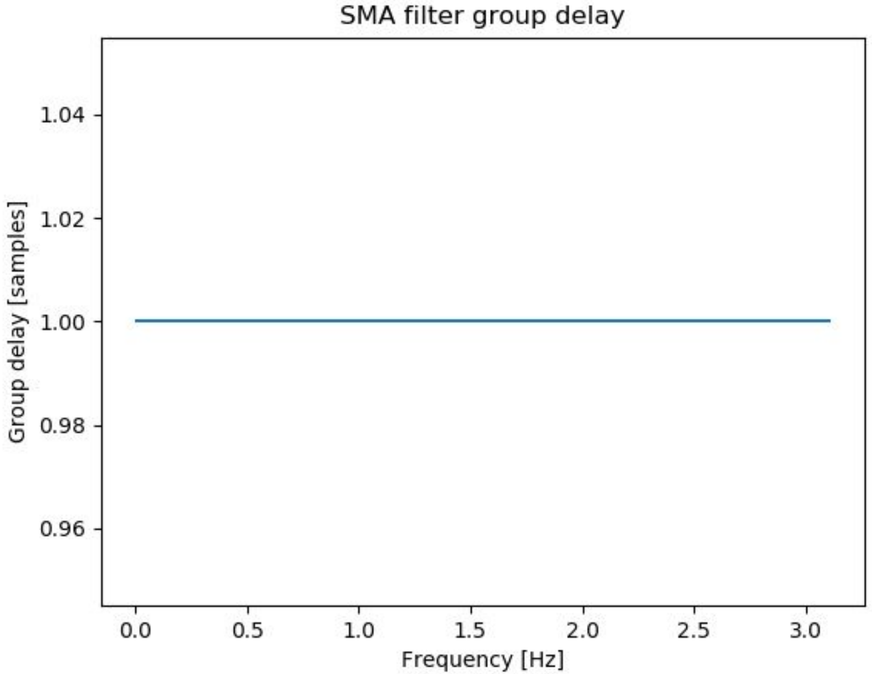
Filter #3 SMA Filter(.3π cutoff)



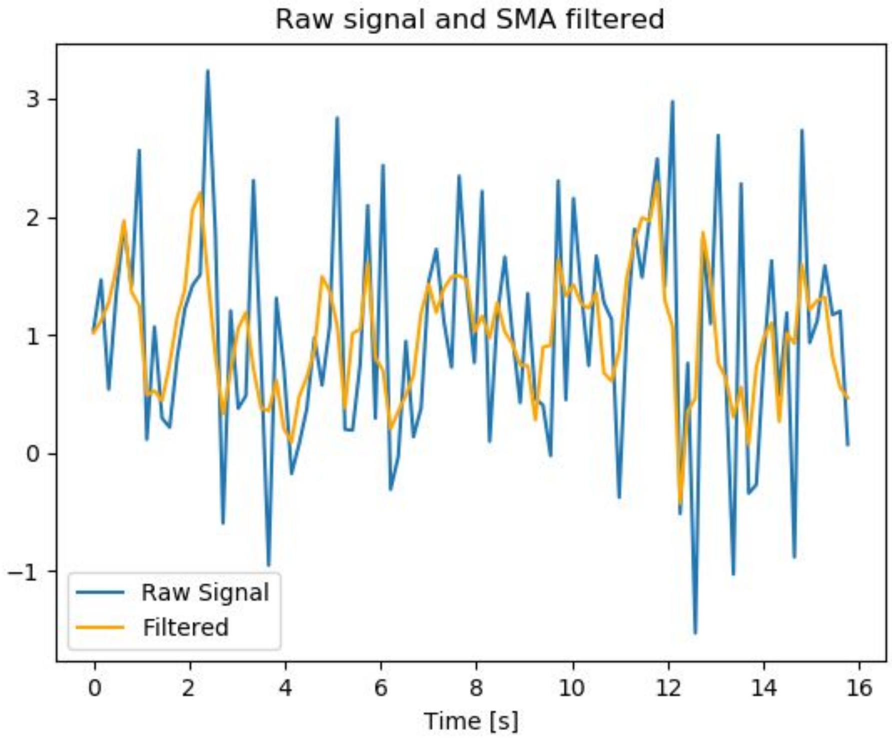


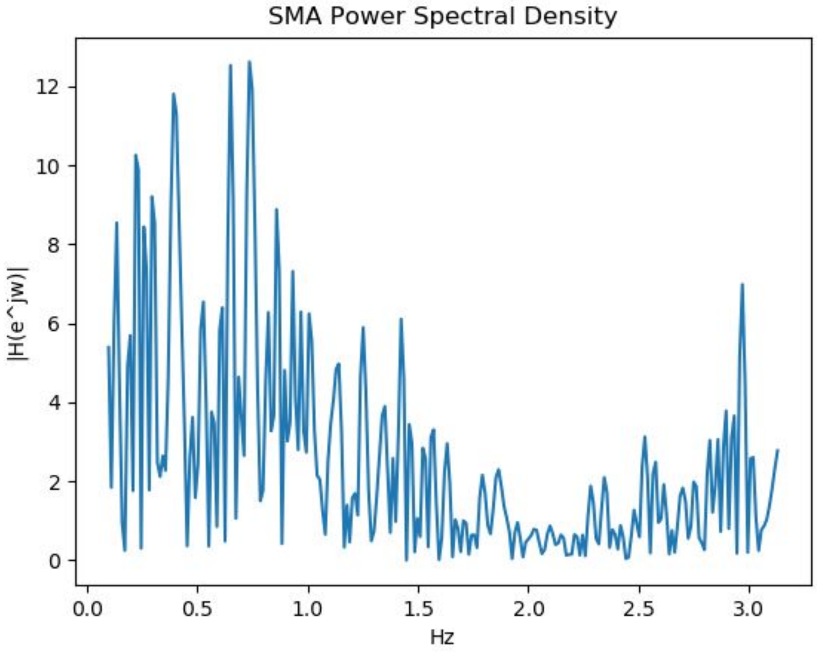
Filter #3 SMA Filter(.3π cutoff)





Filter #3 SMA Filter(.3π cutoff)

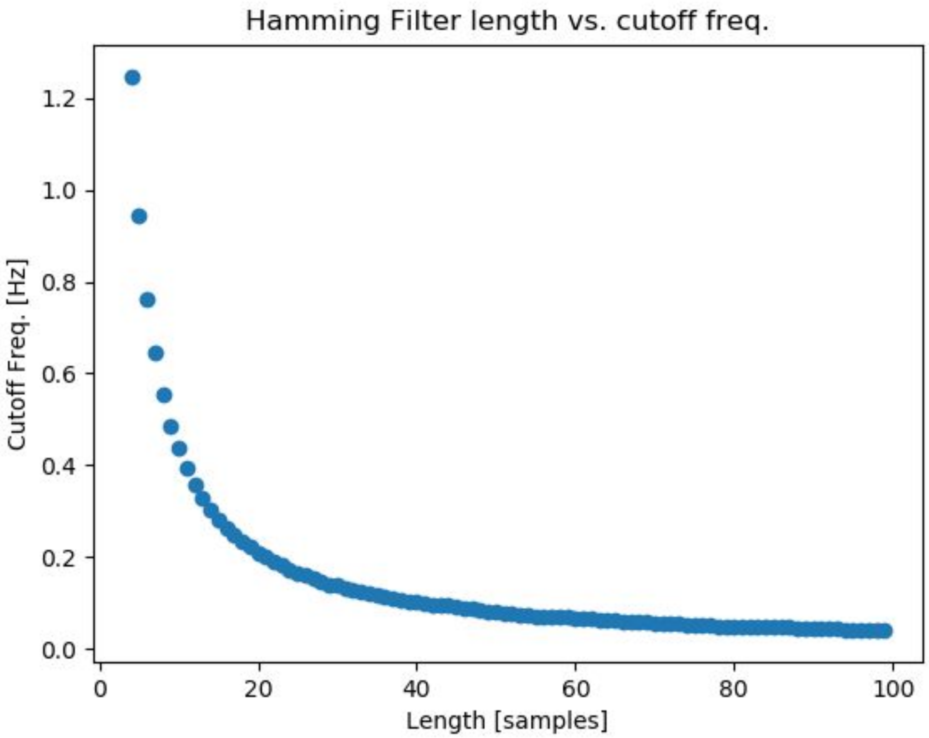




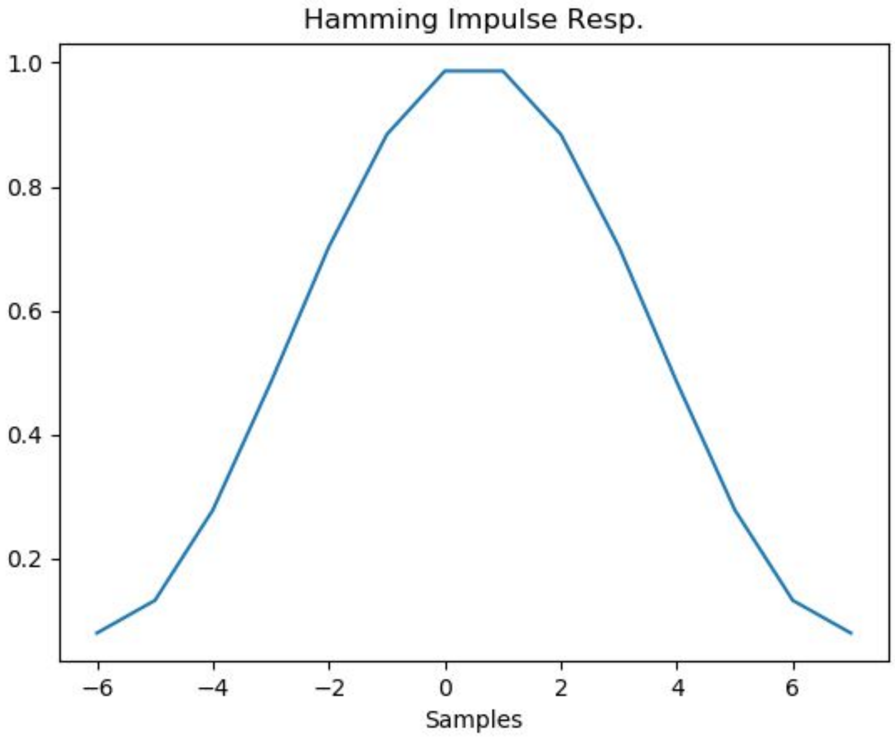
SMA Filter Explanation

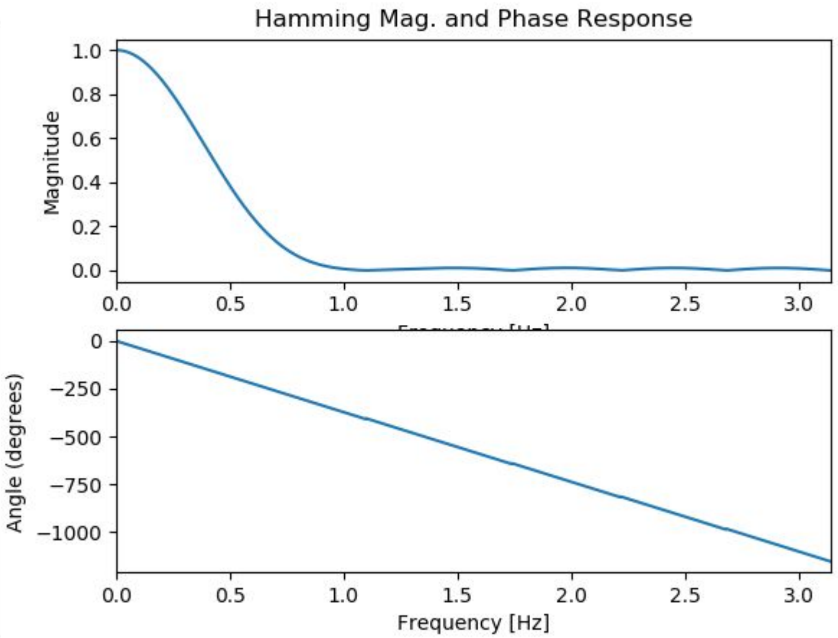
- $b[n] = (1/N)\sum^{N}_{i=1}1$
- Fits the noncausal, symmetric, and positive
- Numerator coefficients were normalized by sum of the numerator coefficients

Filter #4 Hamming Filter

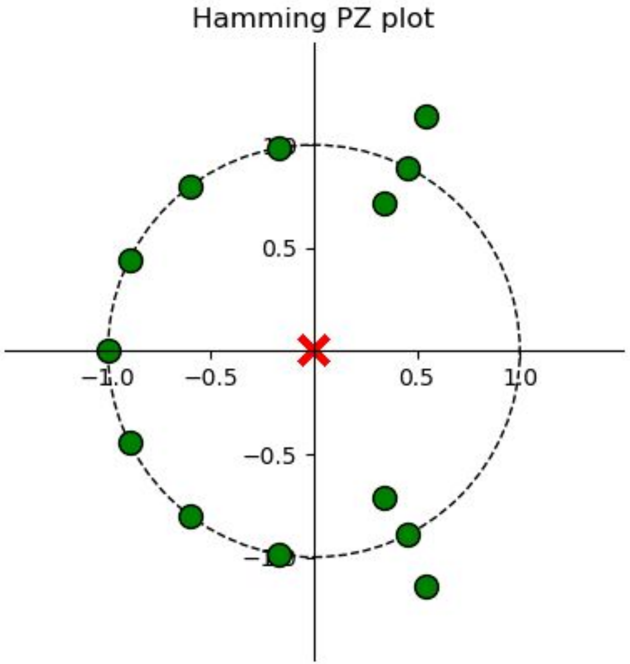


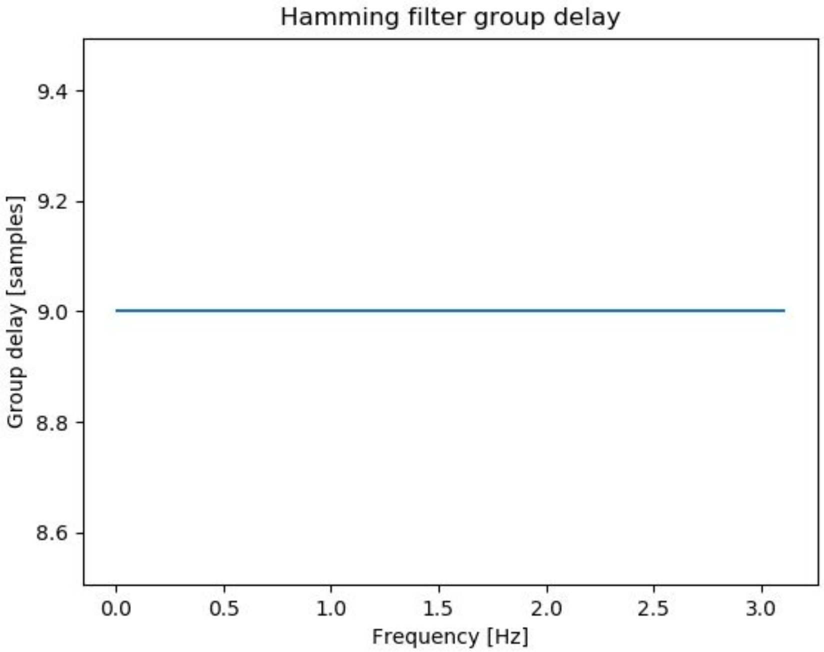
Filter #4 Hamming Filter(.1π cutoff)



