EE386 Digital Signal Processing Lab **Jul-Dec 2021**

Experiment : 6

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This lab experiment covers various practicality of Digital Signal Processing such as filter designing,filtering in time frequency analysis,various filter designs. Along with Python, I have used libraries such as numpy, pandas, scipy etc. The code to my entire work in this lab experiment is here. And the input files and my output files can be viewed here.

Please Note : I have used $\alpha = 2$ because my registration number is 191910.

Question 1 - Butterworth Filter Design

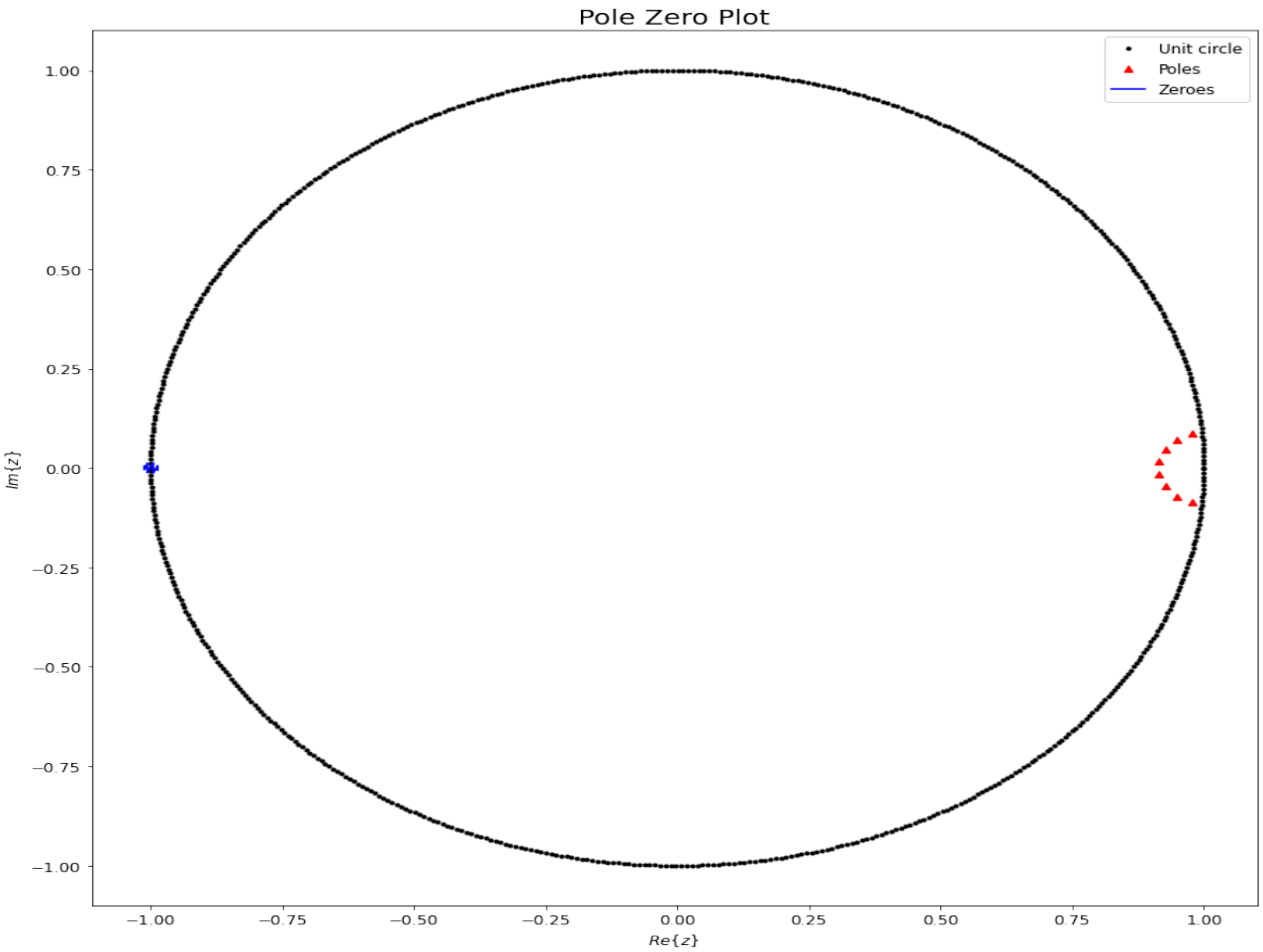
(Subproblem - 1) This question asks us to design a low pass digital Butterworth filter which has a maximum passband ripple of $-\alpha$ dB, and an edge frequency of 10 Hz. The filter also should have a minimum stopband attenuation of 40 dB from a stopband edge frequency of 20 Hz. Assuming a sampling frequency of 720 samples/sec.

The transfer function is

$$\frac{3.192e+14}{z^8 + 333.3\,z^7 + 5.553e+04\,z^6 + 6.004e+06\,z^5 + 4.59e+08\,z^4 + 2.538e+10\,z^3 + 9.922e+11\,z^2 + 2.517e+13\,z + 3.192e+14}$$

(Subproblem - 2)

