BME 544 Assignment 3

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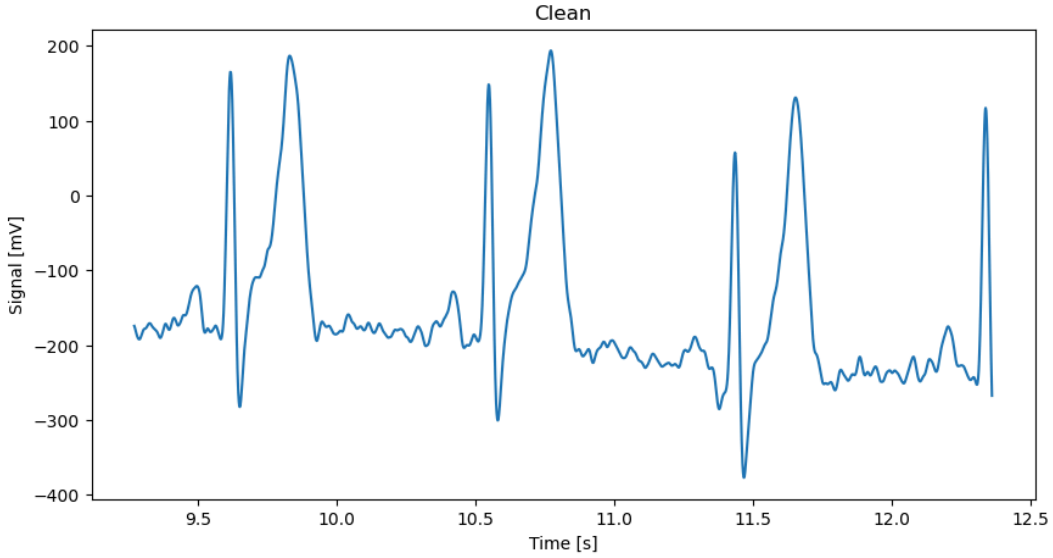