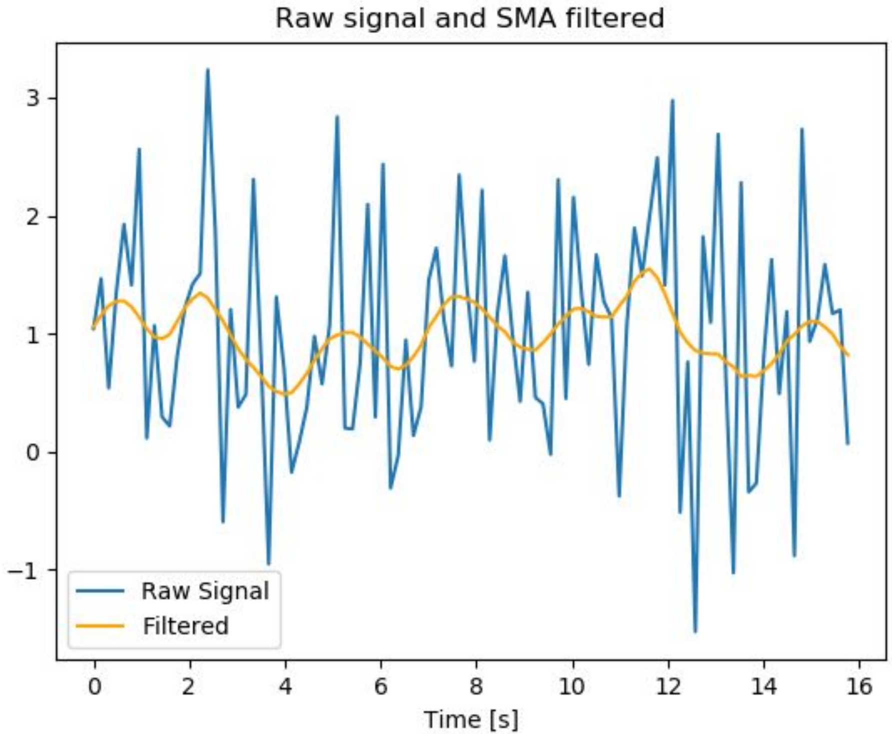


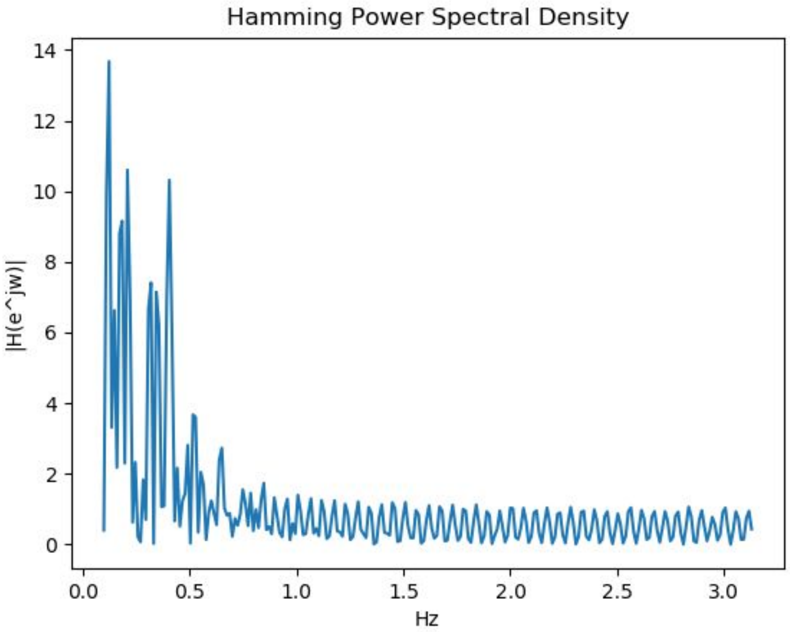
Filter #4 Hamming Filter(.1π cutoff)



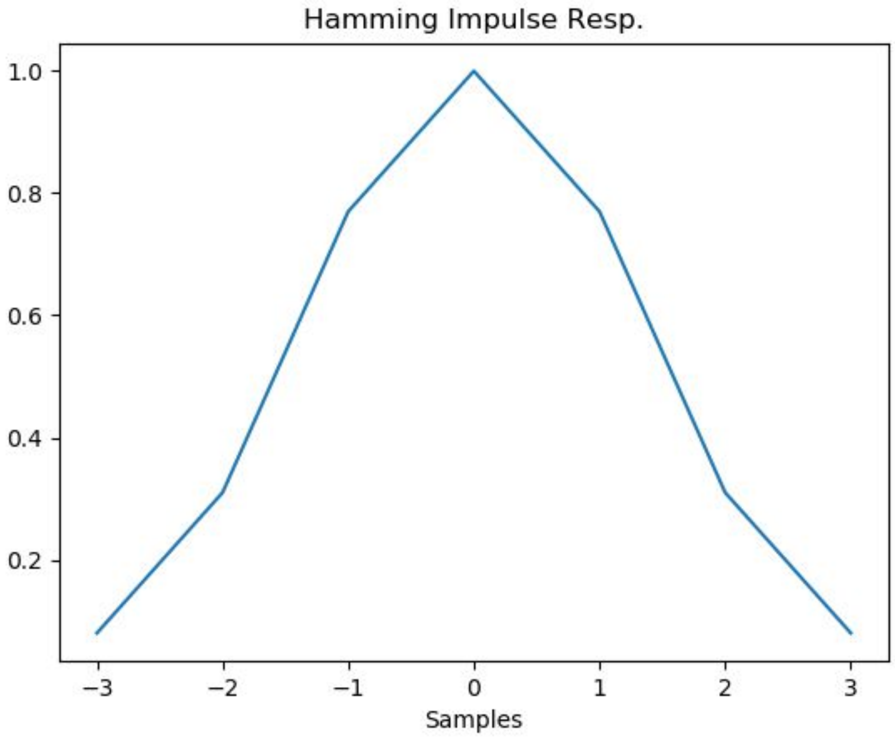


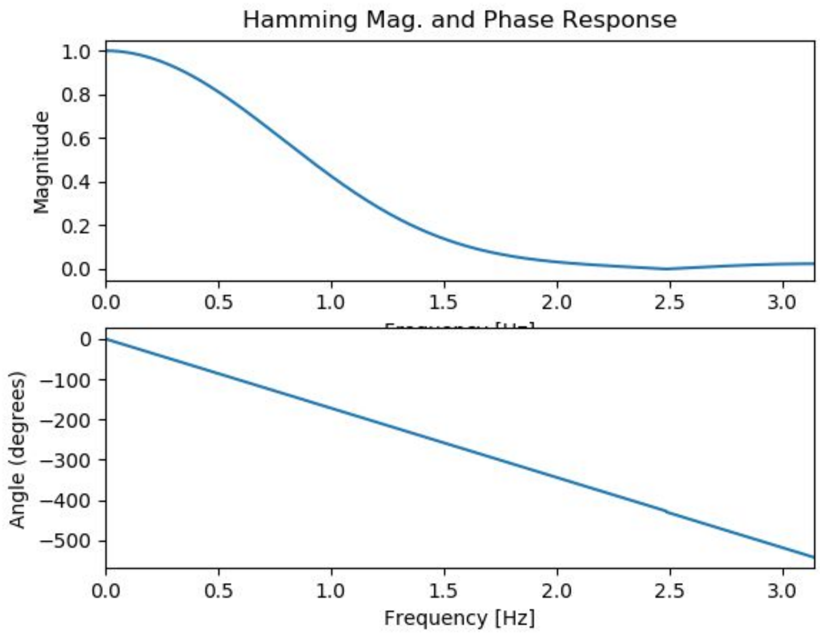
Filter #4 Hamming Filter(.1π cutoff)



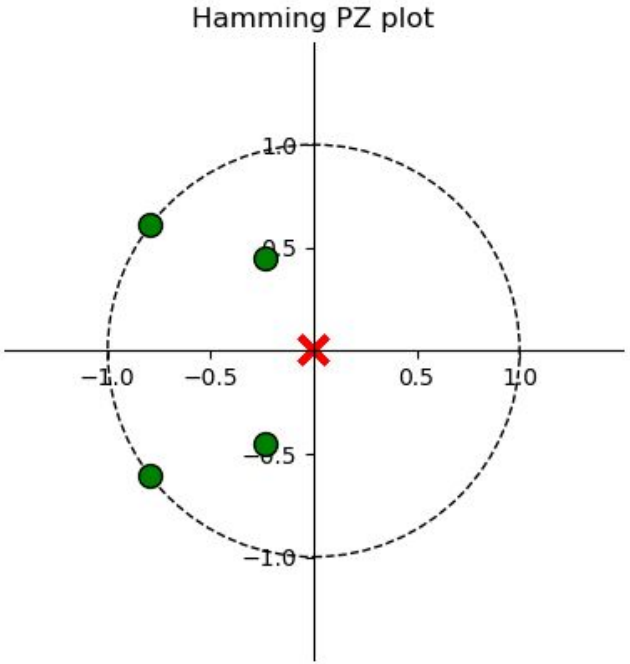


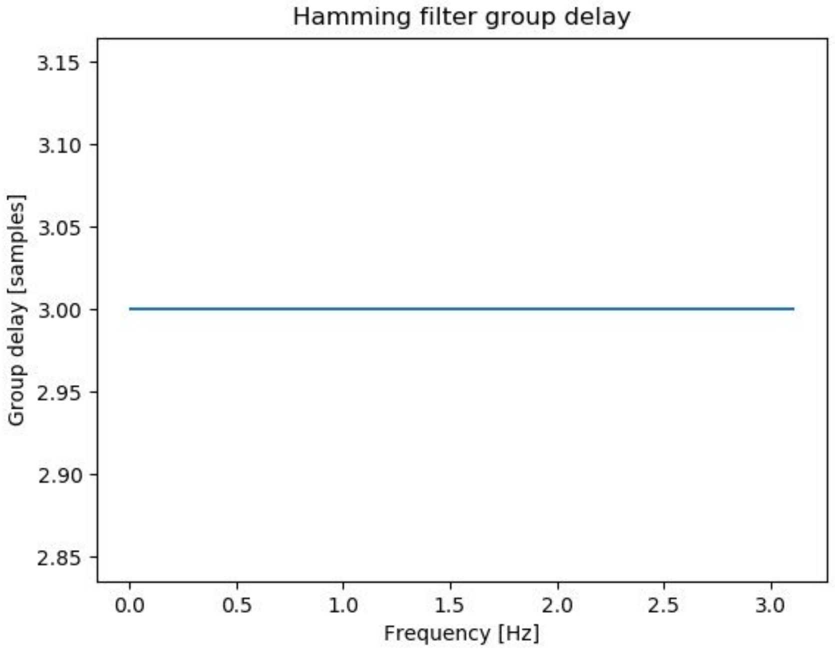
Filter #4 Hamming Filter(.2π cutoff)



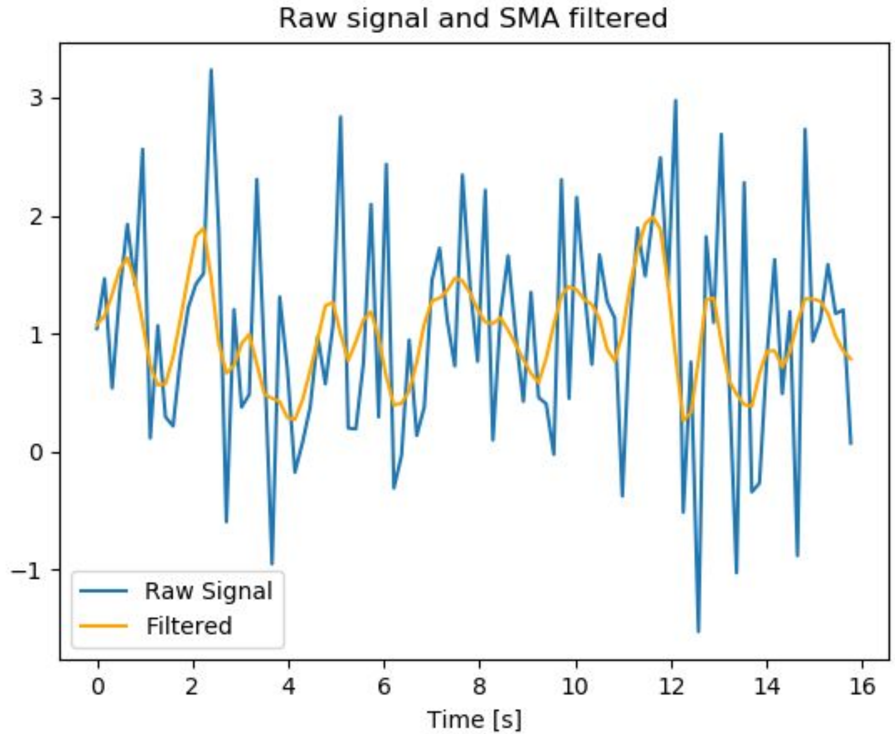


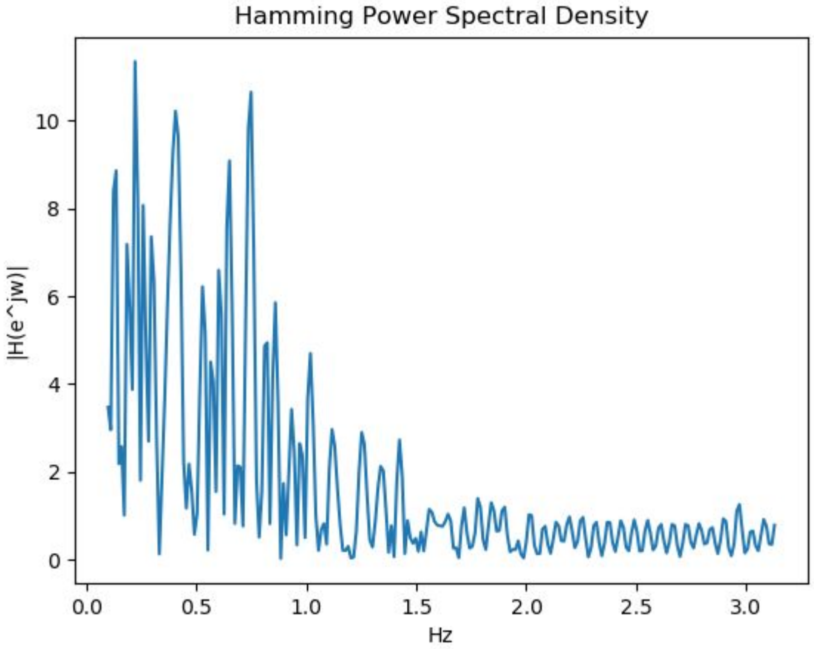
Filter #4 Hamming Filter(.2**π** cutoff)



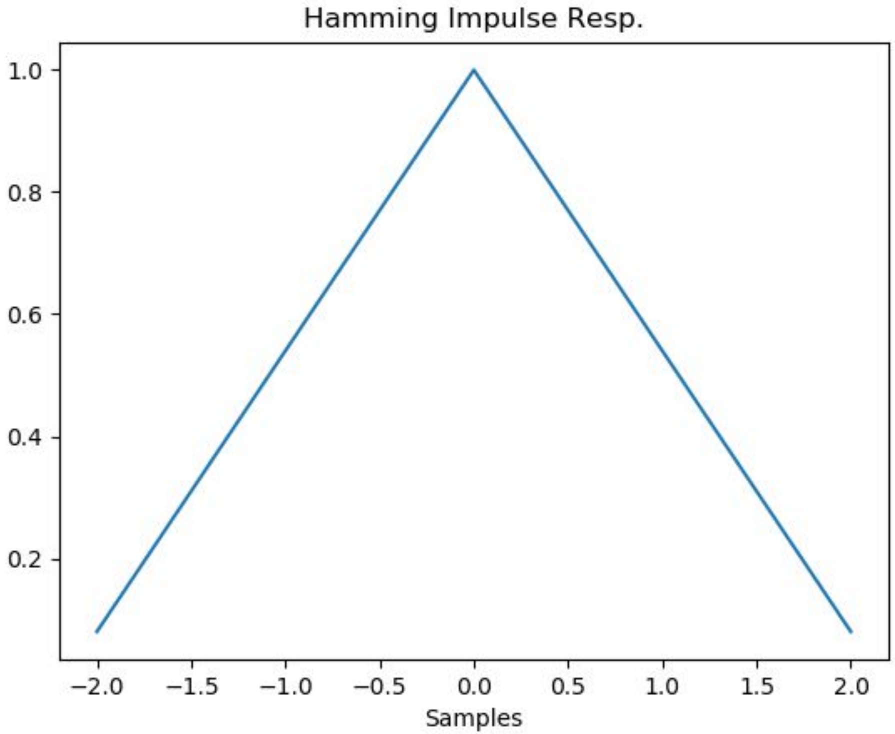


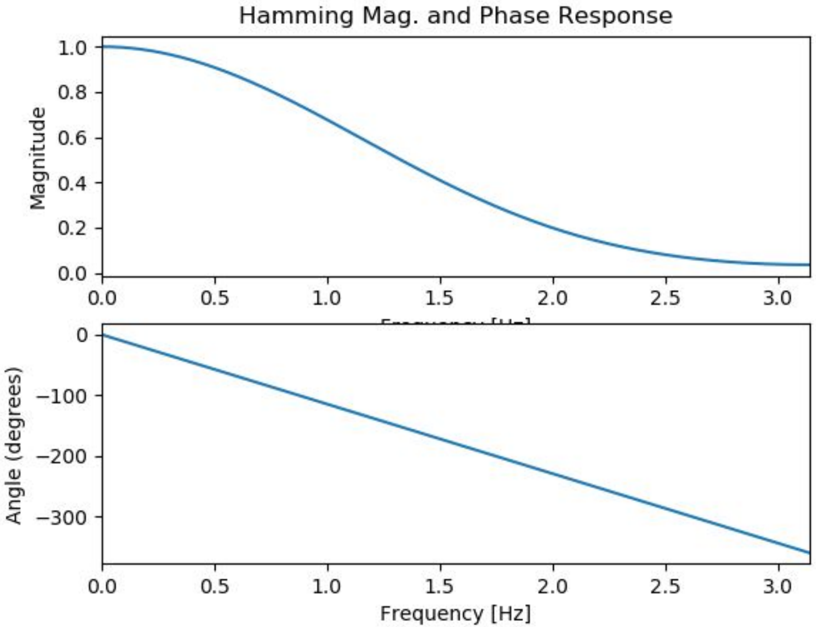
Filter #4 Hamming Filter(.2π cutoff)