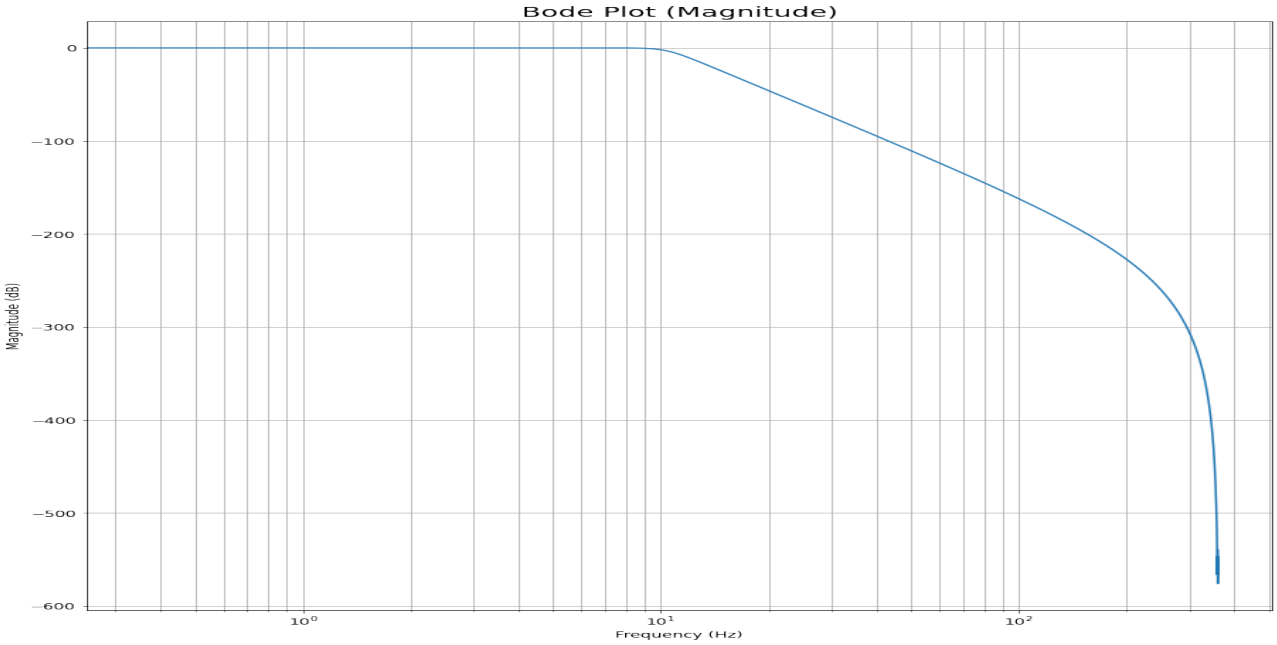
In this task, we are asked to plot the pole-zero plot and comment on its stability