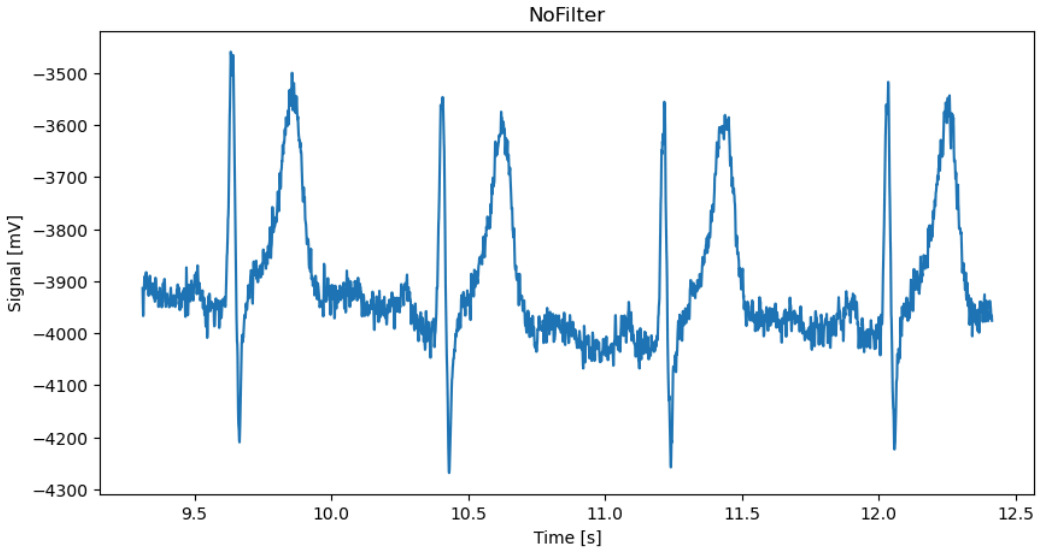
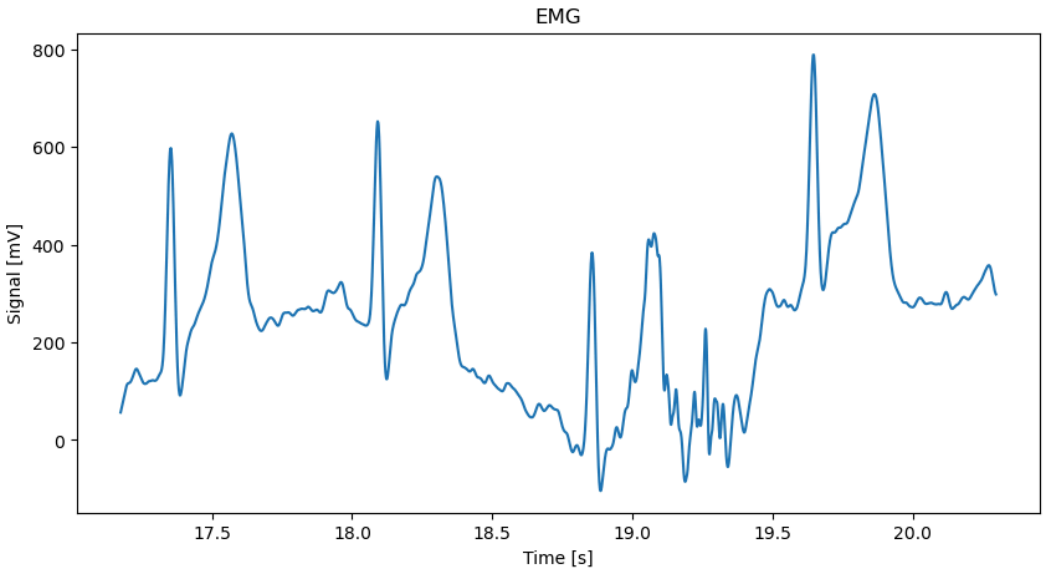
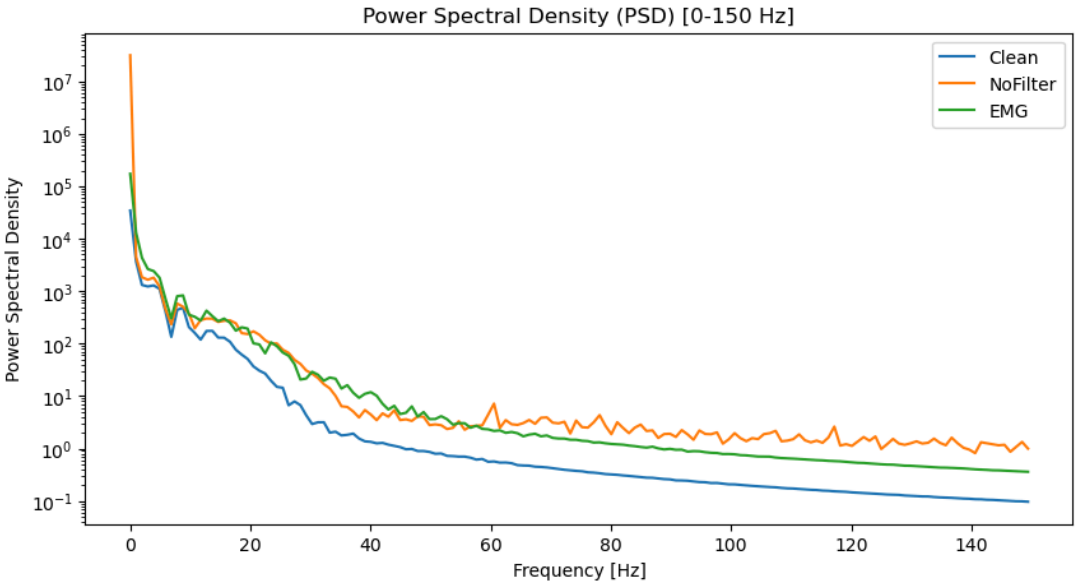
1: Examine Recordings