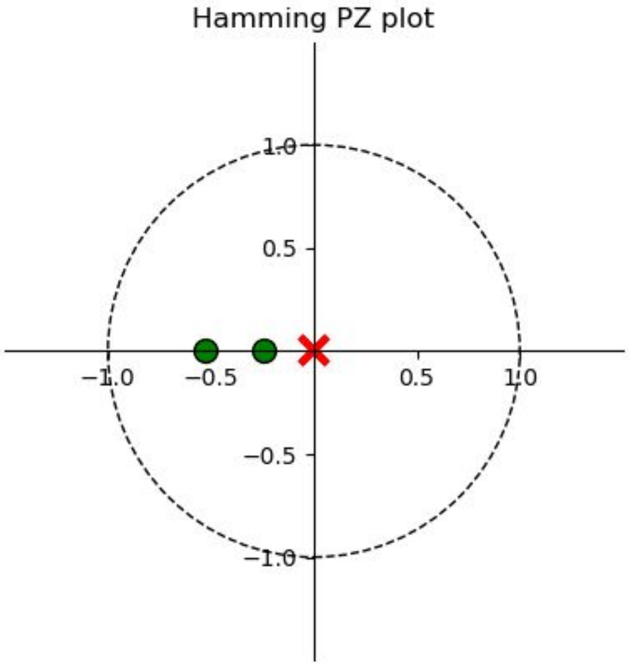


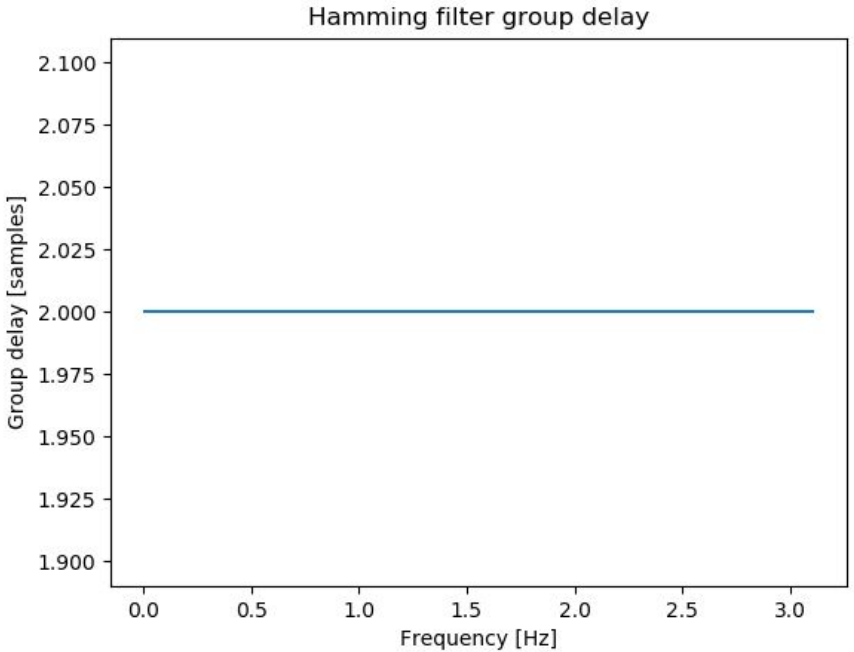
Filter #4 Hamming Filter(.3π cutoff)



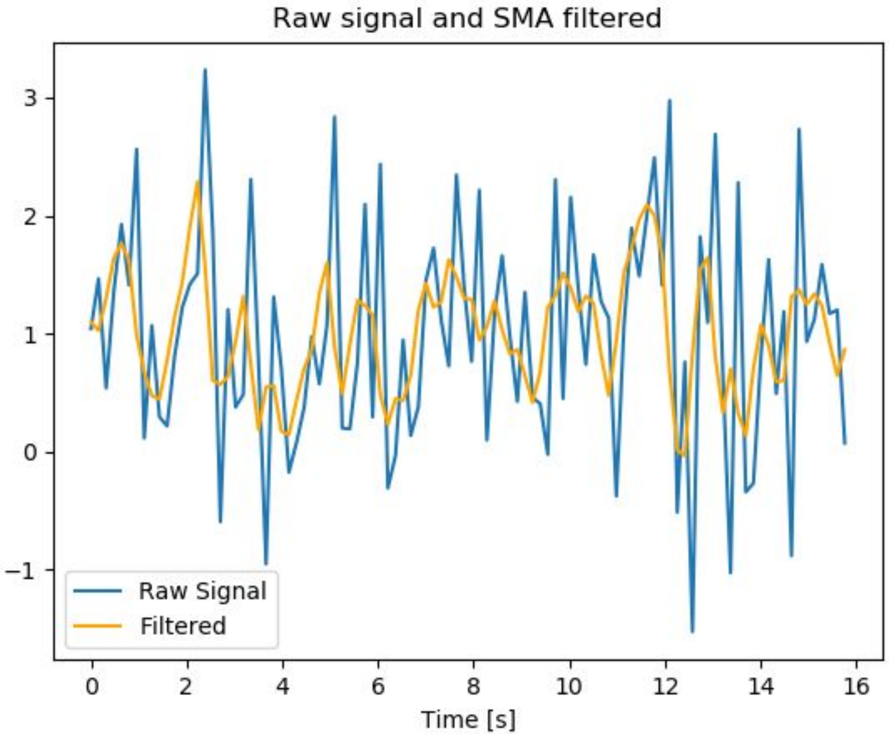


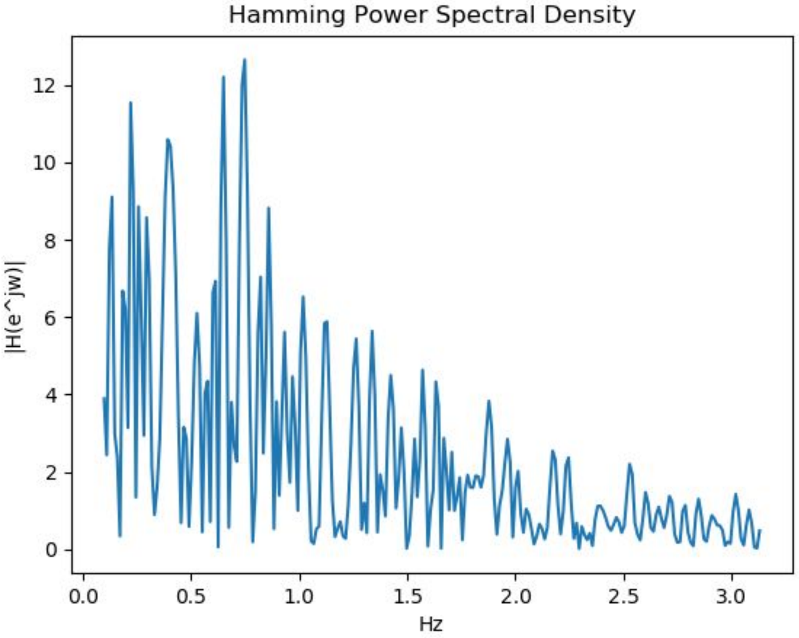
Filter #4 Hamming Filter(.3π cutoff)





Filter #4 Hamming Filter(.3π cutoff)

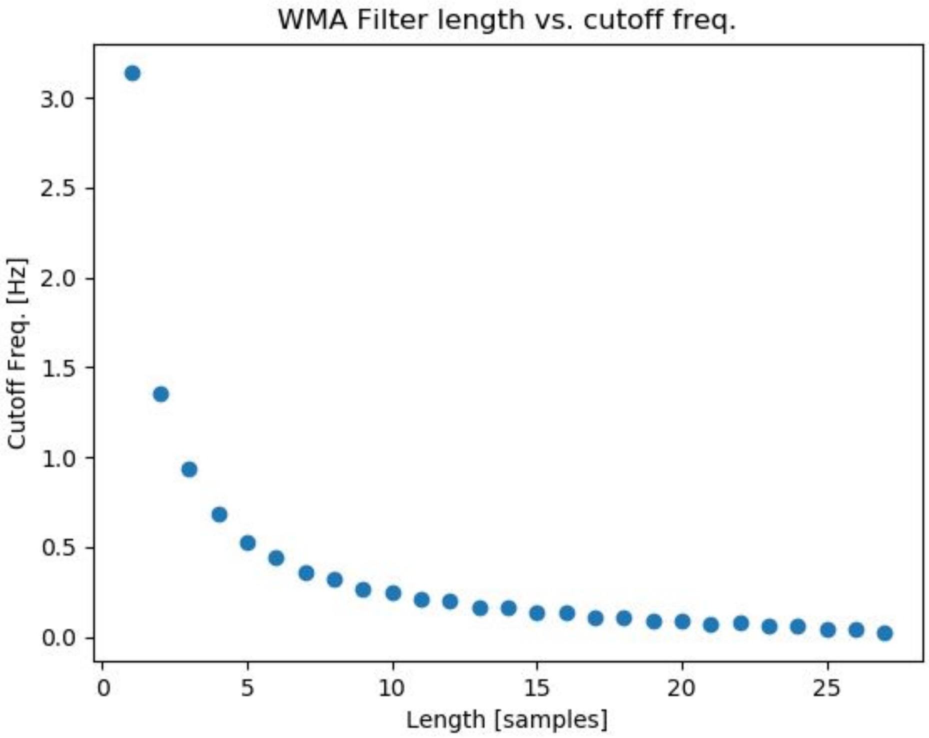




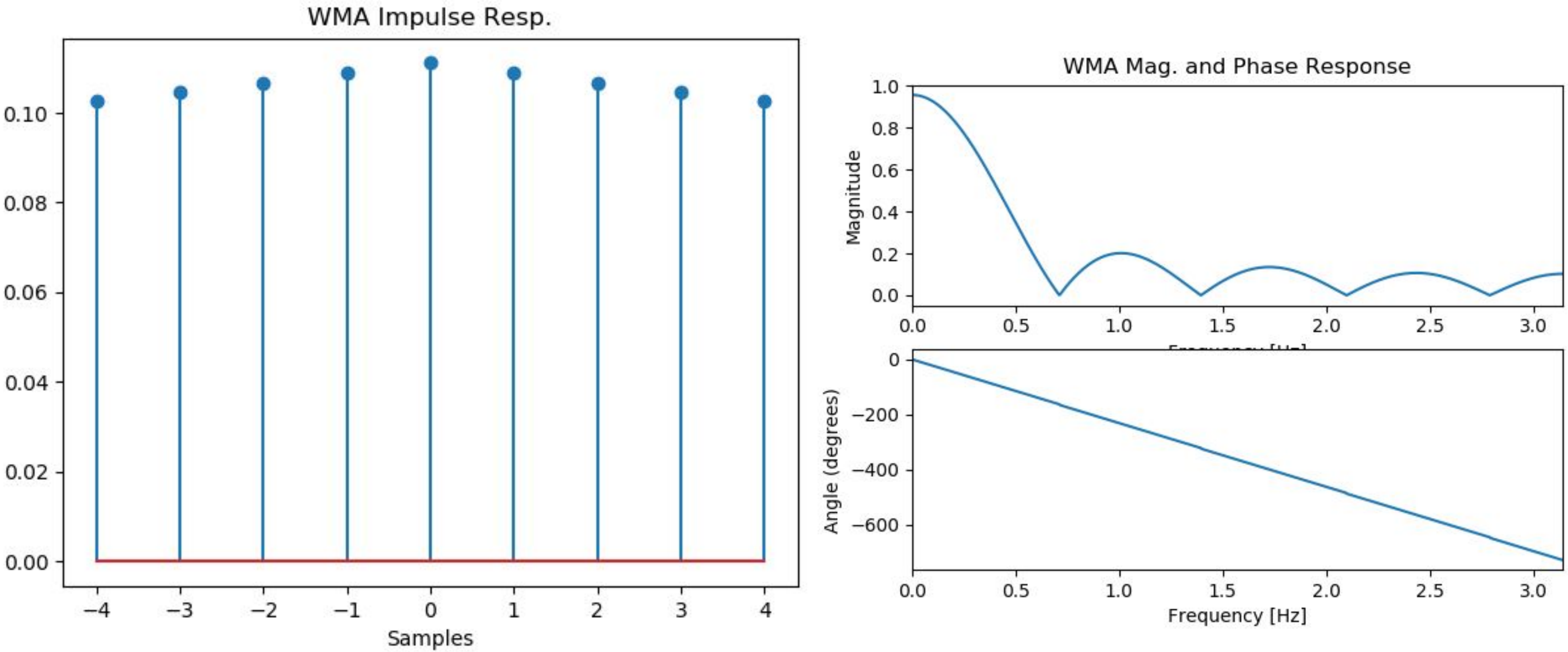
Hamming Filter Explanantion

- $b[n] = .54 - .46\cos(2\pi n/N)$
- Fits the noncausal, symmetric, and positive
- Numerator coefficients were normalized by sum of the numerator coefficients