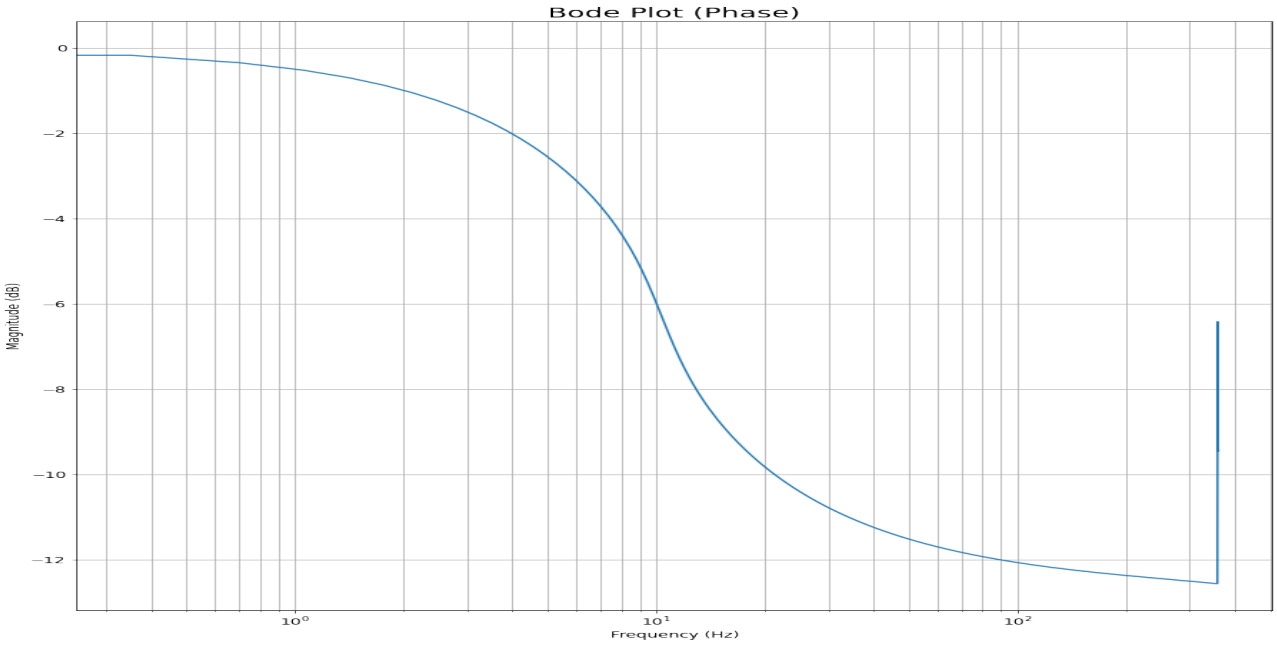


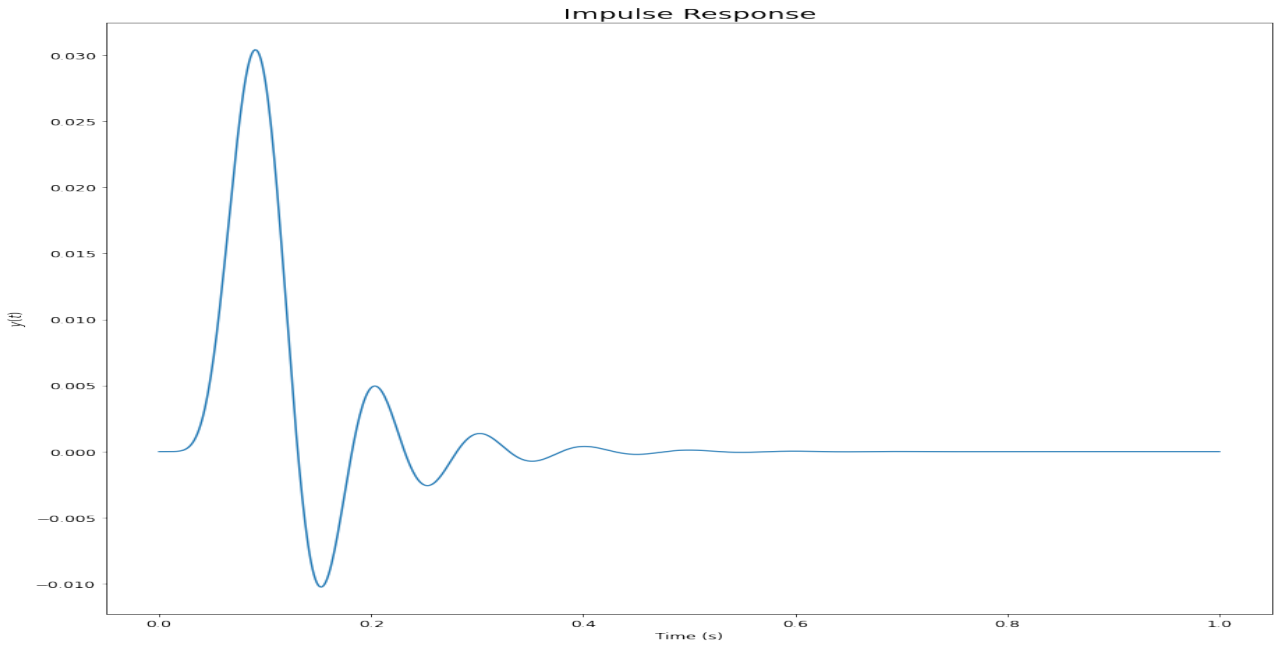
- The system is unstable because the poles lie on the right side of the plane.
- We can compute the poles and zeroes using the f2zpk function by plugging in the transfer function computed in the previous step.

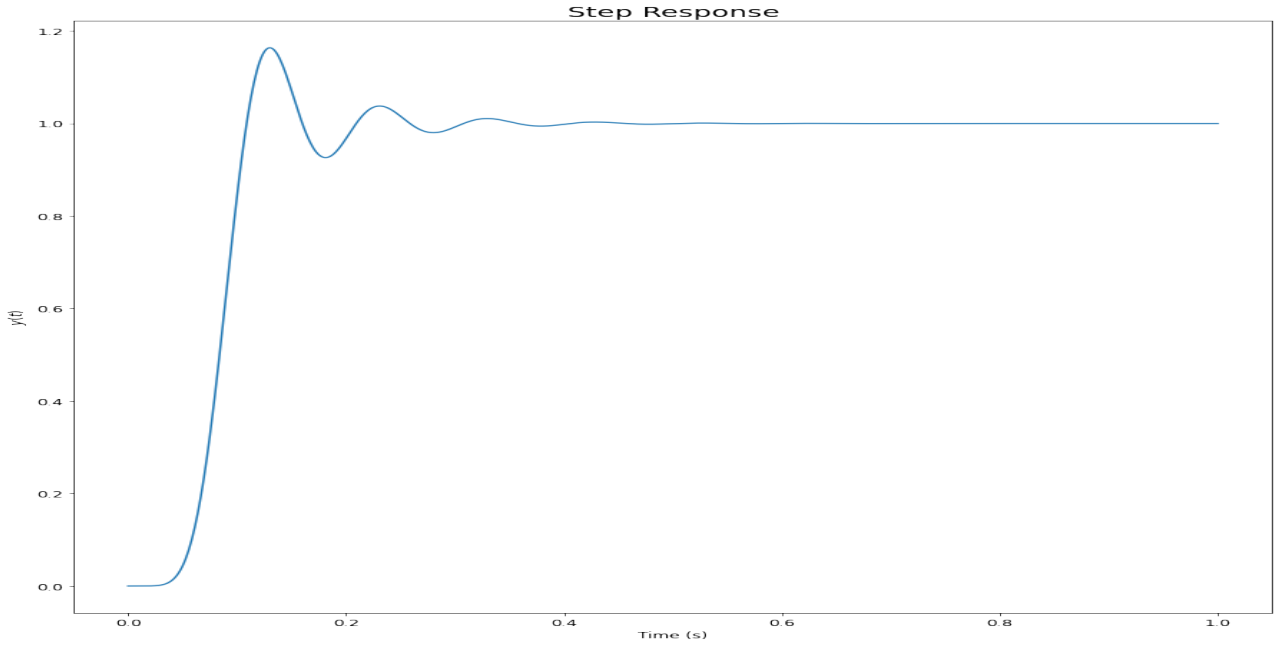
(Subproblem - 3)

The question asks us to plot the Bode plots.