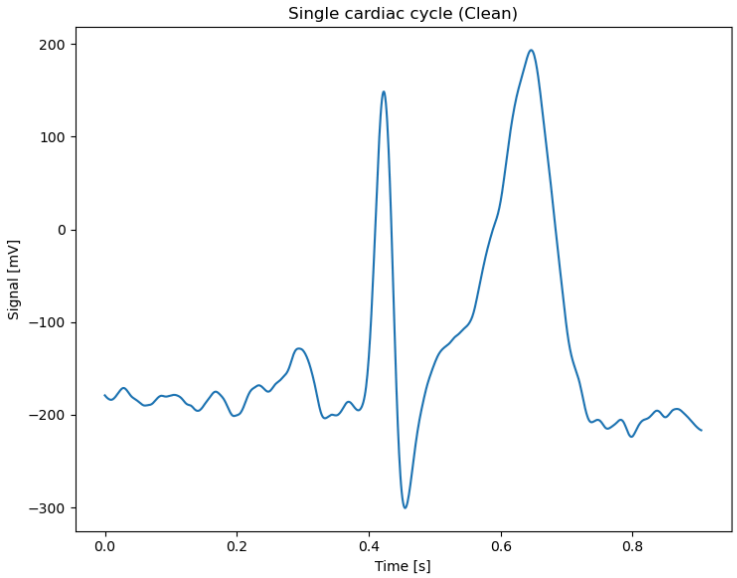


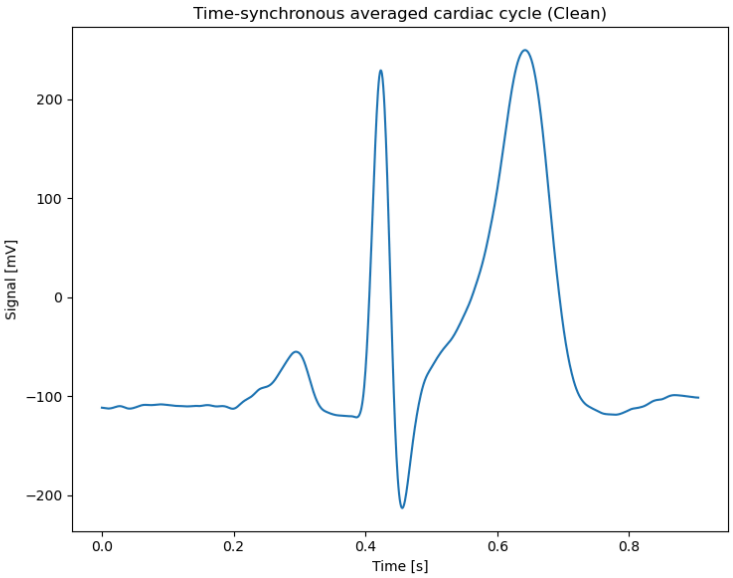


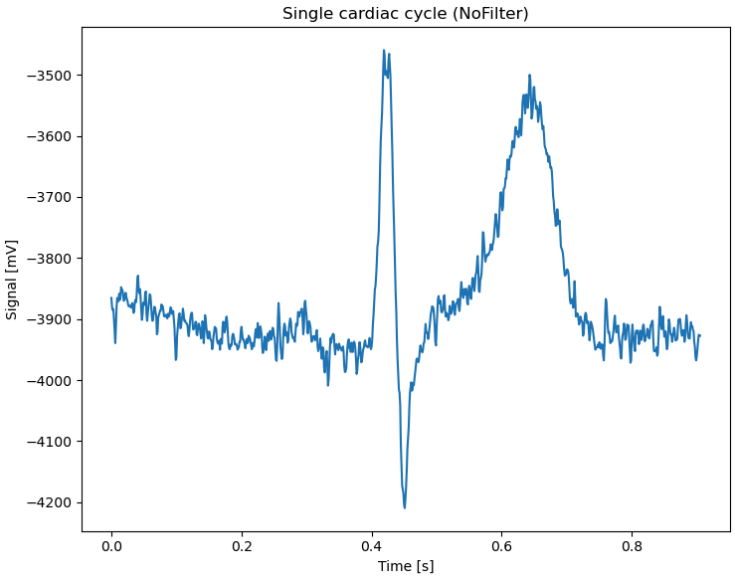


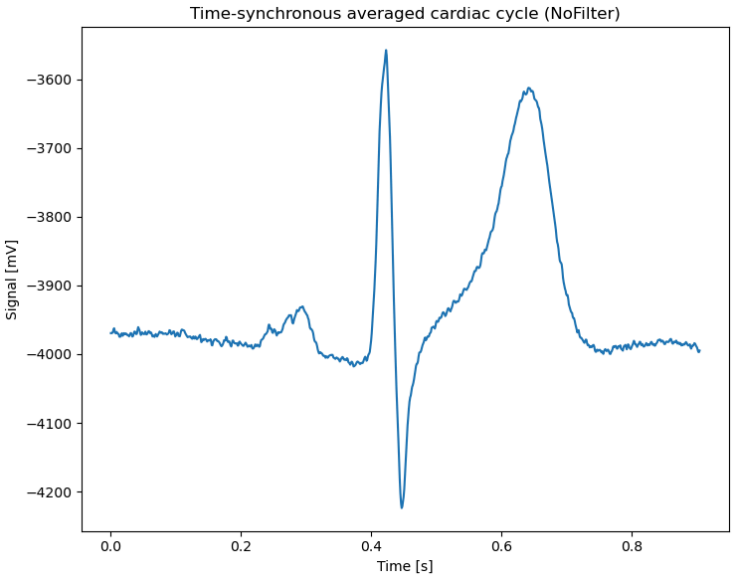

Power Spectral Density (PSD) [0-150 Hz]
Clean
NoFilter
EMG
Power Spectral Density
Frequency [Hz]
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
0
20
40
60
80
100
120
140