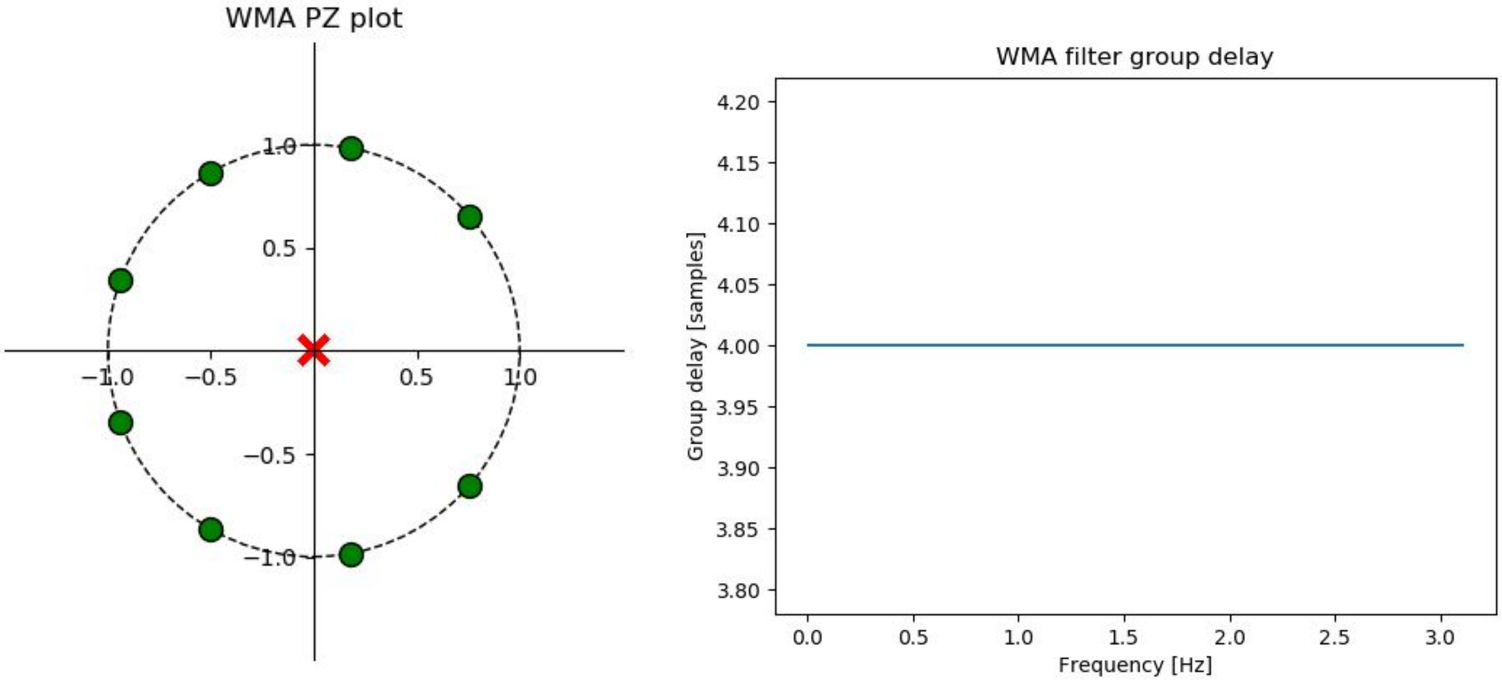
Filter #5 WMA Filter



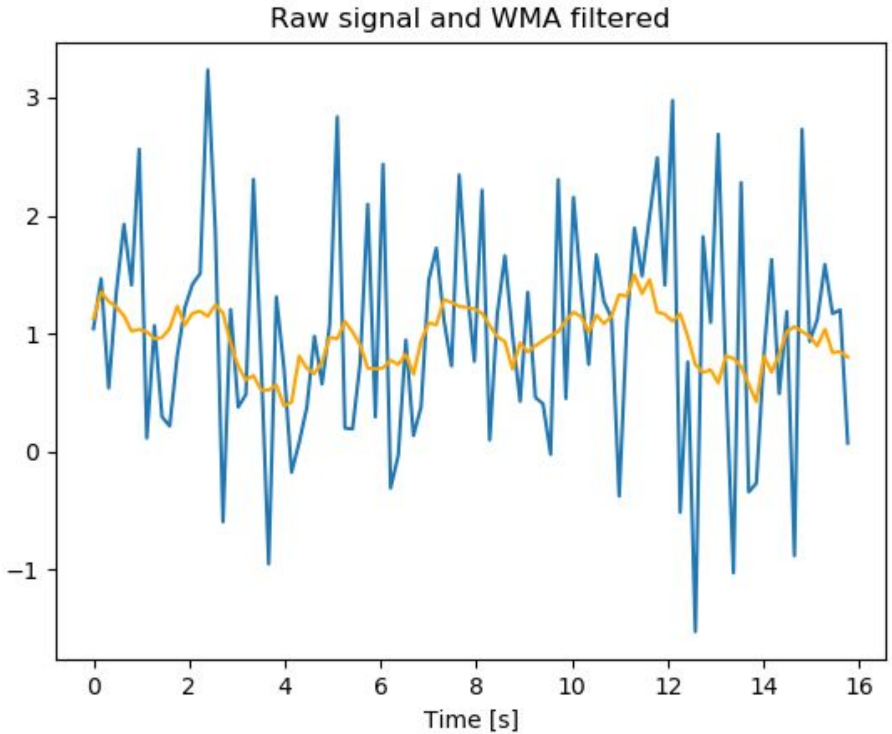
Filter #5 WMA Filter(.1π cutoff)

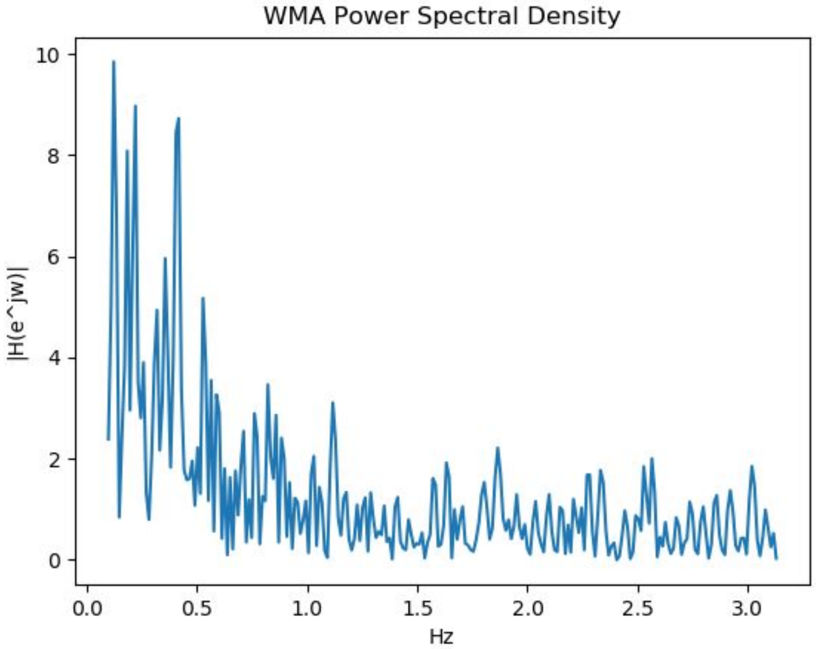


Filter #5 WMA Filter(.1**π** cutoff)

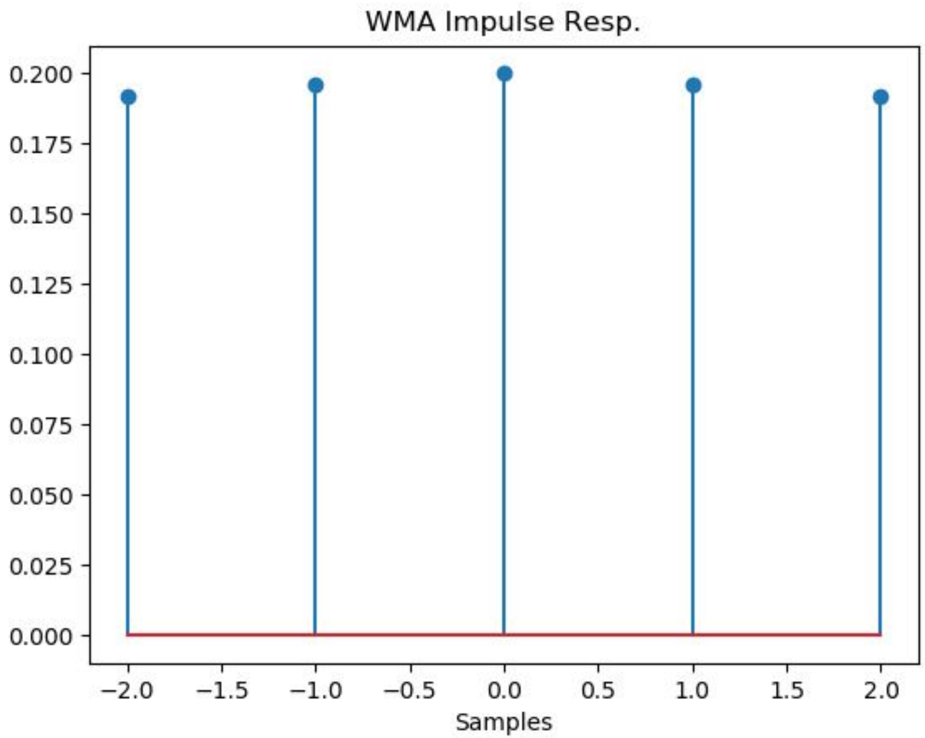


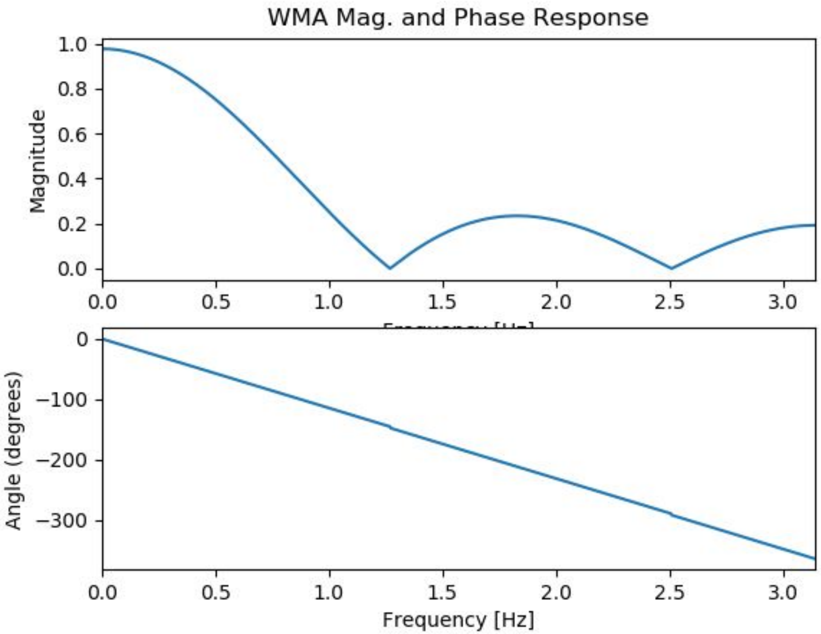
Filter #5 WMA Filter(.1π cutoff)



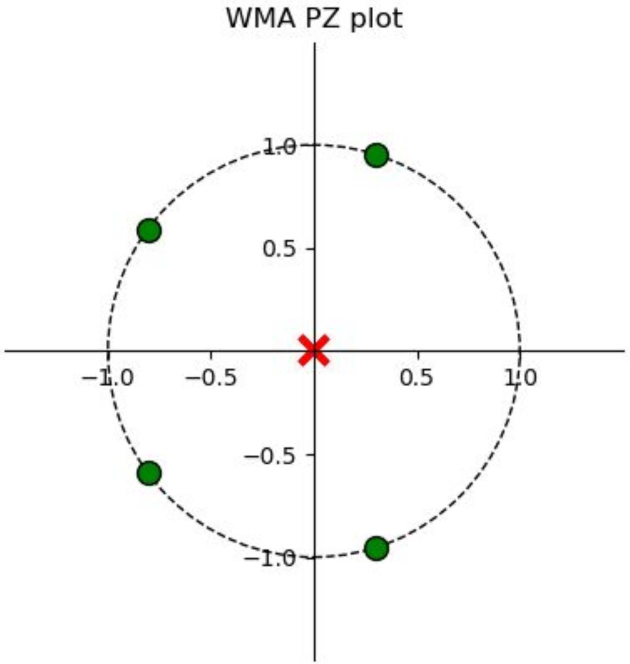


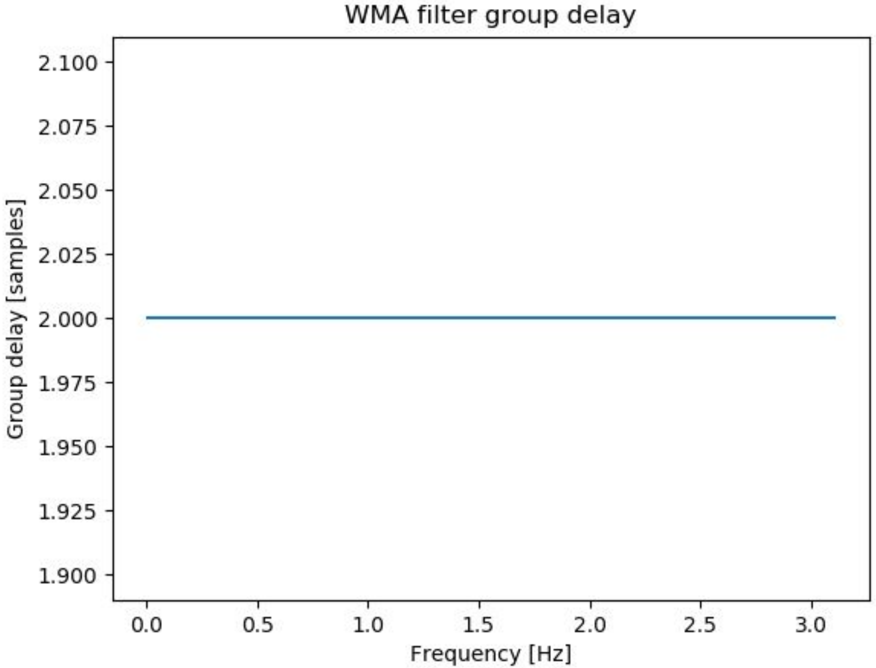
Filter #5 WMA Filter(.2π cutoff)



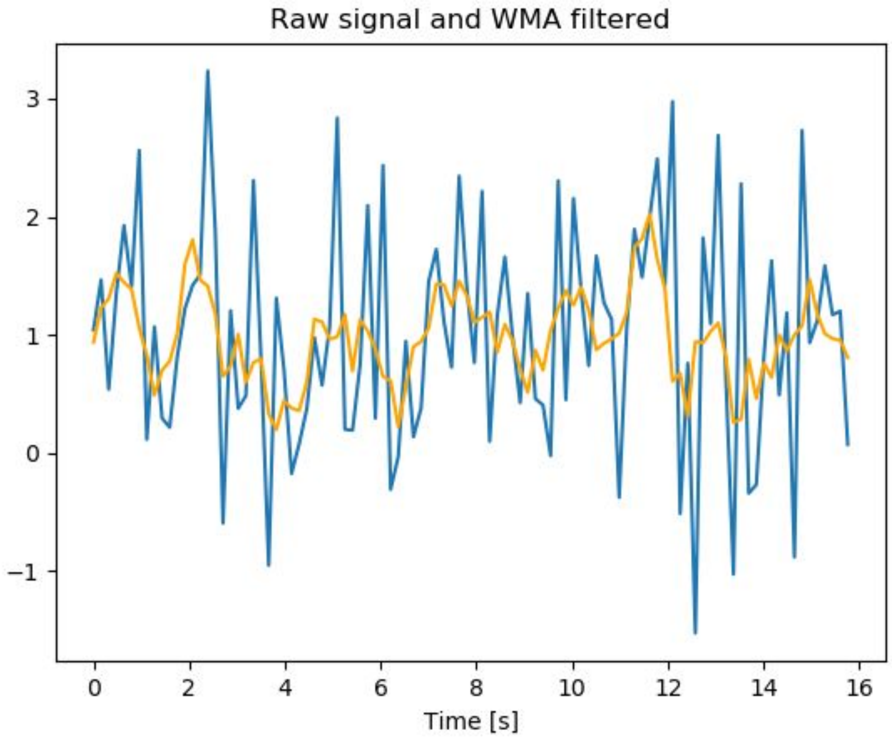


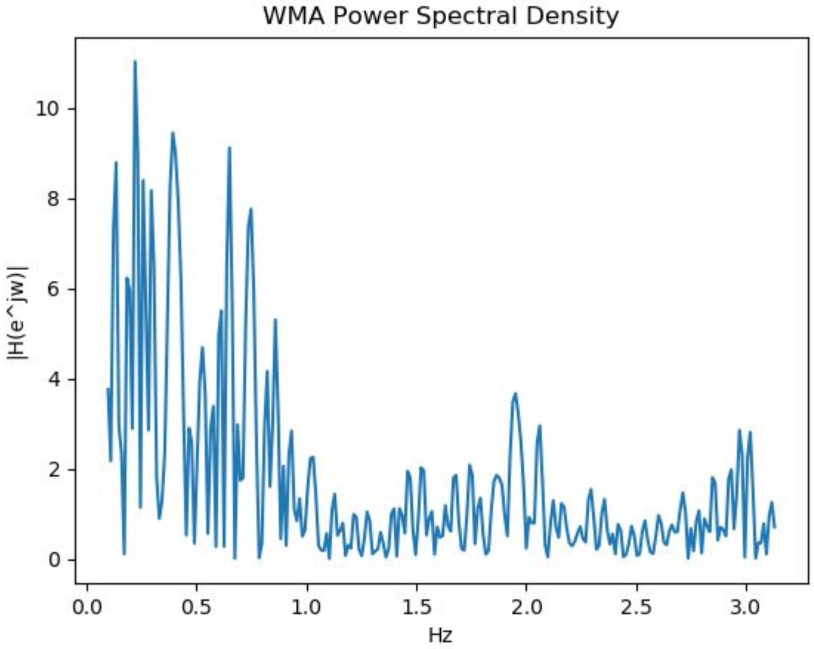
Filter #5 WMA Filter(.2π cutoff)