Bode Plot (Magnitude)
Magnitude (dB)
0
−100
−200
−300
−400
−500
−600
10^0
10^1
10^2
Frequency (Hz)

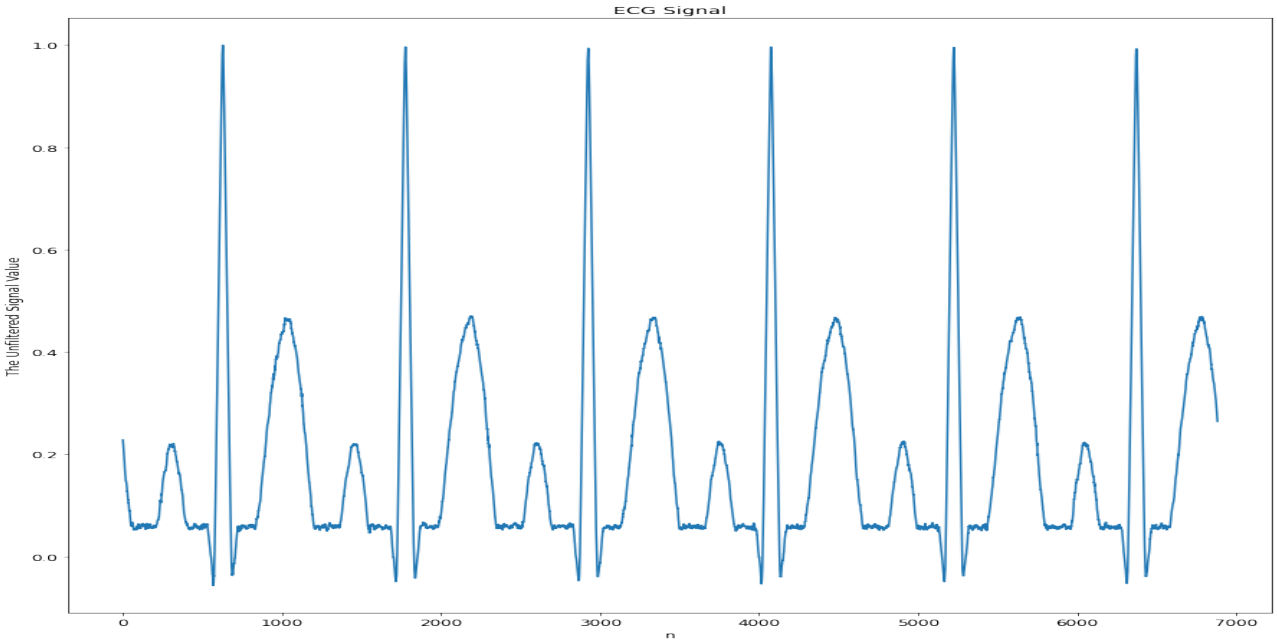

Bode Plot (Phase)
Magnitude (dB)
0
−2
−4
−6
−8
−10
−12
10^0
10^1
10^2
Frequency (Hz)

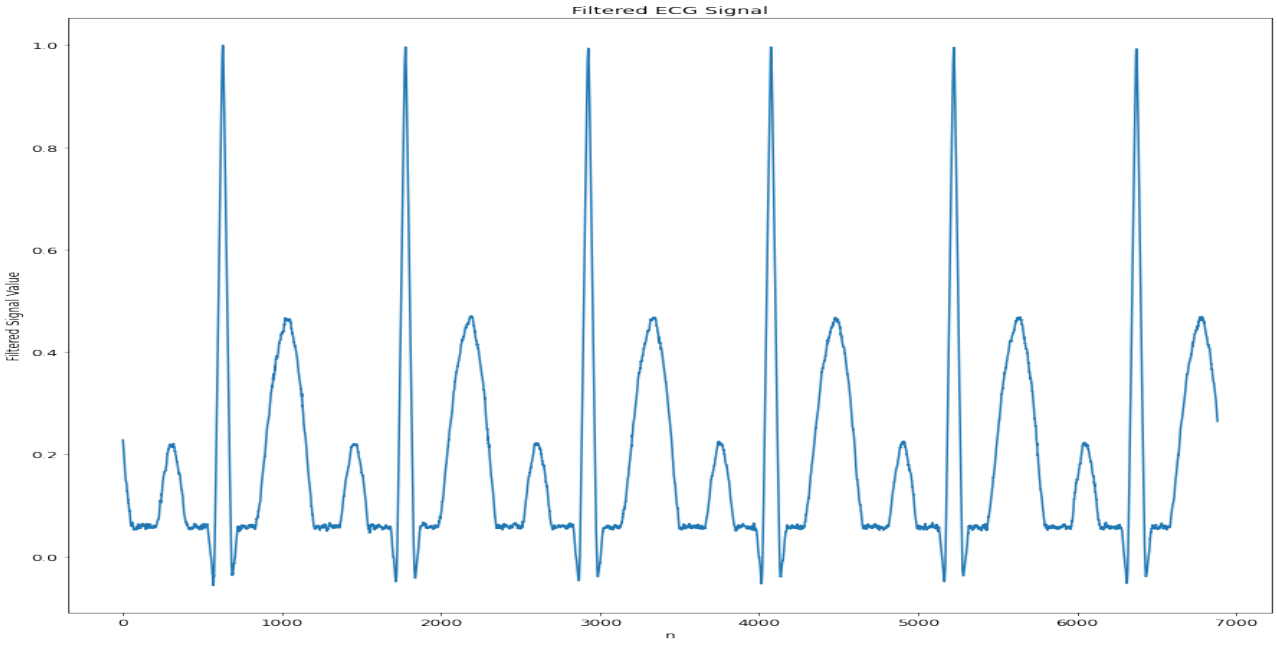

Impulse Response
y(t)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
0.0
0.2
0.4
0.6
0.8
1.0
Time (s)

