

**School of Engineering and Applied Science (SEAS)
Ahmedabad University**

BTech(ICT) Digital Signal Processing (Section 1)

Laboratory Assignment-7 Question 1

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AIM : Design an IIR filter using impulse in-variance method using Butterworth

1. Solution Problem-1

(a) Approach:

In this question, we had to find the transfer function co-efficients from the $H(Z)$. This part was done in the pen-paper. From the pen-paper analysis we got $b=[0, 0.1160, 0.0715]$ and $a=[1, -1.6014, 1.0211, -0.2321]$ where a and b are the transfer function co-efficients.

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b, a — Transfer function coefficients
row vectors

Transfer function coefficients of the filter, returned as row vectors of length $n + 1$ for lowpass and highpass filters and $2n + 1$ for bandpass and bandstop filters.

- For digital filters, the transfer function is expressed in terms of b and a as
$$H(z) = \frac{B(z)}{A(z)} = \frac{b(1) + b(2)z^{-1} + \dots + b(n+1)z^{-n}}{a(1) + a(2)z^{-1} + \dots + a(n+1)z^{-n}}.$$
- For analog filters, the transfer function is expressed in terms of b and a as
$$H(s) = \frac{B(s)}{A(s)} = \frac{b(1)s^n + b(2)s^{n-1} + \dots + b(n+1)}{a(1)s^n + a(2)s^{n-1} + \dots + a(n+1)}.$$

Data Types: double

Figure 1: Description of Transfer function coefficients.

In order to plot the frequency response, freqz was considered and sampling frequency of 8000Hz was taken as an input to avoid normalization. Then the values were matched with W_p , W_s , $\Delta(p)$ etc. which were given in the question.

(b) Matlab Script:

```
1 % Name : Samarth Shah
2 % Roll No: AU1841145
3 % Lab7 ( Question_1 ) From the given transfer function co-efficients, get a plot
  of the
4 % IIR lowpass Butterworth Prototype Filter
5
6 clc ;
7 clear all ;
8 close all ;
9 %Transfer Function Co-efficients
10 b=[0,0.1160,0.0715];
11 a=[1,-1.6014,1.0211,-0.2321];
12 %Plotting
13 freqz(b,a,1024,8000) %Frequency Response
```

(c) Simulation Output:

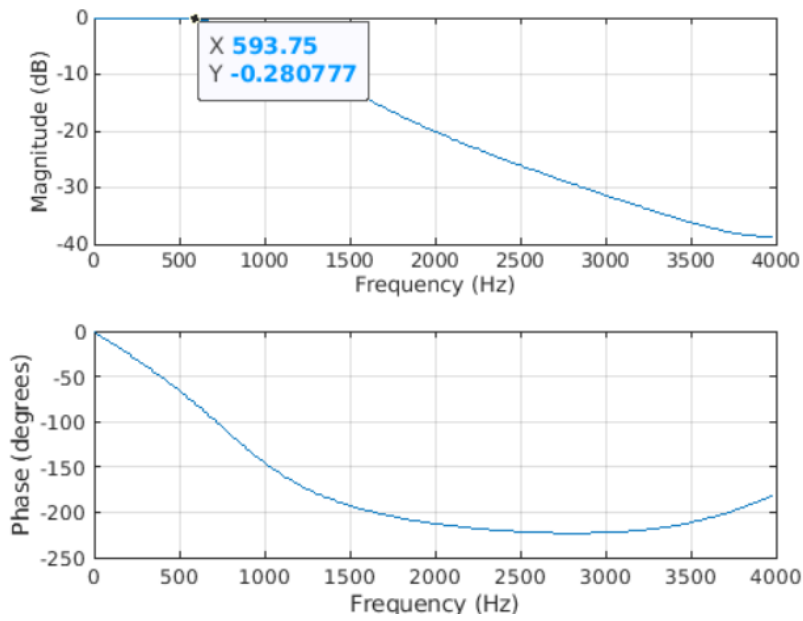


Figure 2: IIR lowpass Butterworth Prototype Filter (Magnitude and Phase Response)

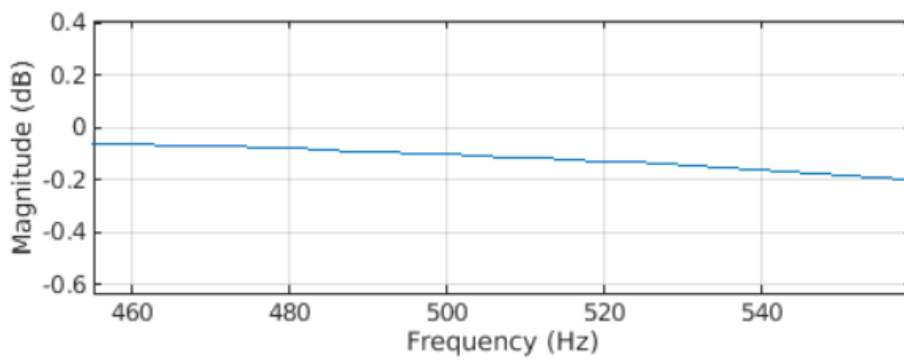


Figure 3: The image shows that the value of passband ripple is 0.1 which is similar to the value given in the question.

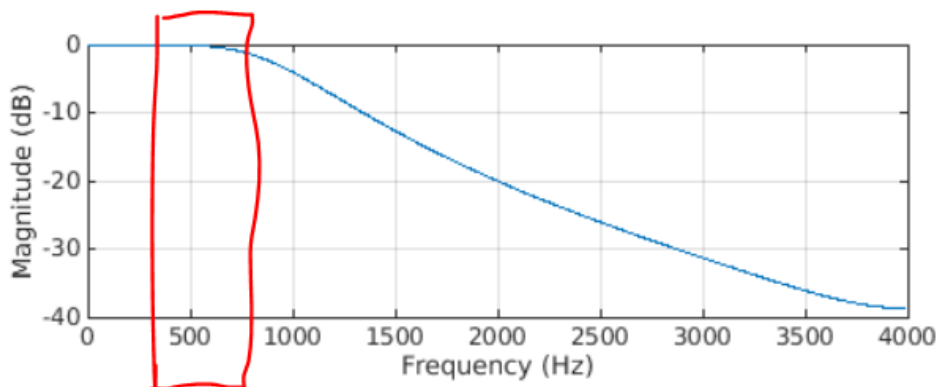


Figure 4: The image shows that the value of passband edge is 500 Hz which is similar to the value given in the question.