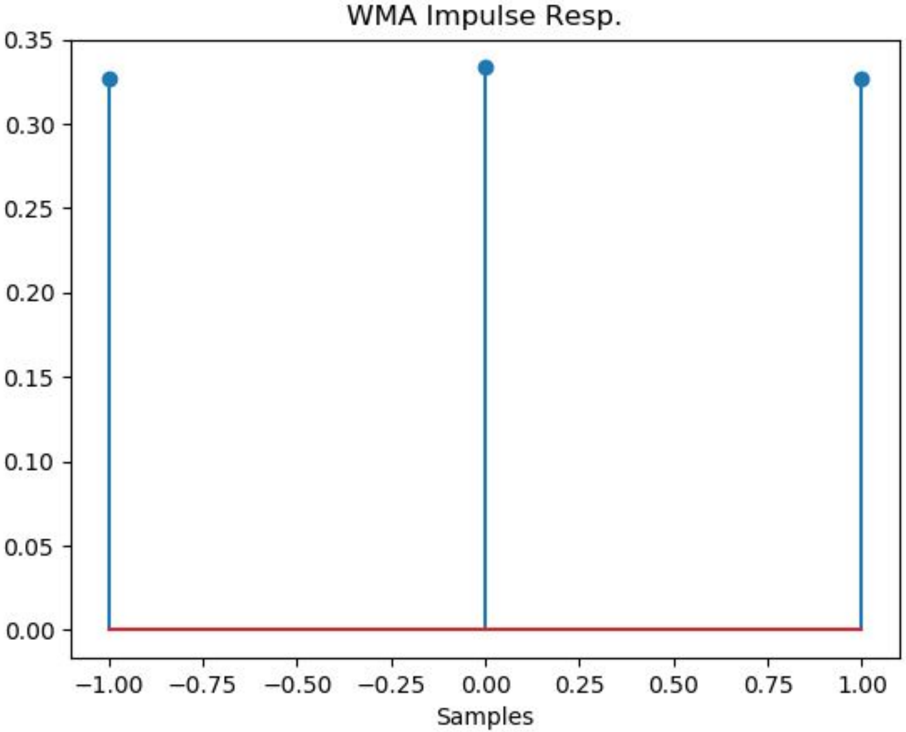


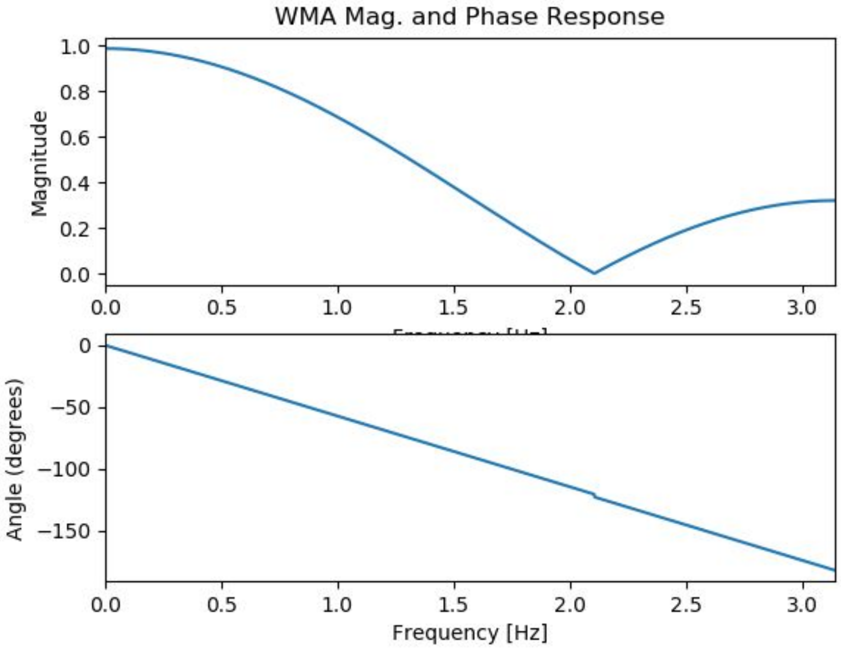
Filter #5 WMA Filter(.2π cutoff)



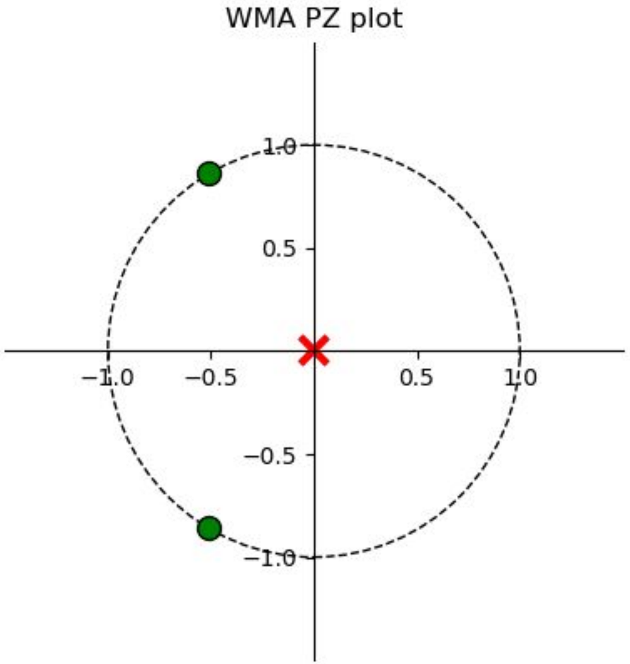


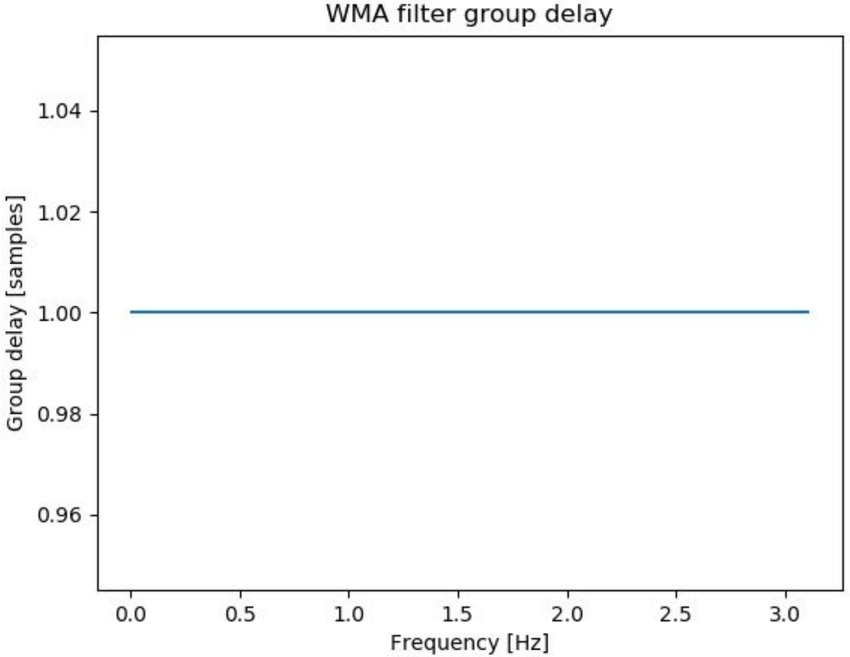
Filter #5 WMA Filter(.3π cutoff)



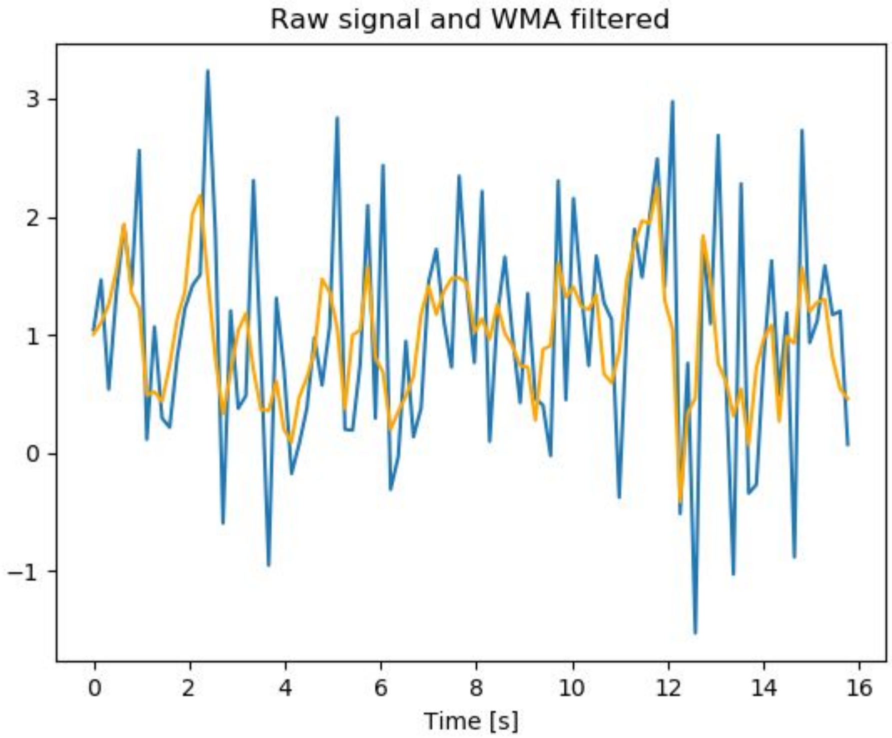


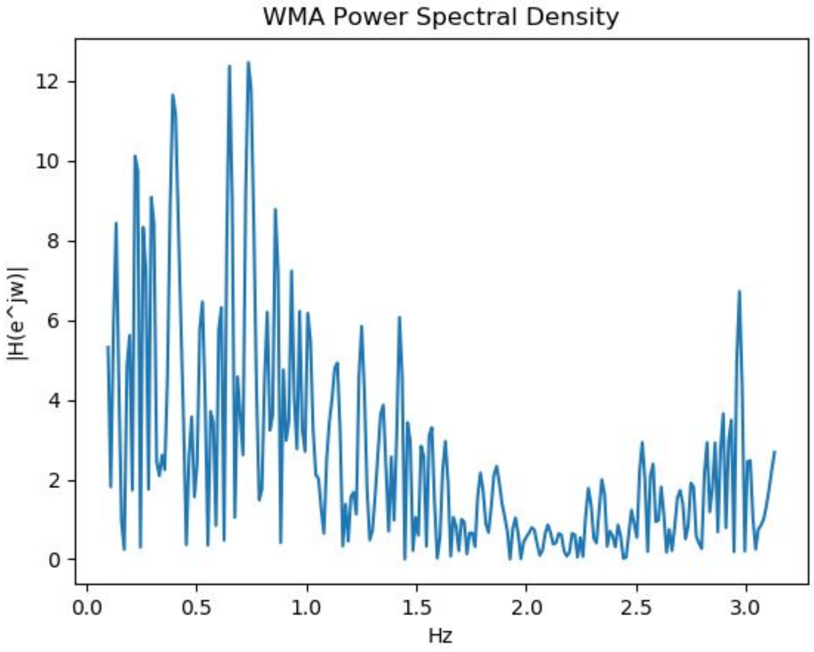
Filter #5 WMA Filter(.3π cutoff)





Filter #5 WMA Filter(.3π cutoff)

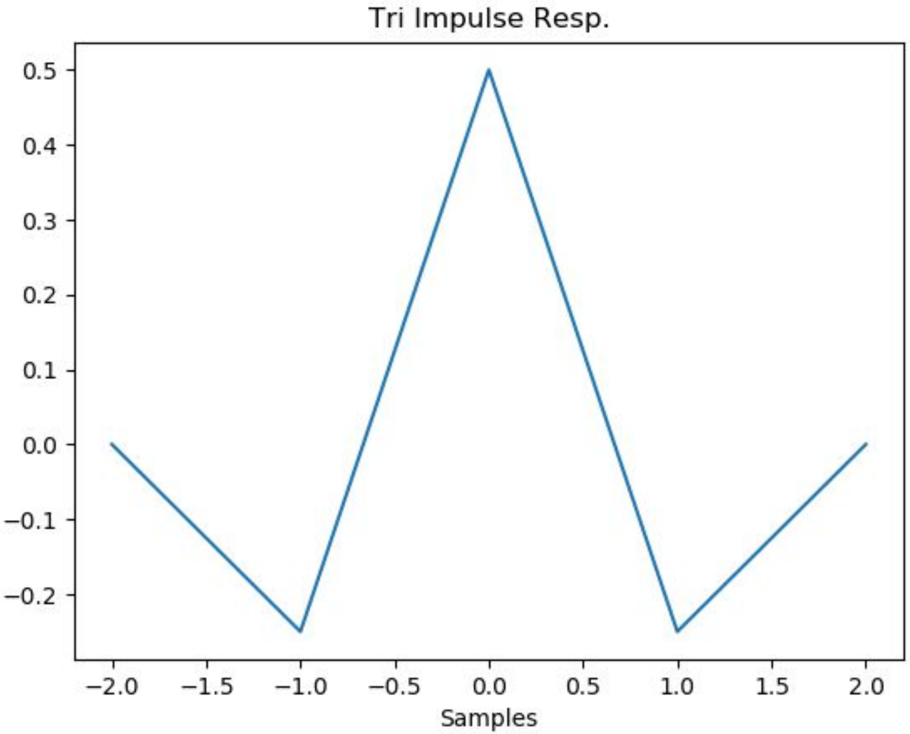


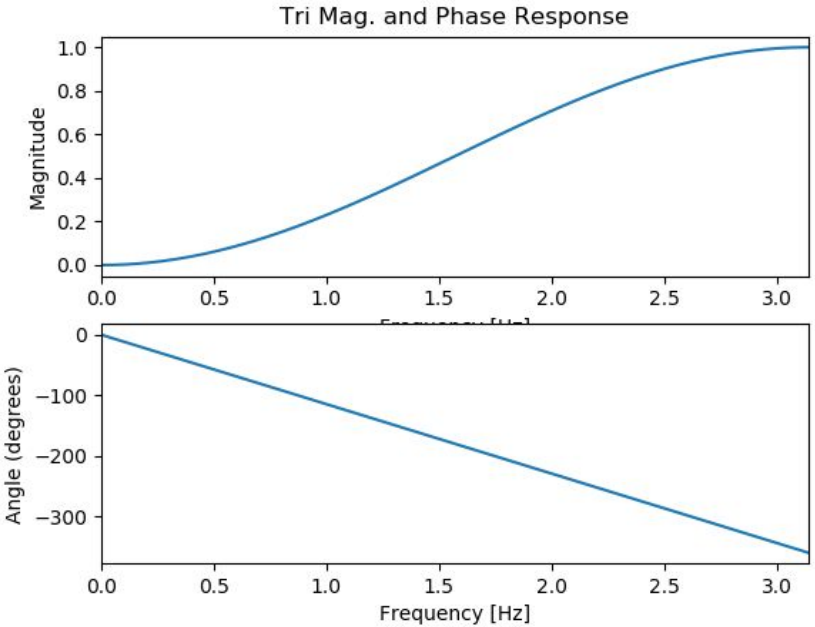


WMA Filter Explanation

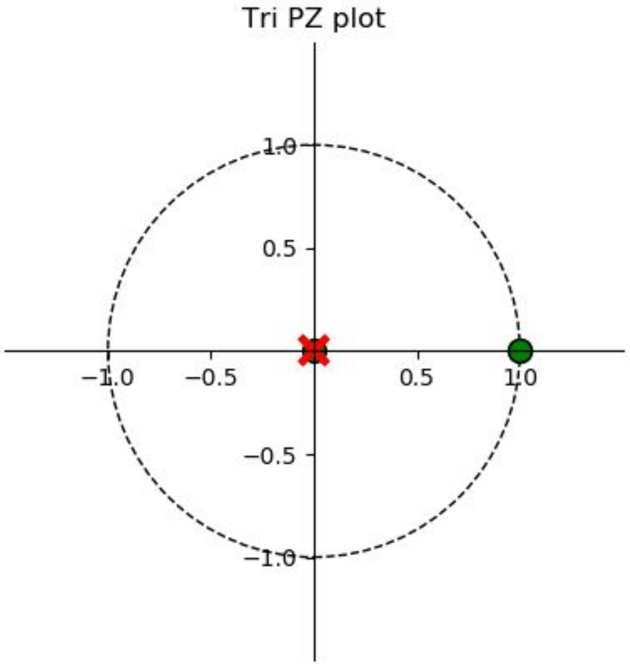
- $b[n] = \alpha^{(n)}$
- Fits the noncausal, symmetric, and positive
- Numerator coefficients were normalized by sum of the numerator coefficients