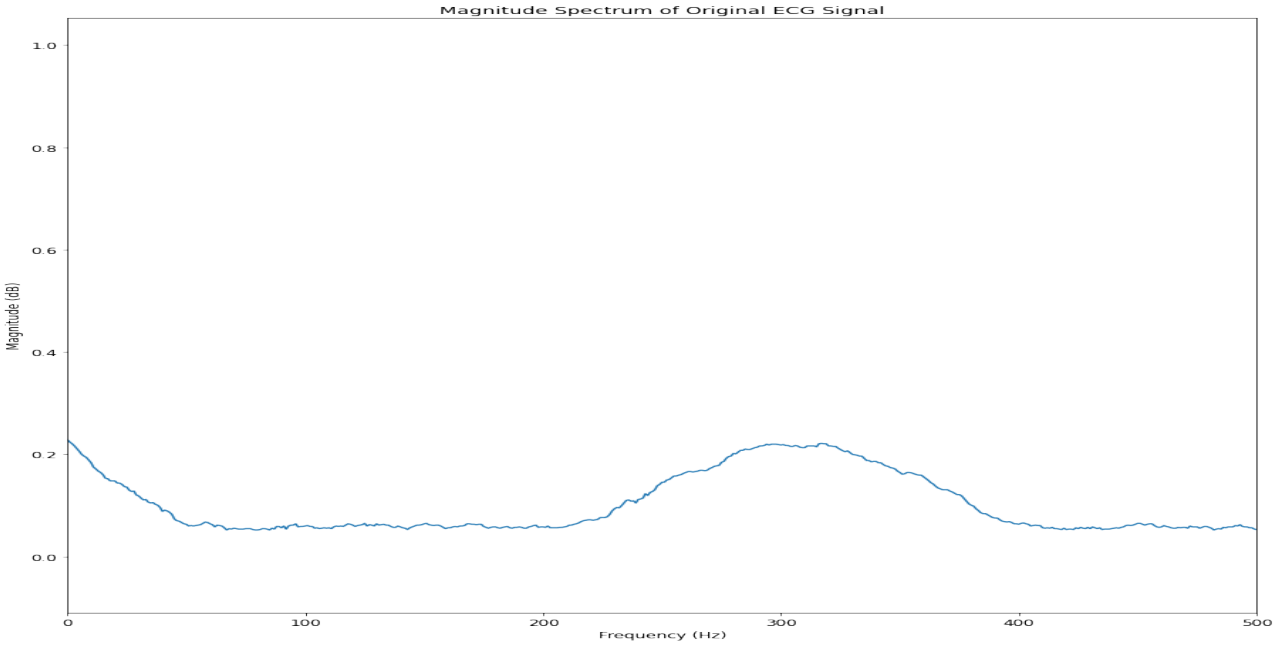


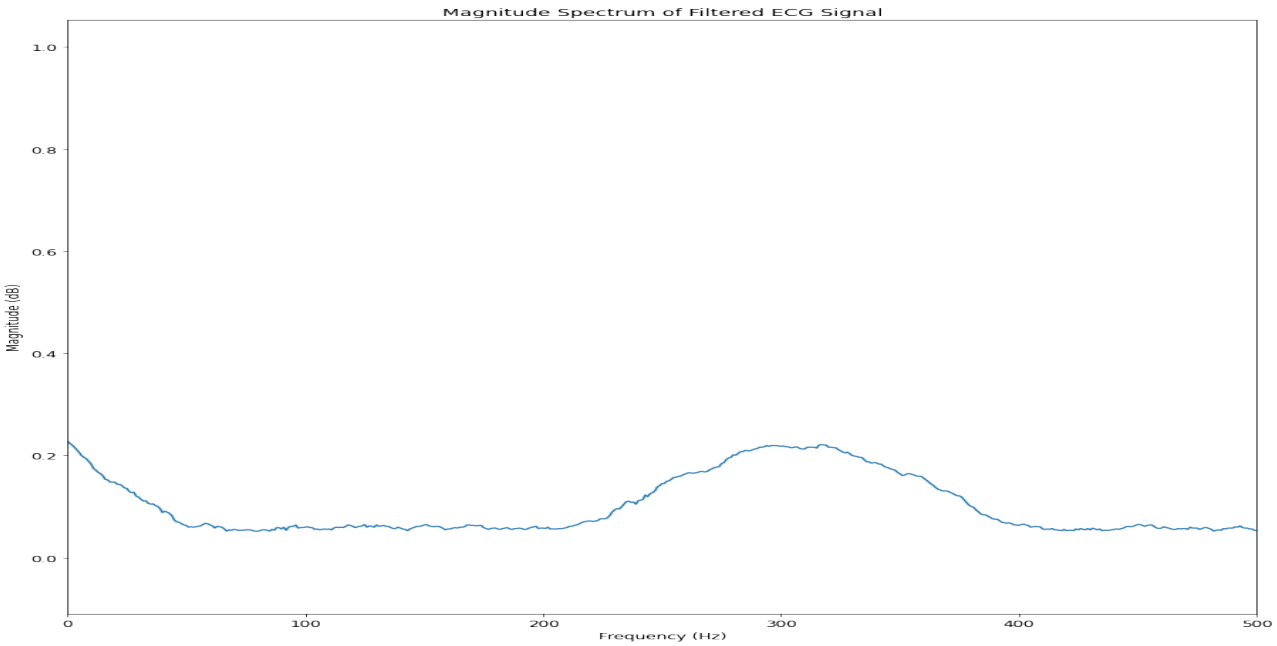
Question 2 - Filtering

This problem asks us to use the Butterworth filter to filter the ECG data (FS = 720 Hz) stored in the text file. And Plot the filtered output and compare it with the original signal in the same figure.