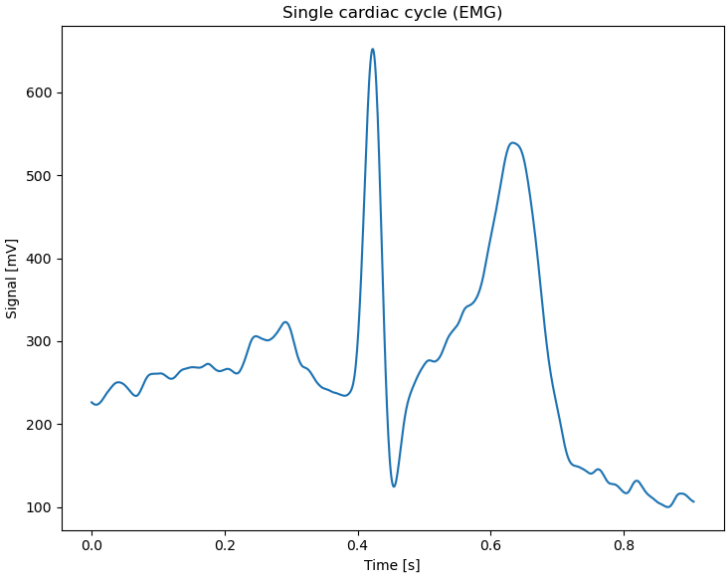
2: Time-synchronous Averaging

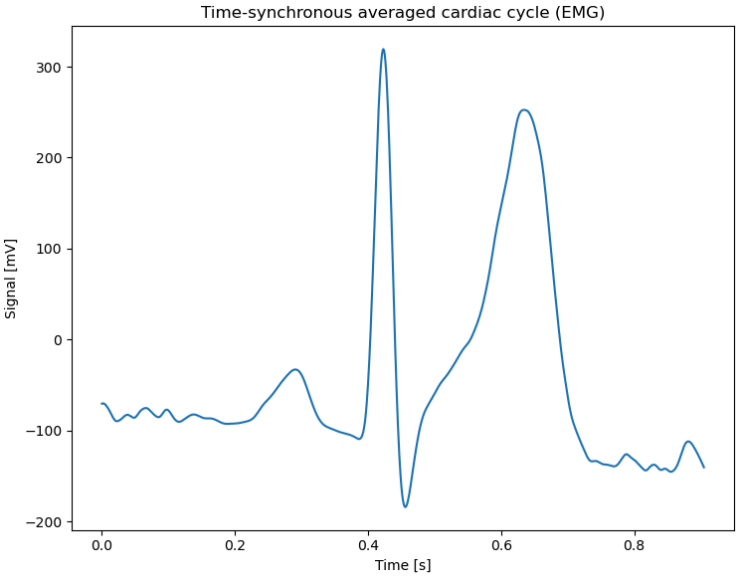




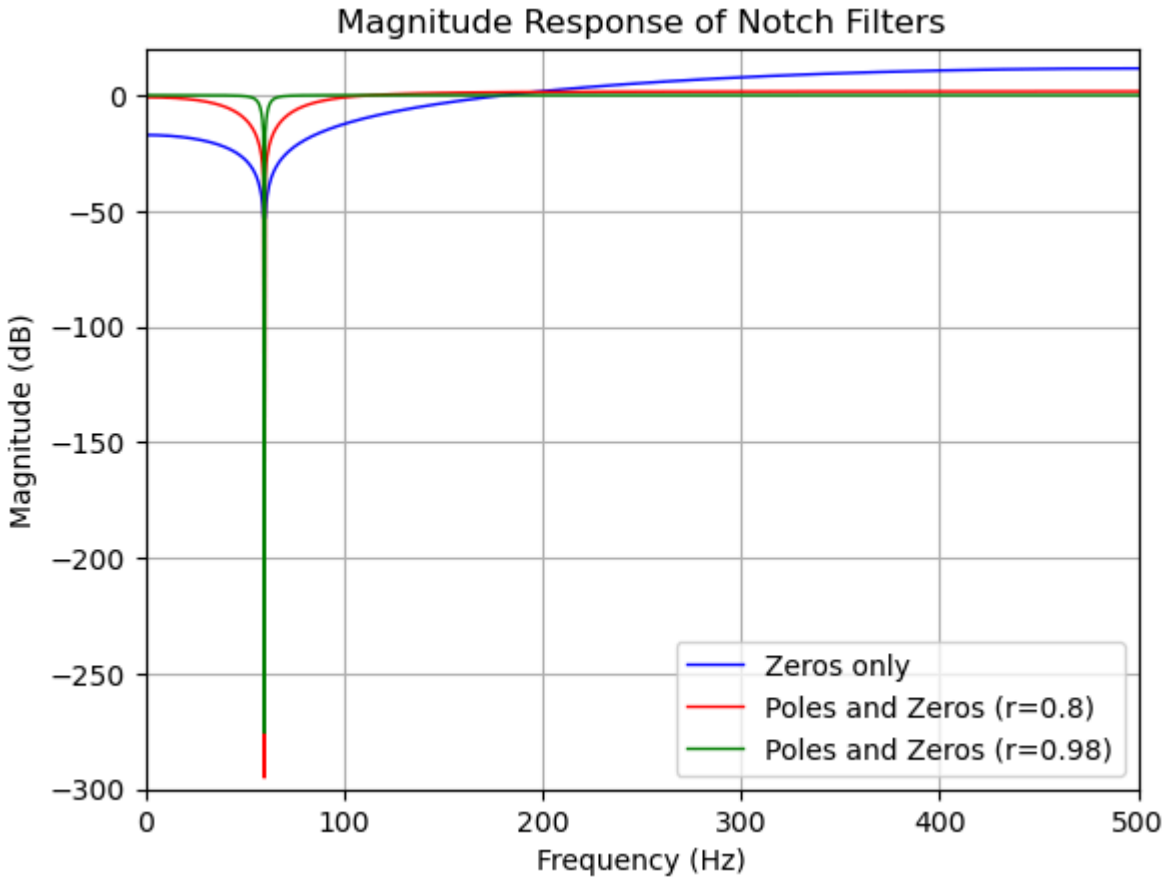

Single cardiac cycle (NoFilter)
Signal [mV]
Time [s]


Time-synchronous averaged cardiac cycle (NoFilter)
Signal [mV]
Time [s]