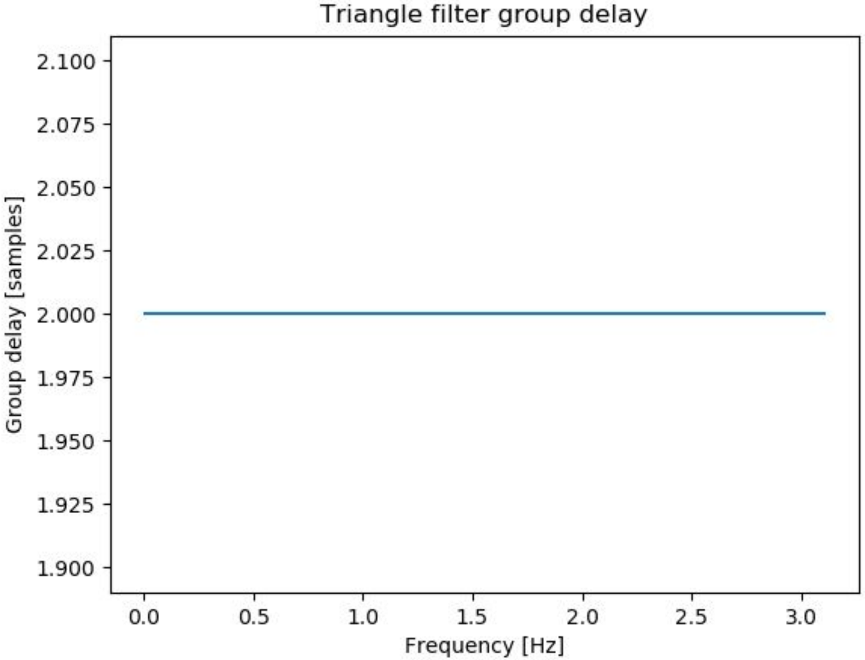
Filter #1 Triangle HP Filter



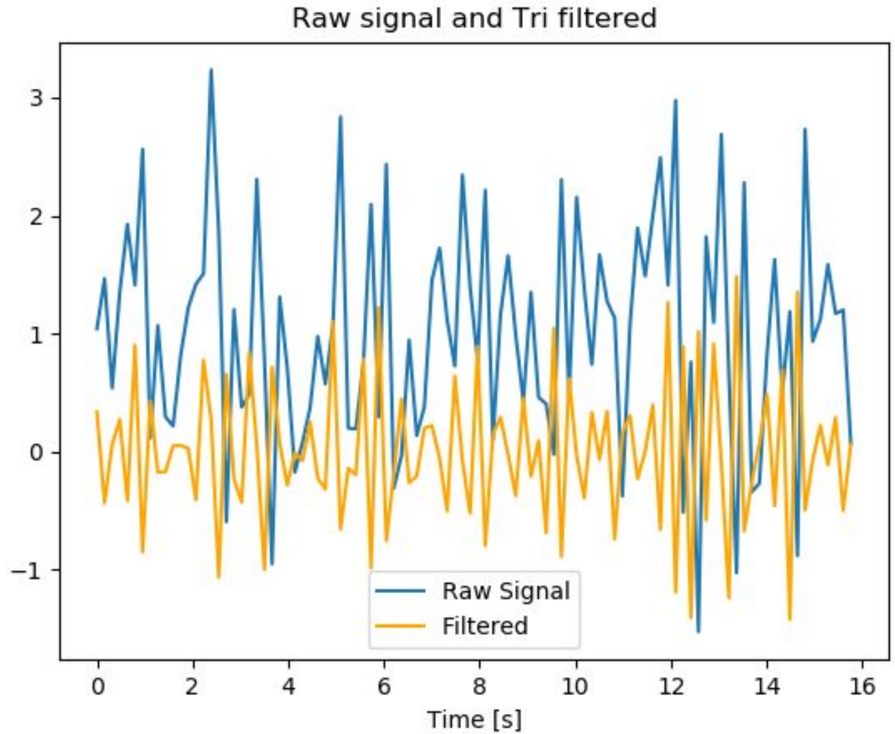


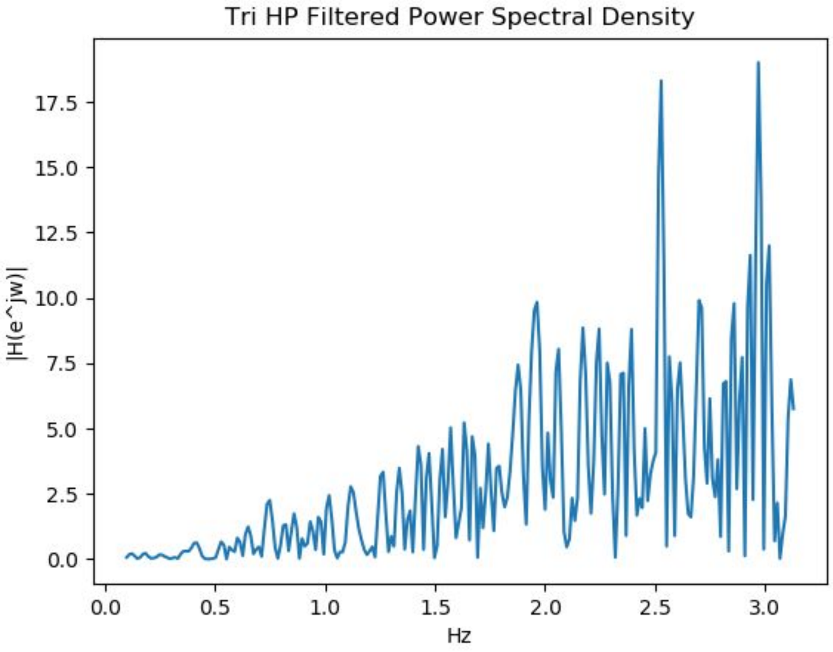
Filter #1 Triangle HP Filter



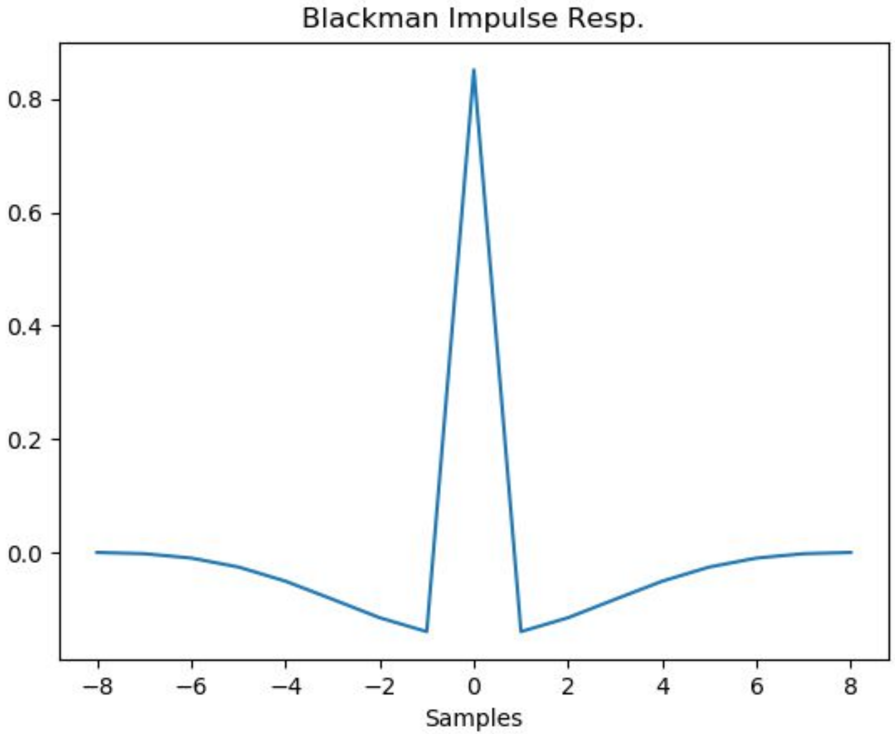


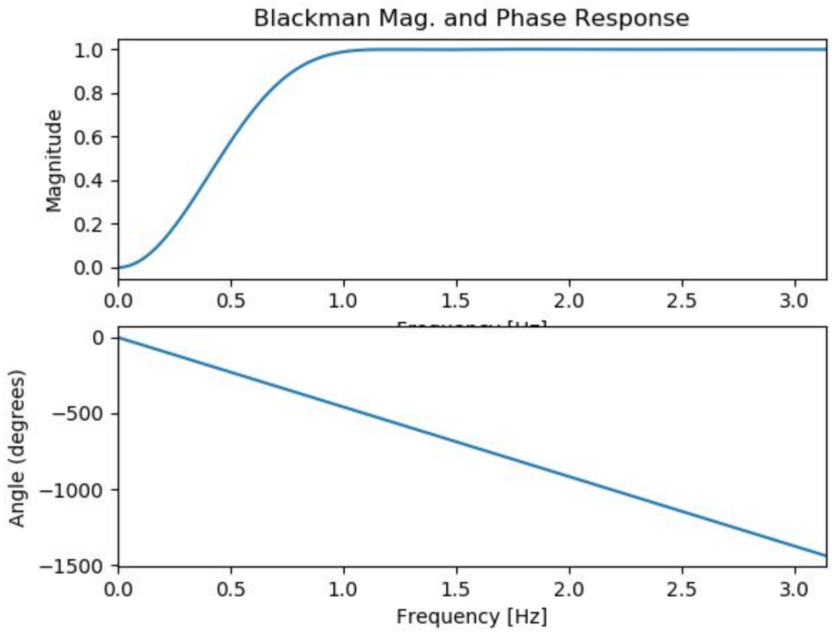
Filter #1 Triangle HP Filter



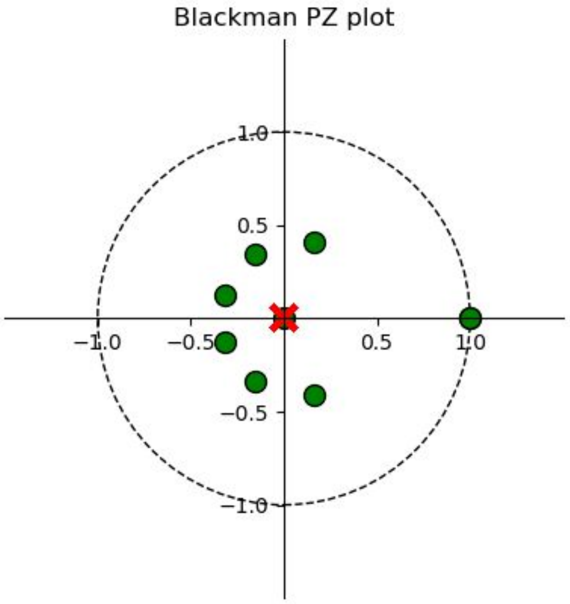


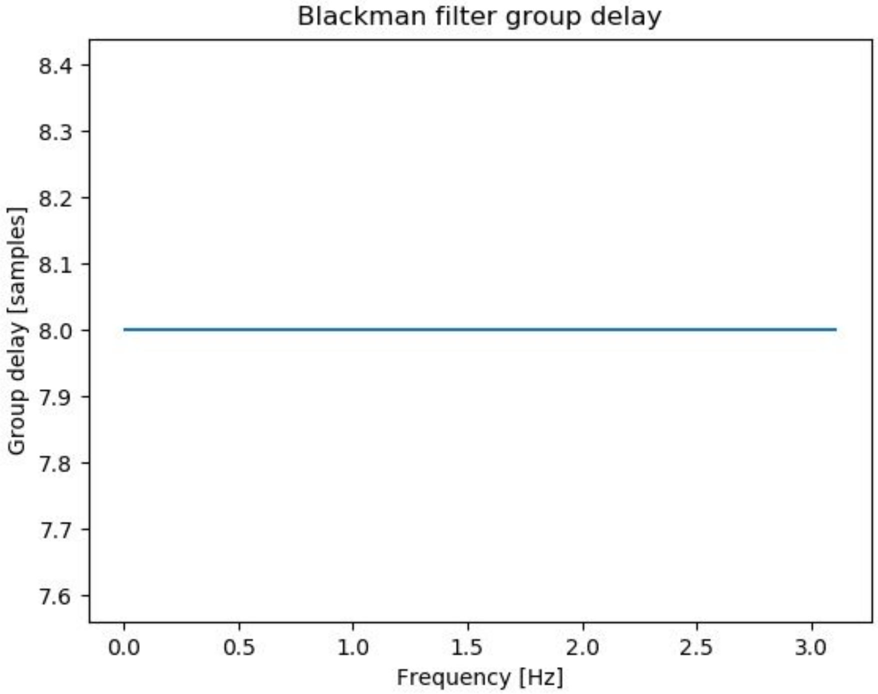
Filter #2 Blackman High Pass Filter



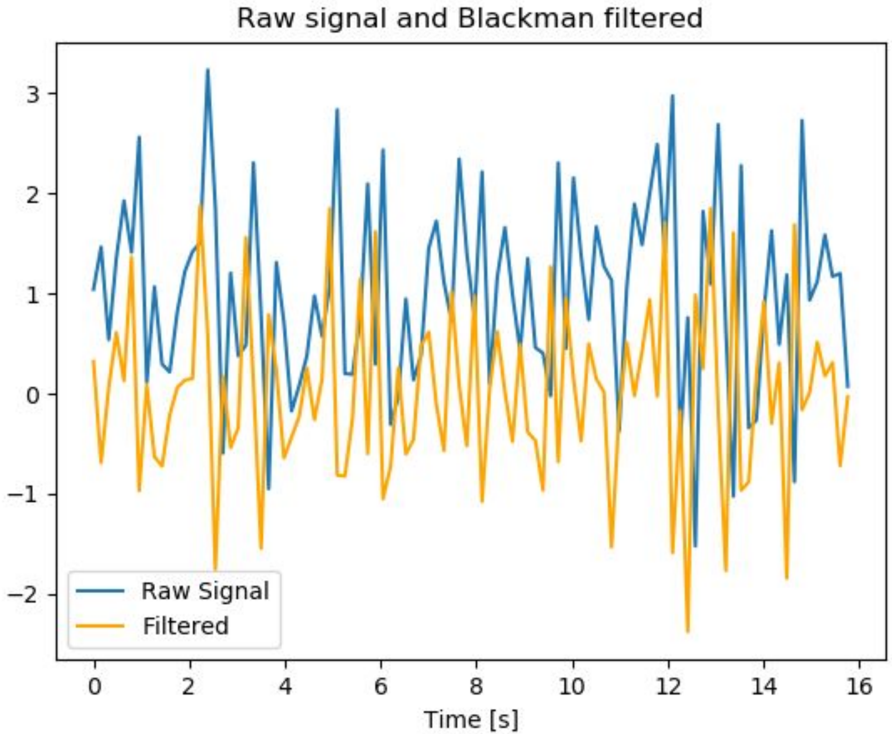


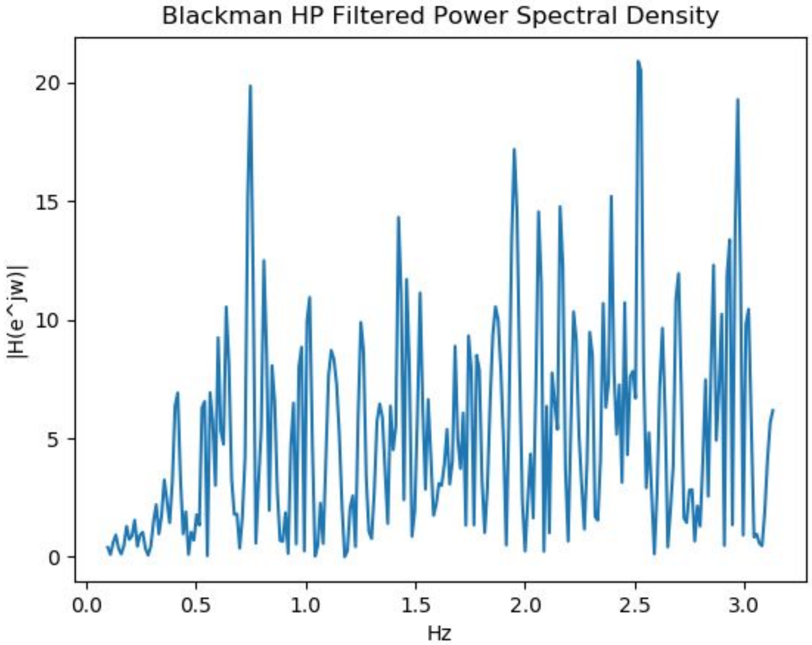
Filter #2 Blackman High Pass Filter



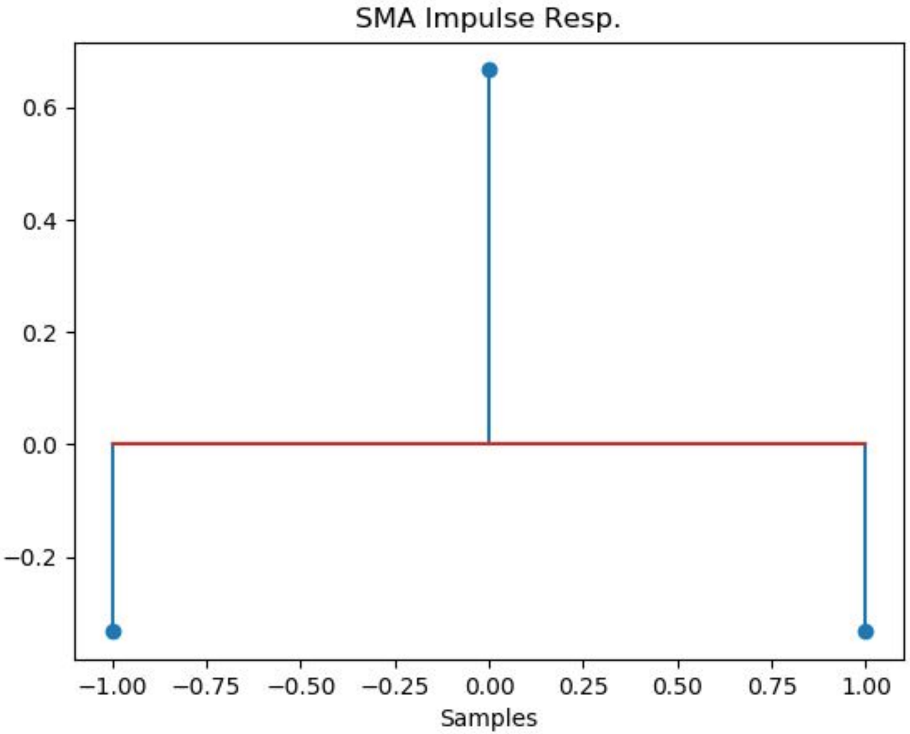


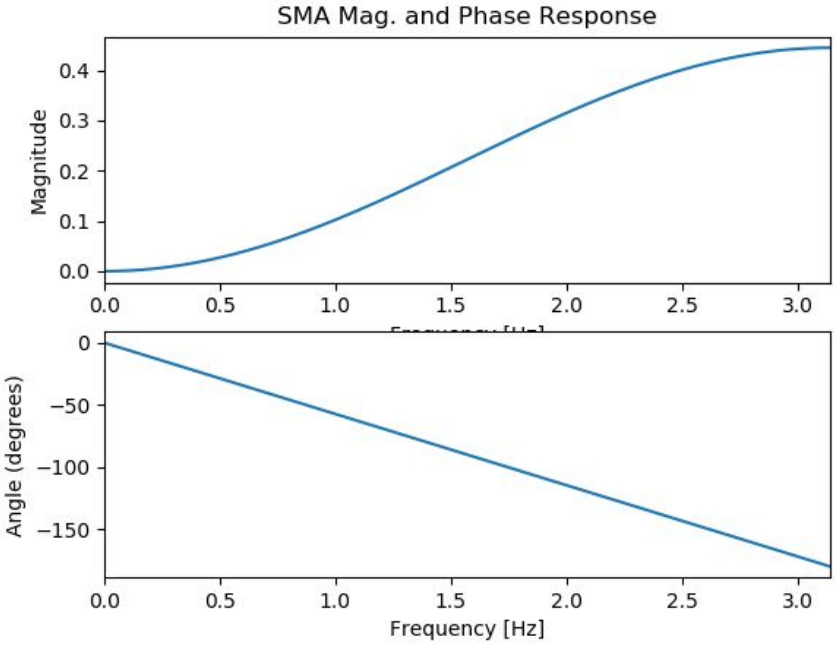
Filter #2 Blackman High Pass Filter



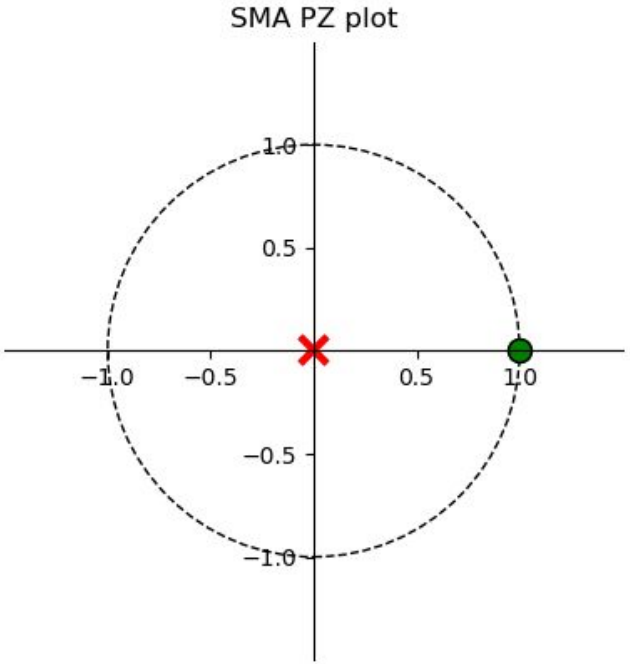


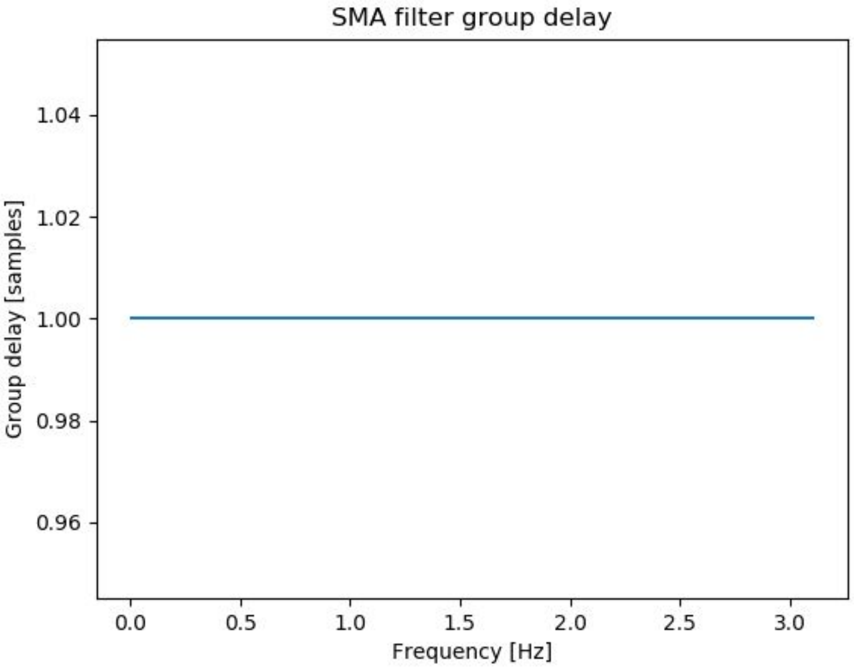
Filter #3 SMA HP Filter



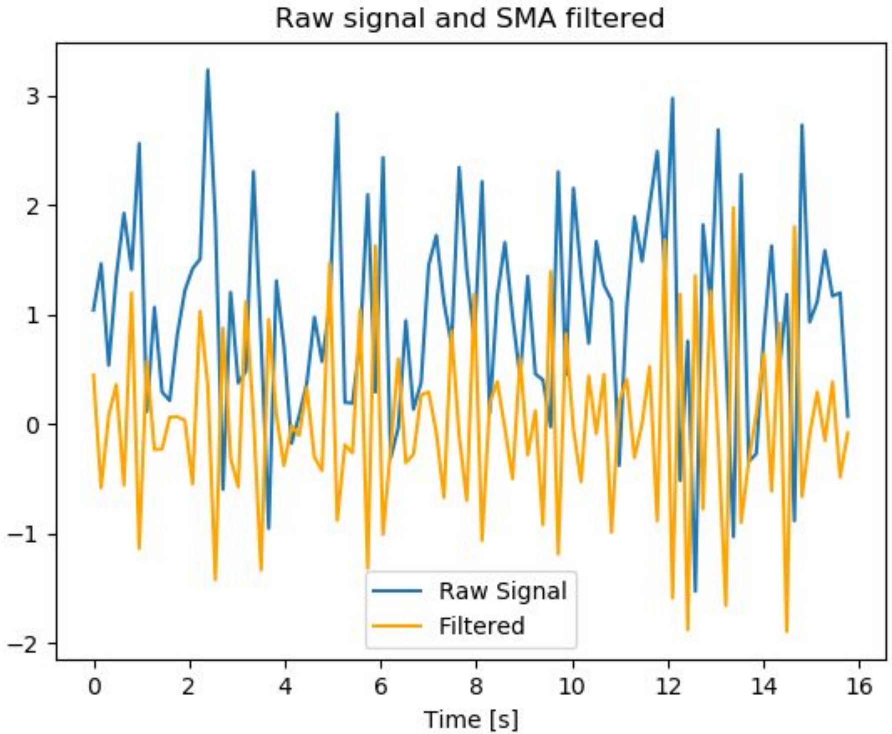


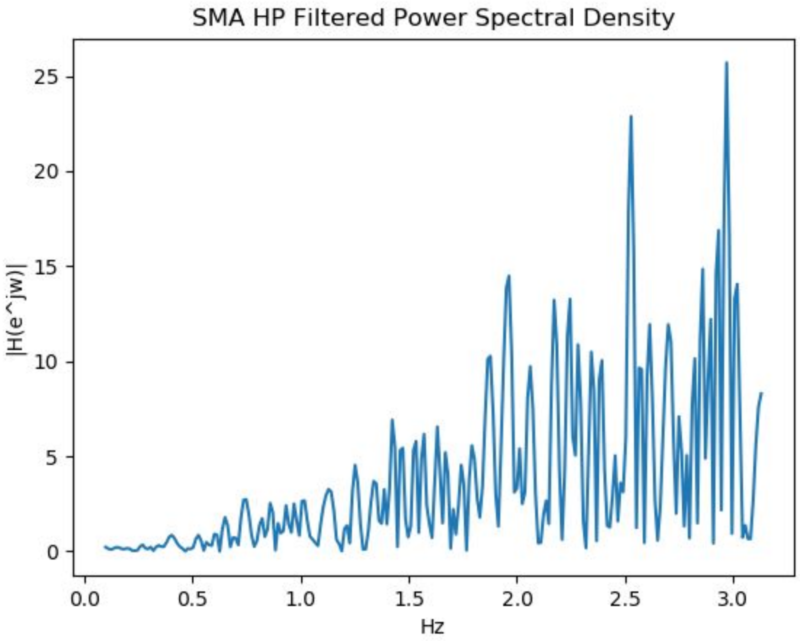