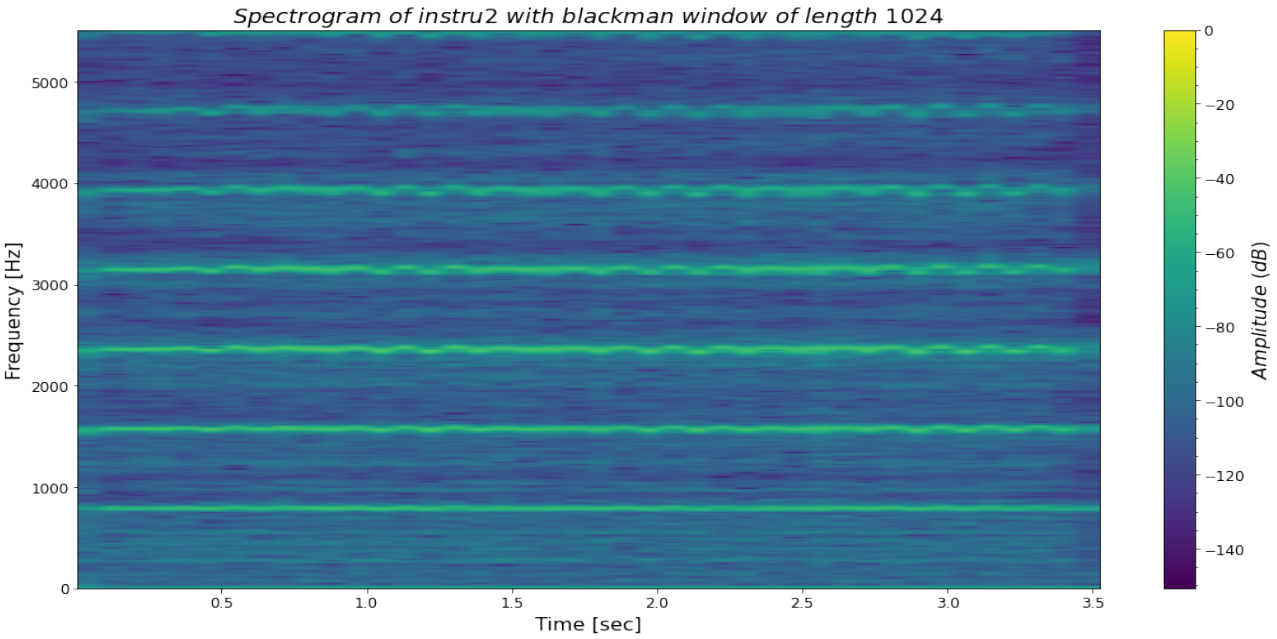

Filtered ECG Signal
Filtered Signal Value
n
0
1000
2000
3000
4000
5000
6000
7000
0.0
0.2
0.4
0.6
0.8
1.0


Magnitude Spectrum of Original ECG Signal
Magnitude (dB)
Frequency (Hz)
0
100
200
300
400
500
0.0
0.2
0.4
0.6
0.8
1.0


Magnitude Spectrum of Filtered ECG Signal
Magnitude (dB)
Frequency (Hz)
0
100
200
300
400
500
0.0
0.2
0.4
0.6
0.8
1.0

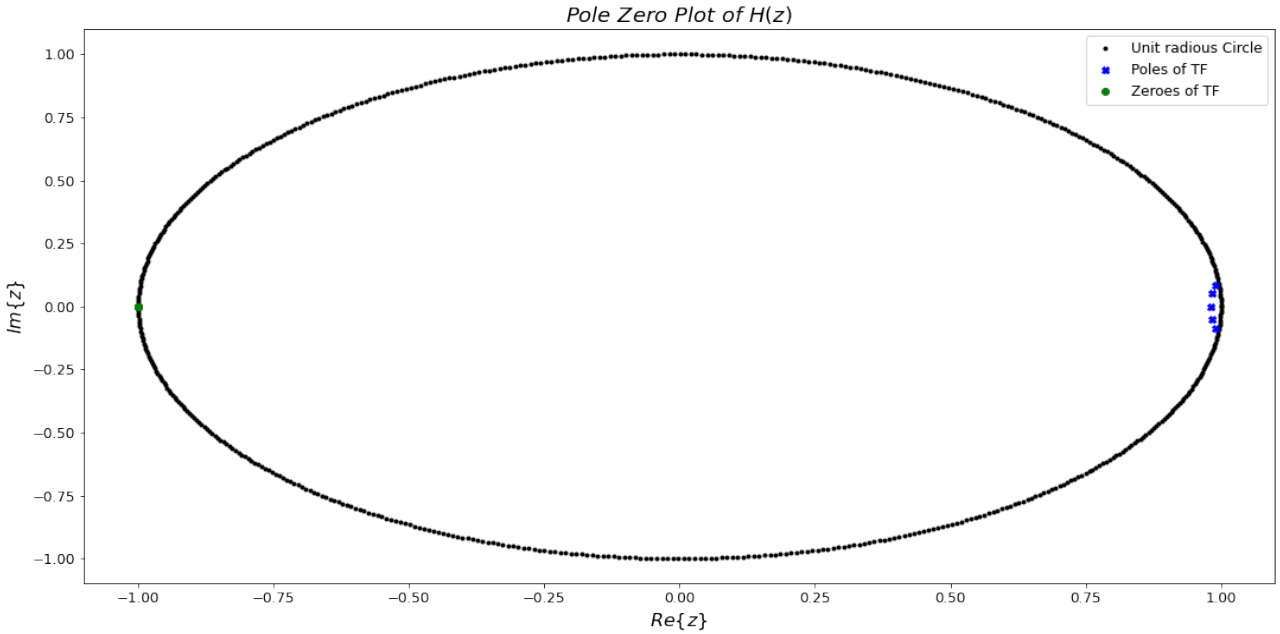
Question 3 - Filtering - Time Frequency Analysis