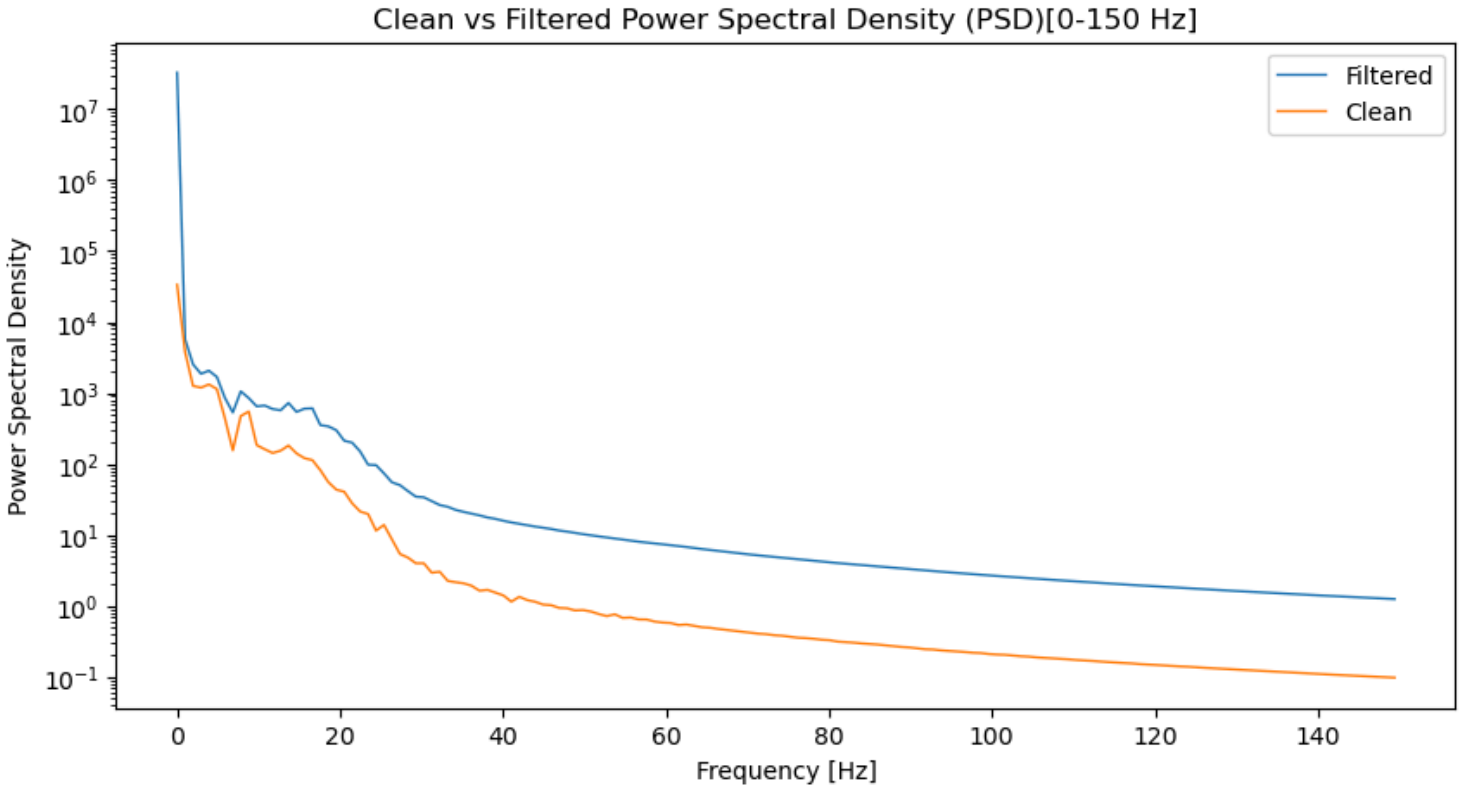

Single cardiac cycle (EMG)
Signal [mV]
Time [s]

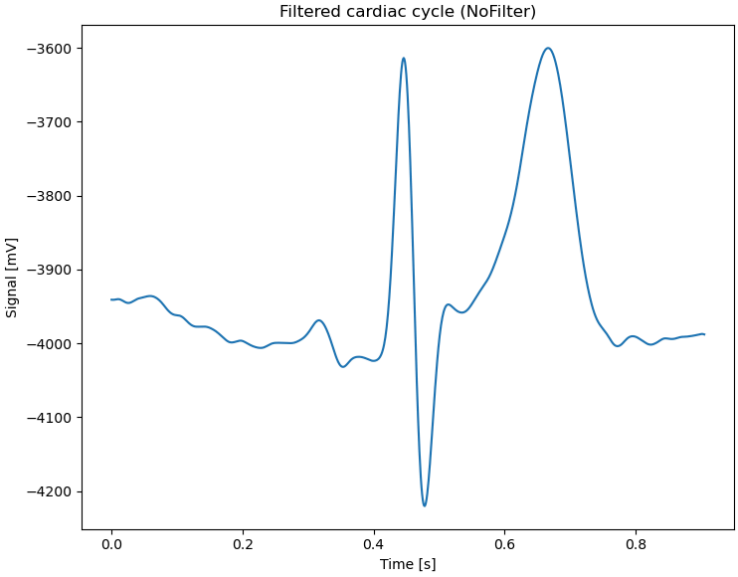

Time-synchronous averaged cardiac cycle (EMG)
Signal [mV]
Time [s]