Filter #3 SMA HP Filter



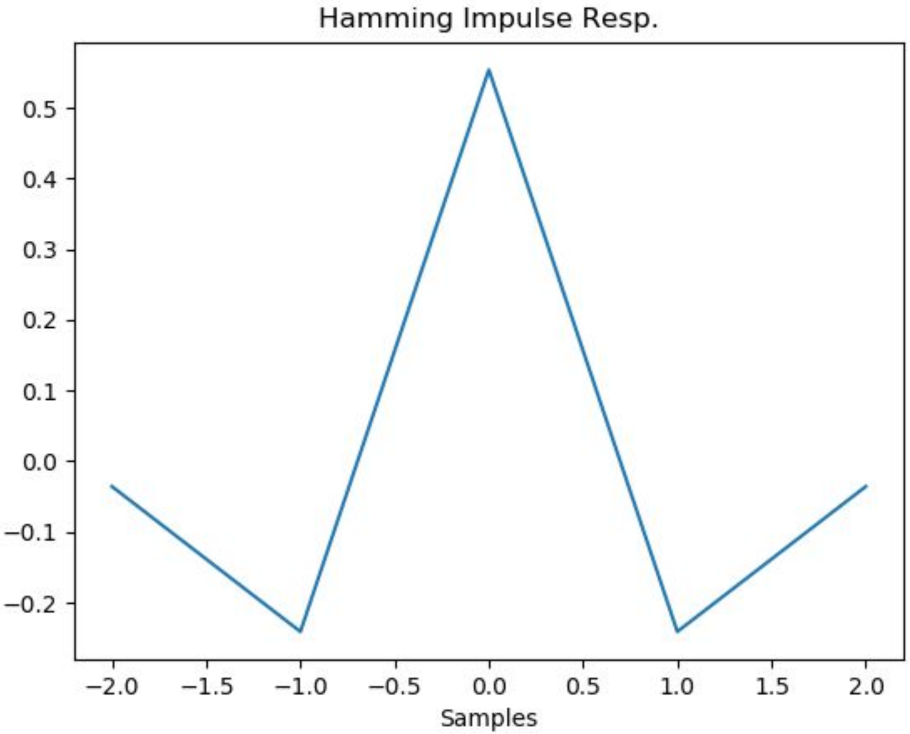


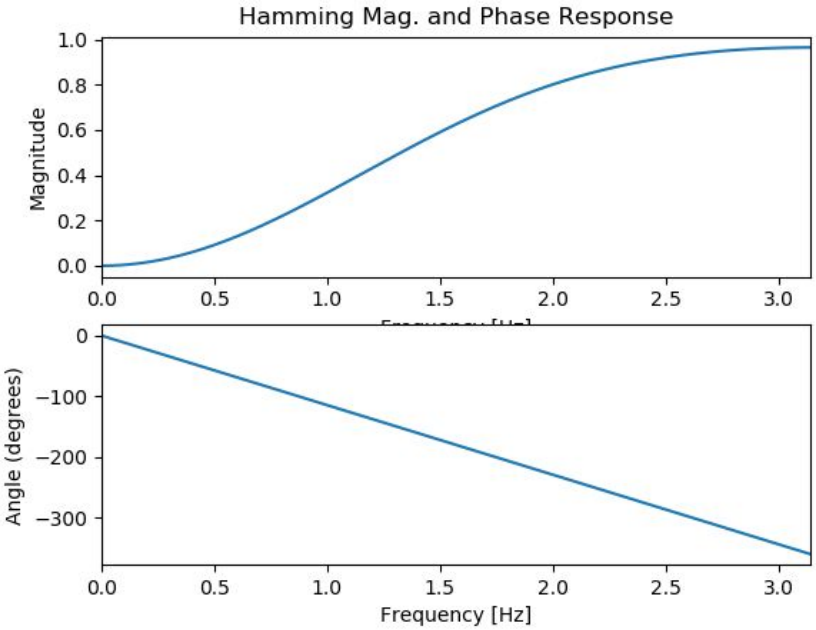
Filter #3 SMA HP Filter



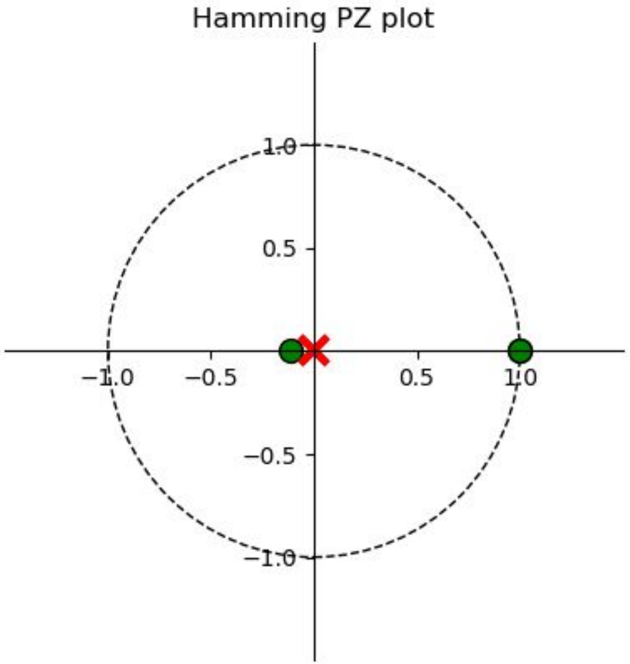


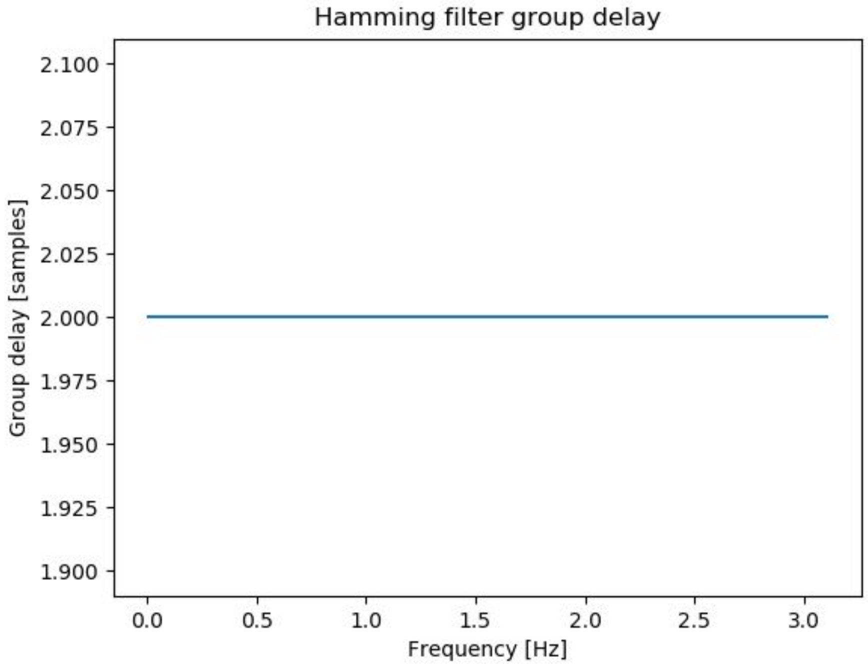
Filter #4 Hamming HP Filter



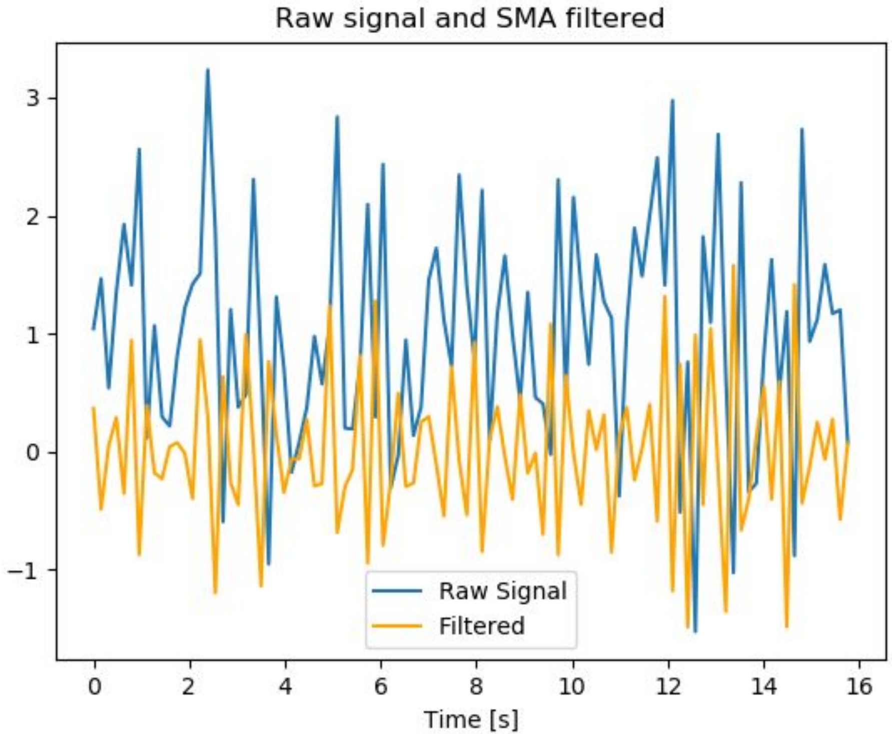


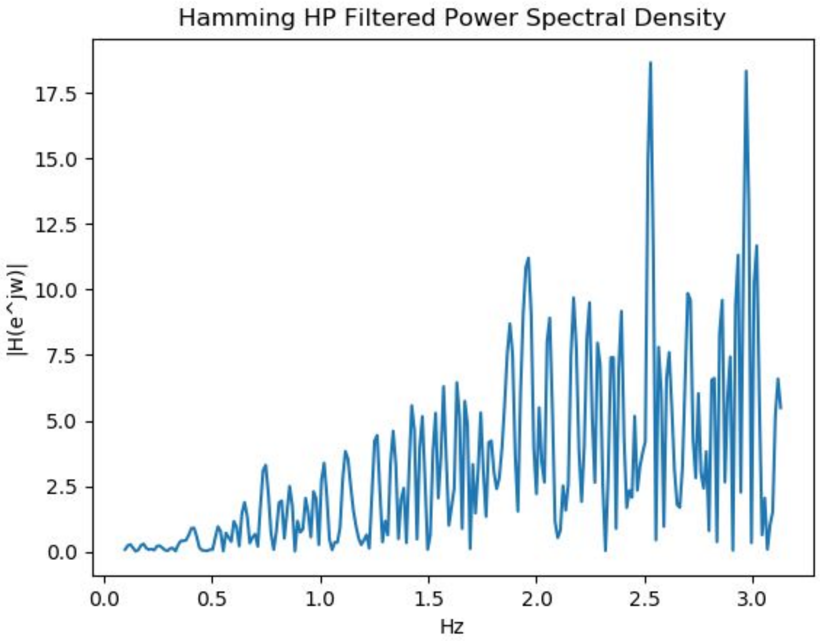
Filter #4 Hamming HP Filter



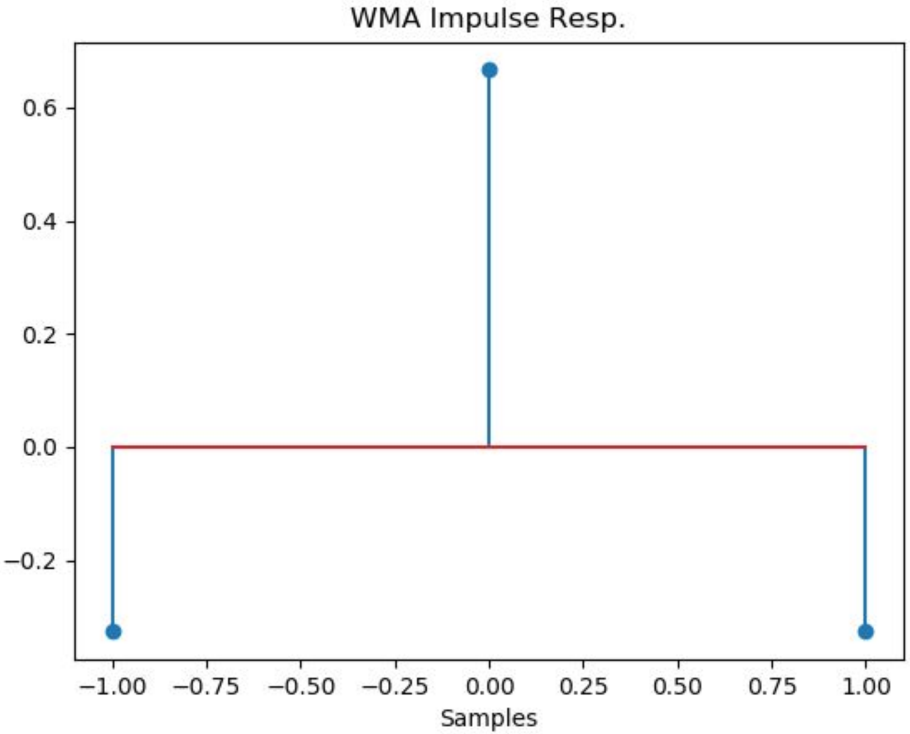


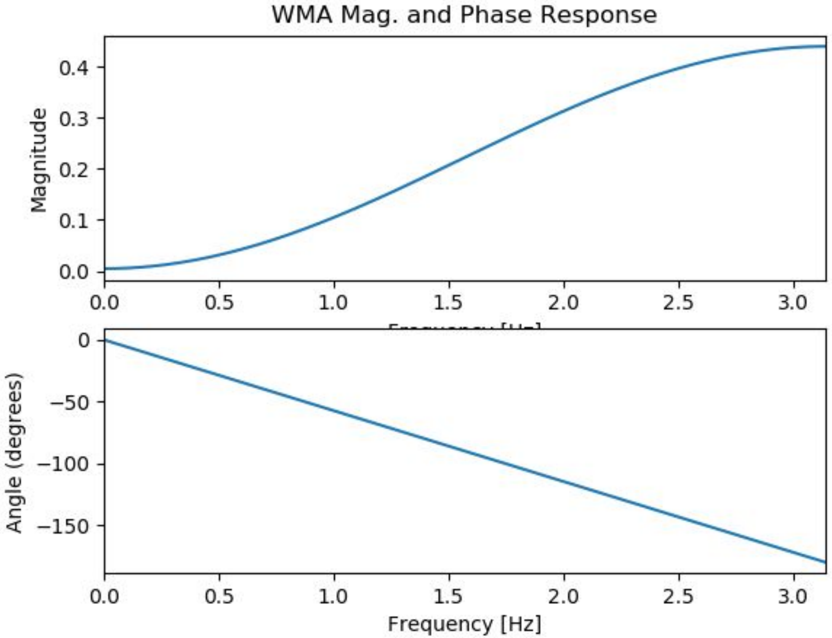
Filter #4 Hamming HP Filter



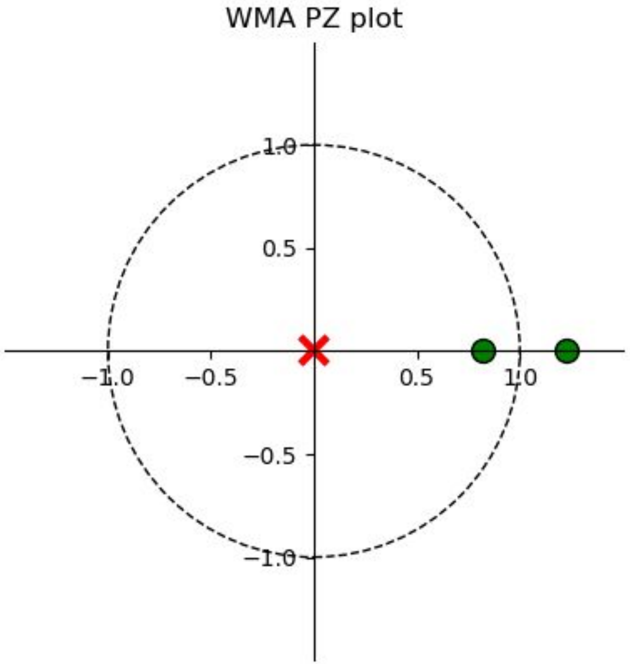


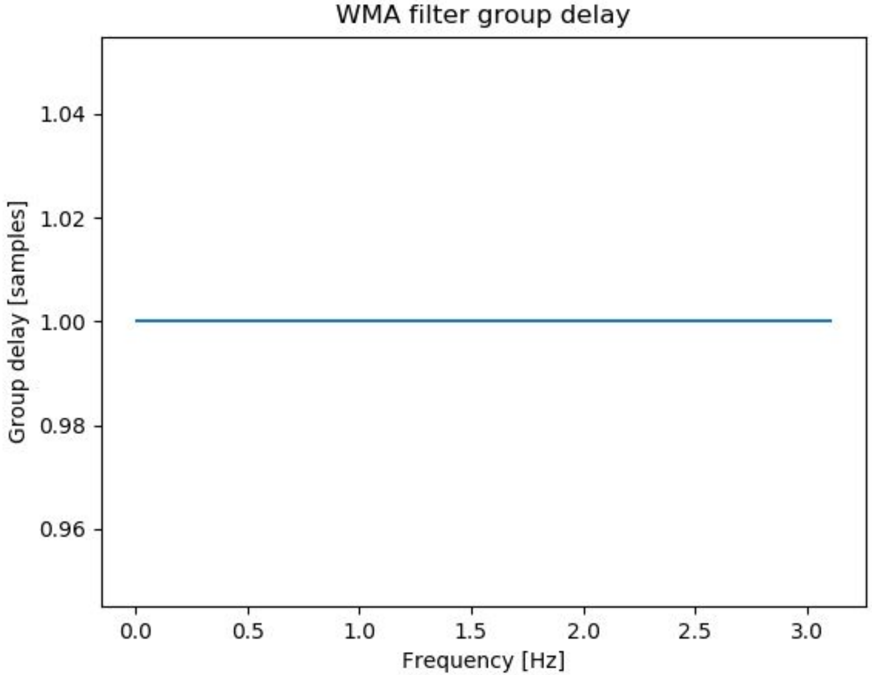
Filter #5 WMA HP Filter



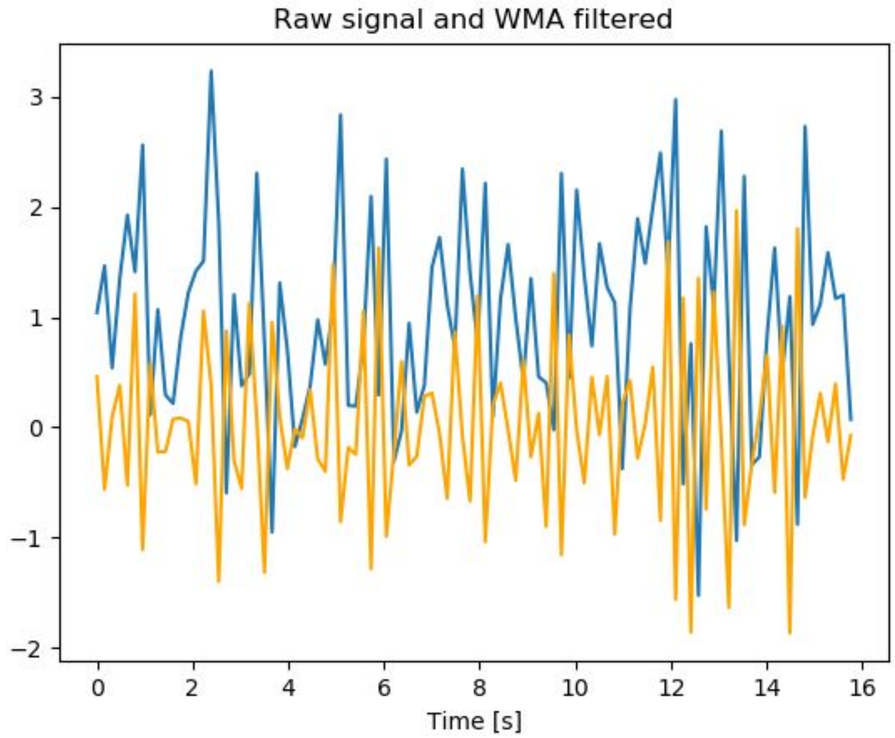


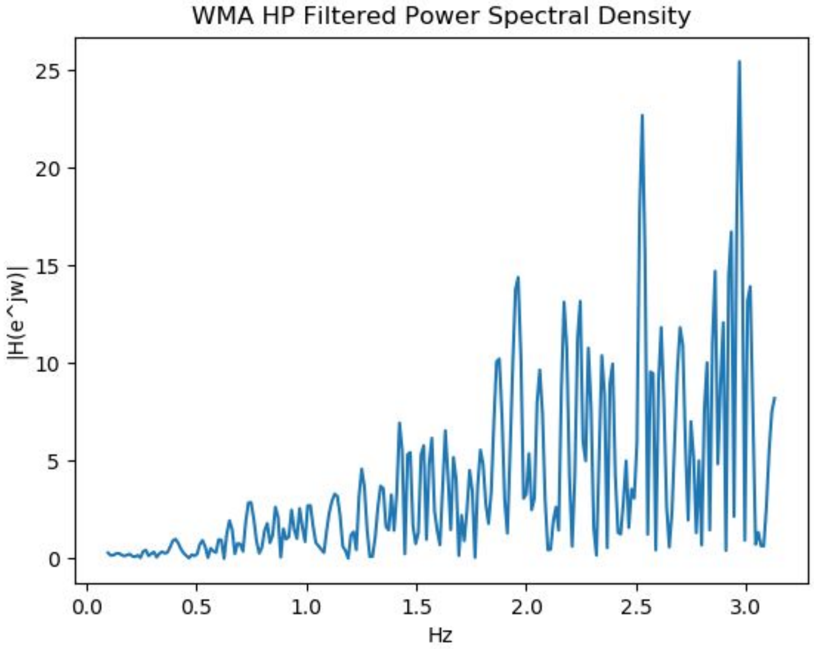
Filter #5 WMA HP Filter





Filter #5 WMA HP Filter





Handling Edge Conditions and Use cases

- **Edge conditions:** I wrote a convolution function to perform a non-causal convolution.
    - i.e using future data values that don't exist in the original recording
    - For all filters, concatenated equivalent statistic white noise edges where filter has no overlap with signal
    - I believe this is an appropriate method because we can assume that the signal is WSS
- **Tradeoffs:**
    - All these noncausal, symmetric, and positive filters have linear phase and are FIR.
        - These types of filters would be most appropriate in applications where phase behavior is a priority
    - These filters are also better for applications with signals that only take on positive values. A well designed frequency selective filter might have some pos./neg. Magnitude ripple that creates negative amplitude artifacts in the output signal.
    - Noncausal, symmetric, and positive FIR filters will be less frequency selective in comparison.