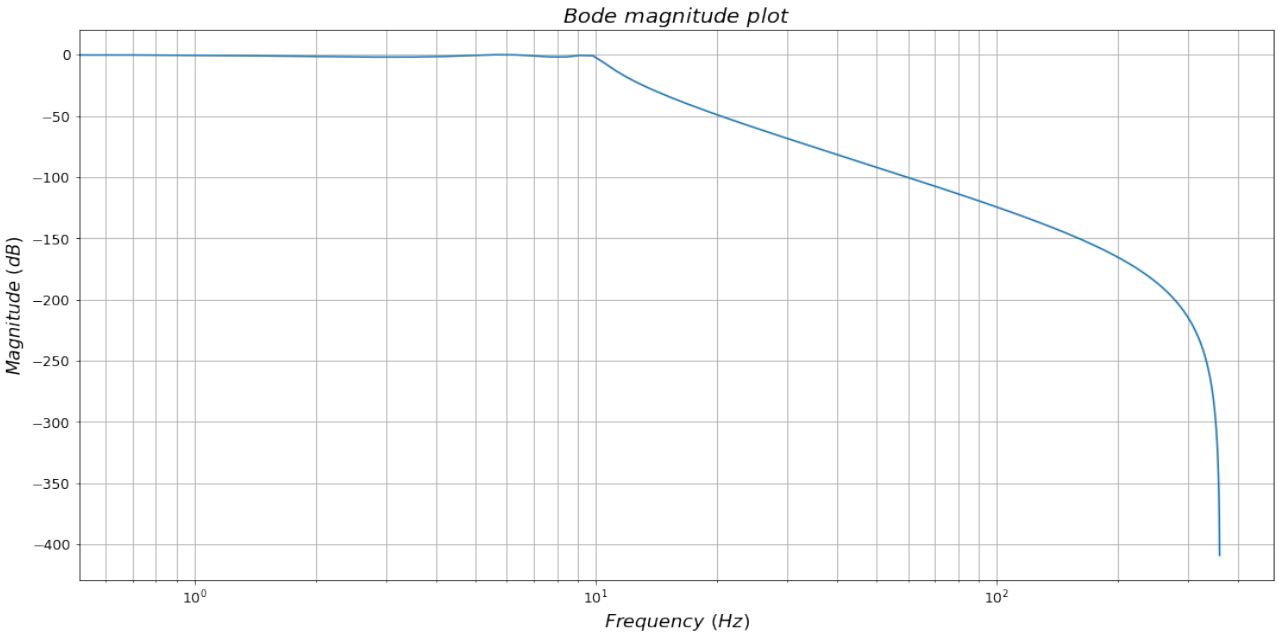
In this problem, we are asked to plot the spectrogram of an instrument and then plot it after filtering it.