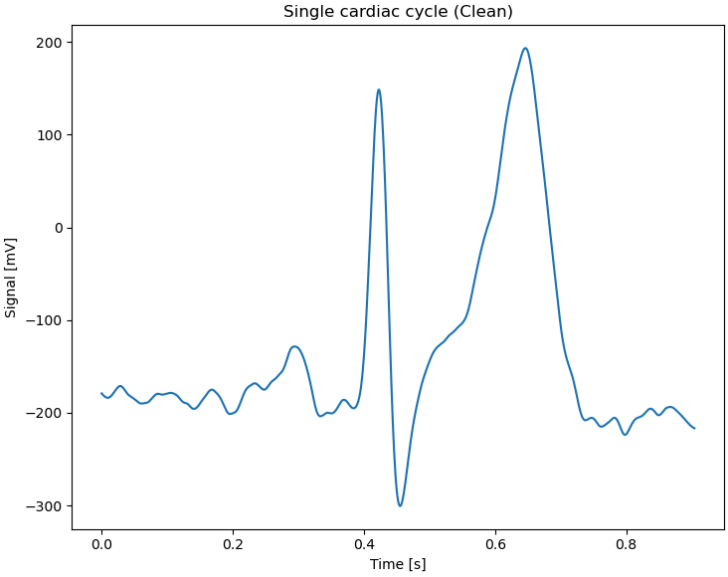
3: Notch Filter



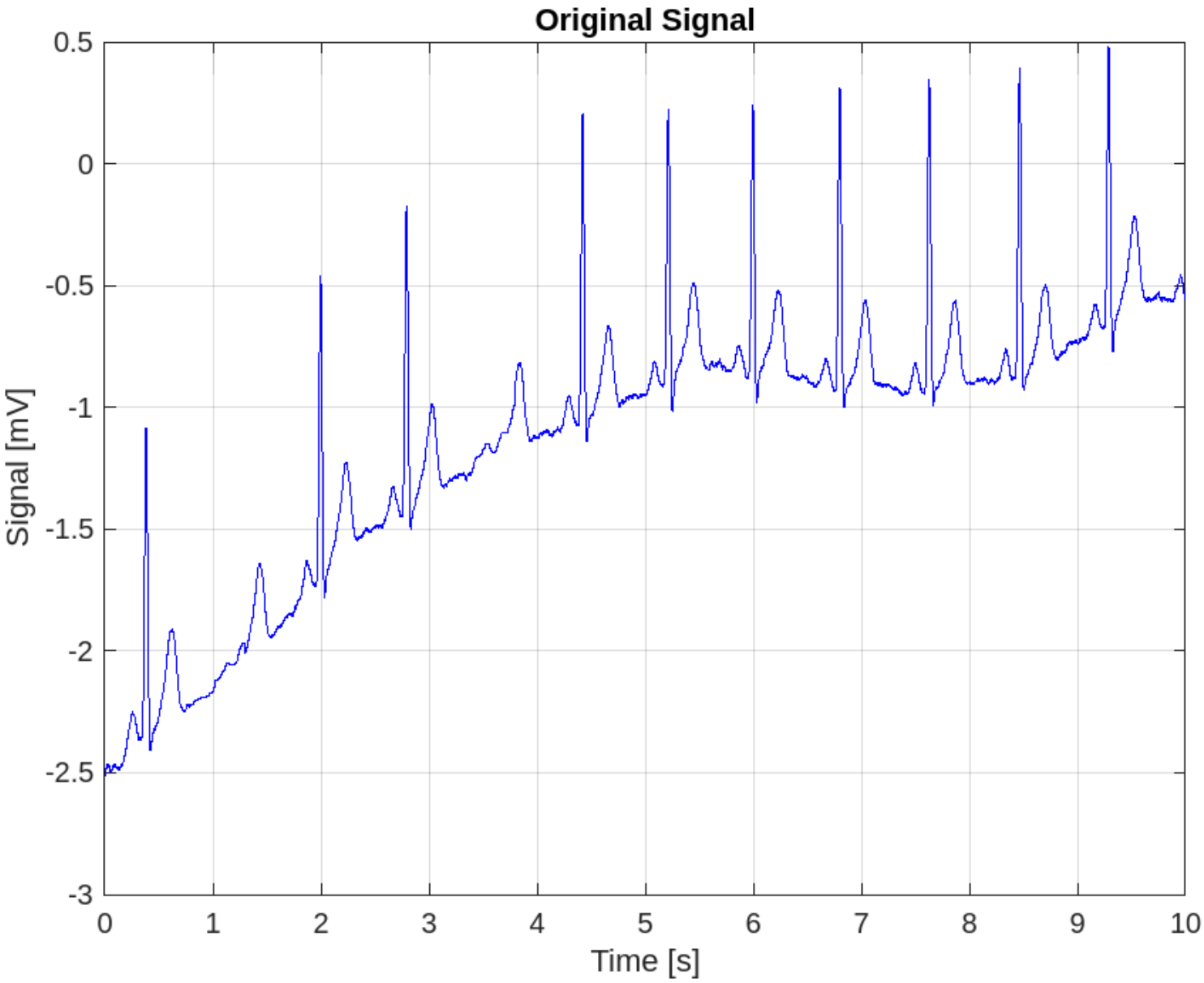
4: Low-pass Filter

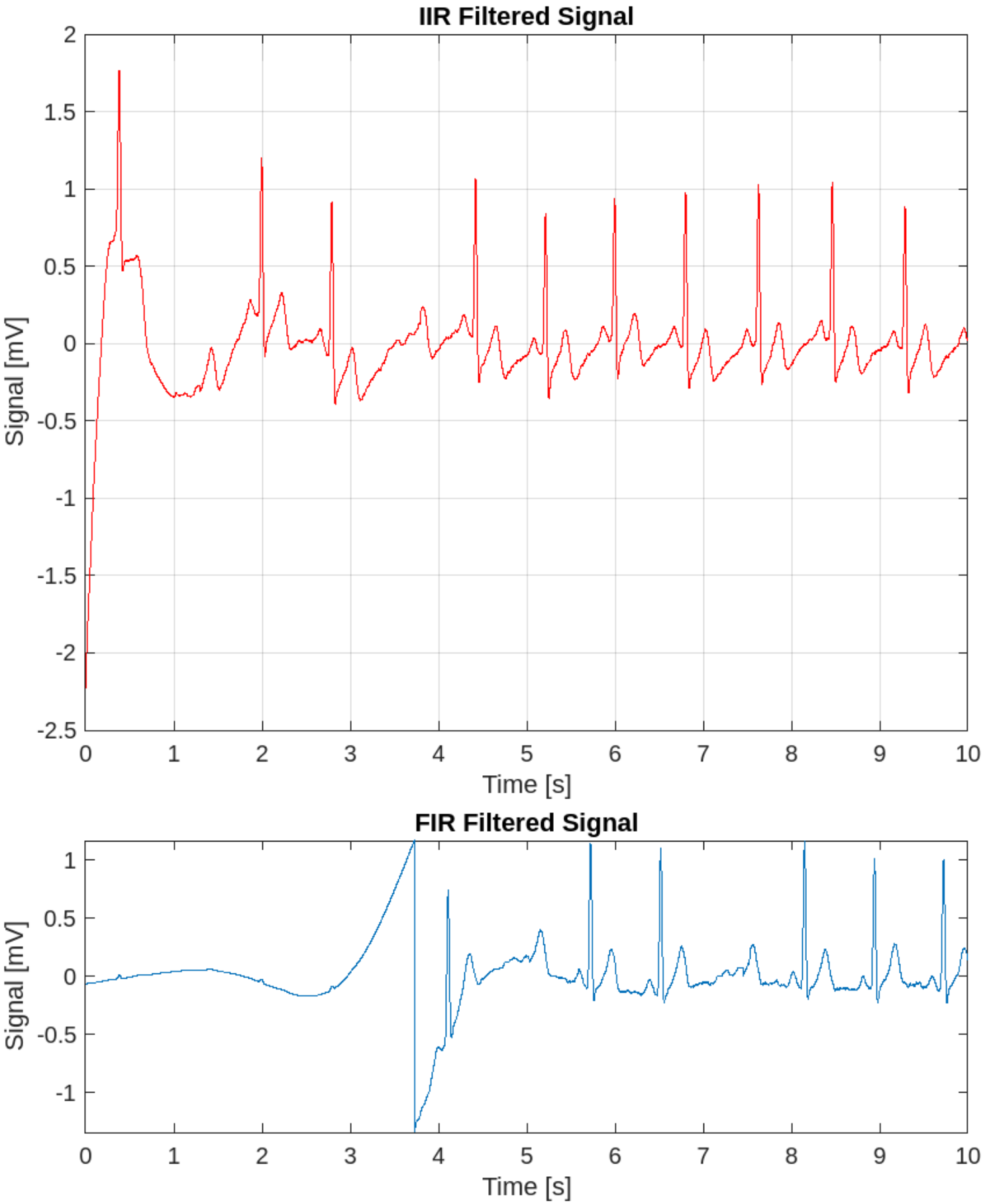






5: High-pass Filter




IIR Filtered Signal
Signal [mV]
Time [s]
FIR Filtered Signal
Signal [mV]
Time [s]

6: Questions

1. Another example where analog filtering prior to sampling is important is in noise suppression in environments with high levels of electromagnetic interference. For instance, in medical devices or sensitive scientific instruments, signals often have a low signal-to-noise ratio (SNR), and external sources of noise (such as power lines, radiofrequency interference, or nearby equipment) can corrupt the measurements. In such cases, analog filters—such as low-pass or band-pass filters—can be used to attenuate high-frequency noise before the signal is digitized by the ADC. By performing this filtering in the analog domain, the noise is reduced, and the ADC can focus on the desired signal, resulting in a cleaner digital representation. This helps to improve the overall performance of the system, as noise can sometimes leak into the sampled signal, degrading the quality of the data and making subsequent digital filtering less effective.
2. When poles are added near the zeros but with a magnitude less than 1 (e.g., r = 0.8 or r = 0.98), they create a more selective filtering effect, narrowing the frequency band where the filter strongly attenuates signals. This is because the poles add resonance around the notch frequency. This results in a sharper notch, which means a much narrower stopband and lower passband attenuation.
3. From the phase response and group delay plots in Question 5, it was evident that the IIR filter has a non-linear phase response (non-linear group delay), and the FIR filter has a linear phase response (constant group delay). Since the FIR filter preserves the original timing relationships between frequency components, the overall shape of the ECG waveform remains intact, which would be more appropriate for diagnostics. Since the IIR filter is able to process the signal in real-time, it would be the more appropriate option for a heart rate monitor.