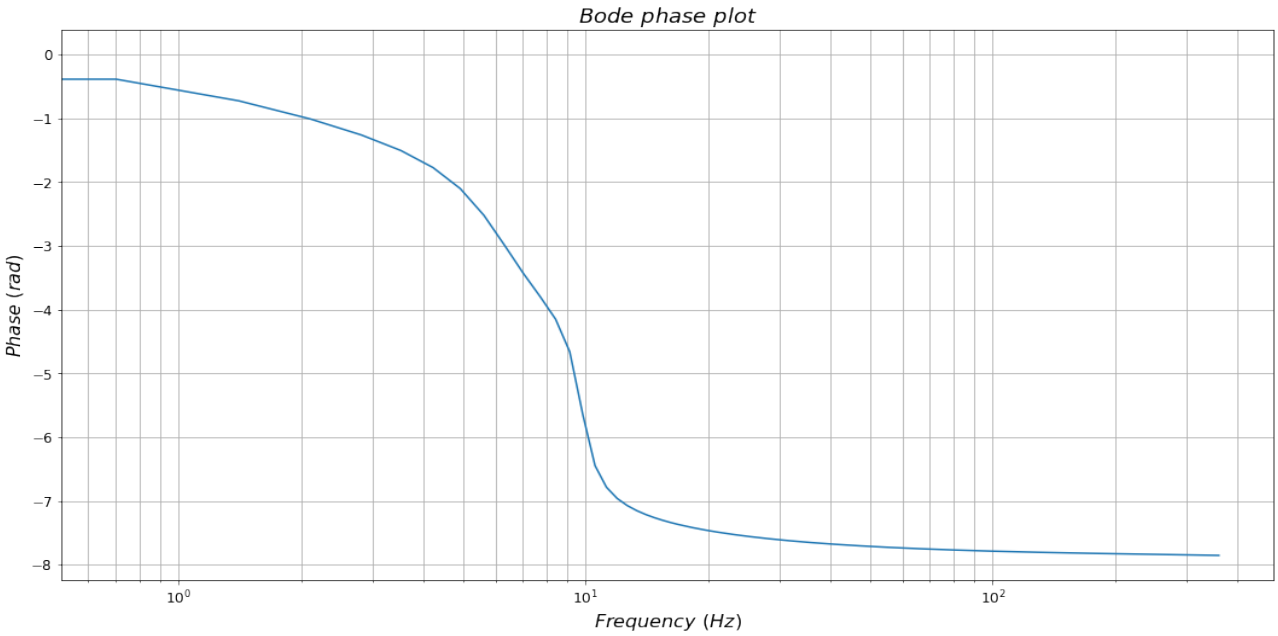


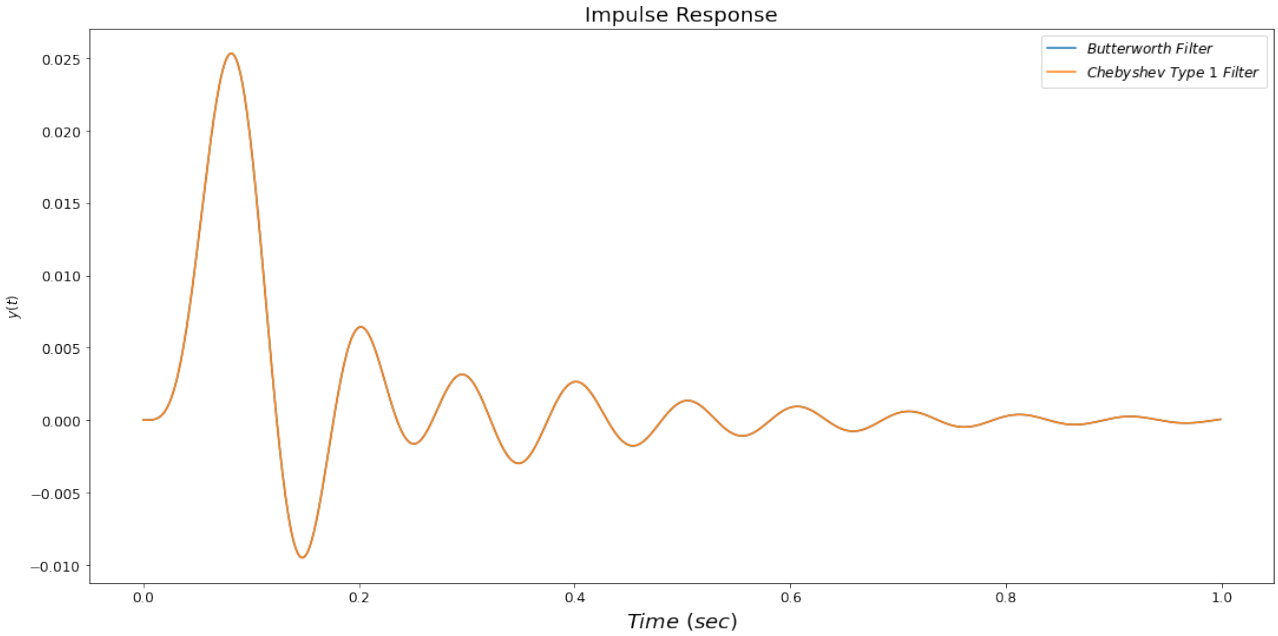
Question 4 - Chebyshev filter design

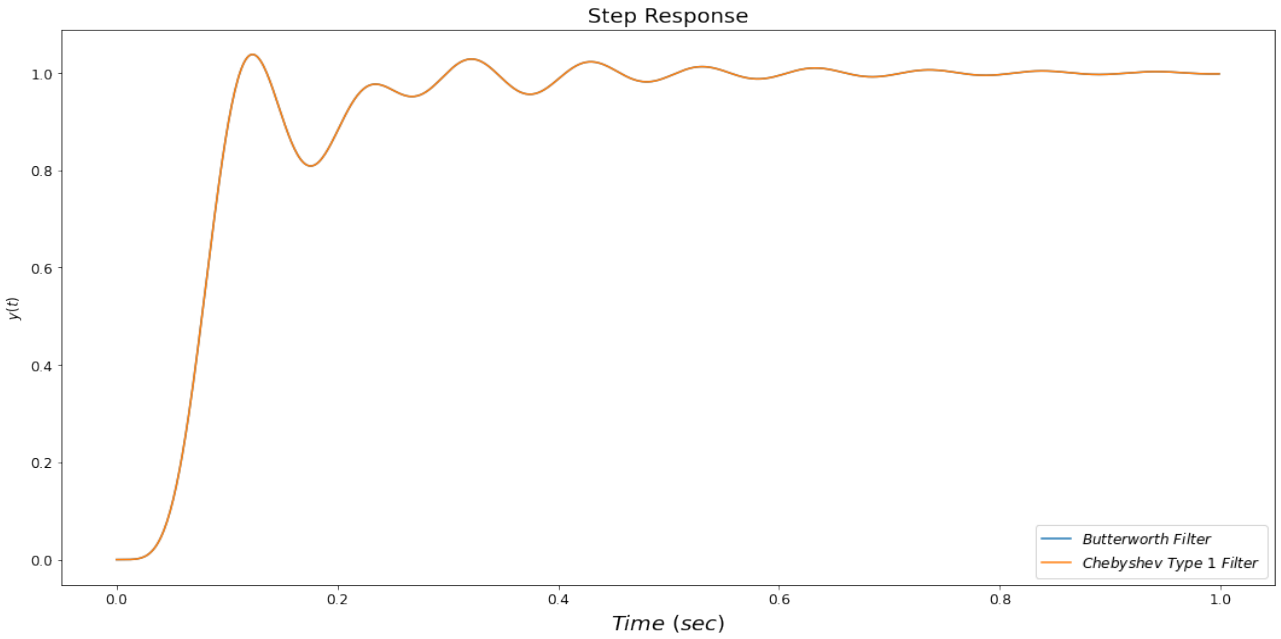
In this problem, we are supposed to compare the outputs of Butterworth low pass filter and Chebyshev Type 1 low pass filter with the same set of specifications as mentioned in problem 1.




Bode magnitude plot
Magnitude (dB)
0
−50
−100
−150
−200
−250
−300
−350
−400
10^0
10^1
10^2
Frequency (Hz)


Bode phase plot
Phase (rad)
0
−1
−2
−3
−4
−5
−6
−7
−8
10^0
10^1
10^2
Frequency (Hz)


Impulse Response
Butterworth Filter
Chebyshev Type 1 Filter
y(t)
0.025
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
0.0
0.2
0.4
0.6
0.8
1.0
Time (sec)



1 Appendix

- Note : I have used $\alpha = 2$ because my registration number is 191910. Since $\alpha = 1 + \text{mod}(910,3) = 2$
- The link to all the code is here. And the input files and my output files can be viewed
- The link to all input and output files are here.
- The Github repo to all code and previous experiments can be found here