Digital Signal Processing
MATLAB HW3 - q2

Table of Contents

Professor: Dr. Sheikhzadeh Author: Maryam Barazande - 9723016 E-mail: maryambarazande7@gmail.com University: Amirkabir University of Technology

Clear recent data

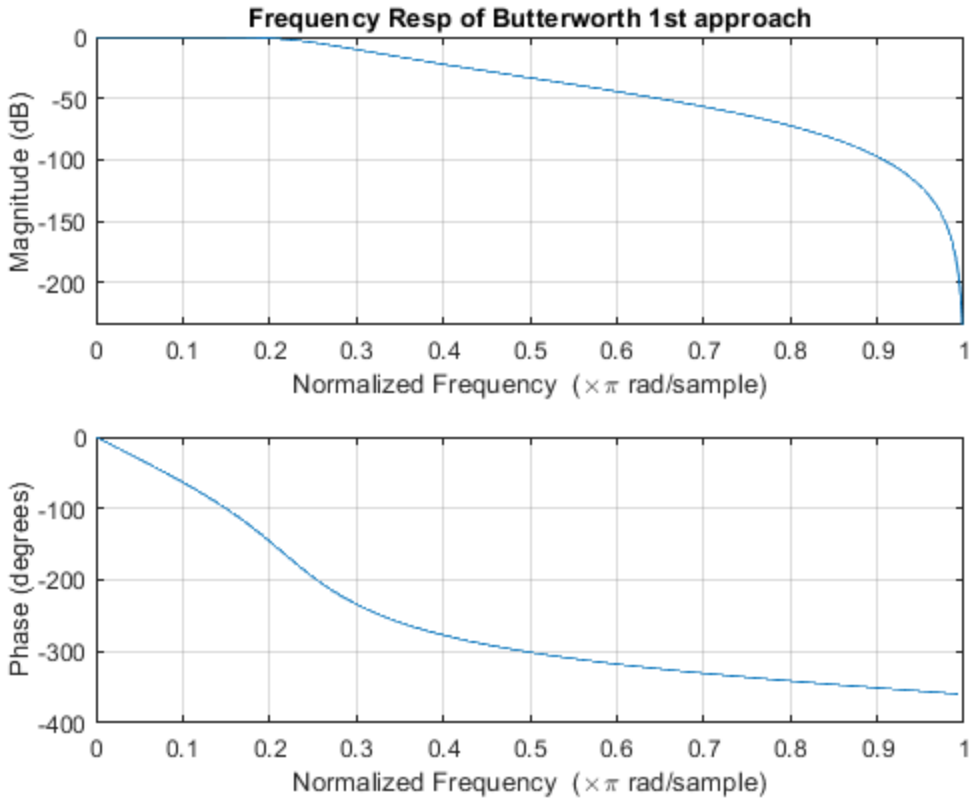
```
clear; close all; clc;
```

A. Bilinear transformation

part 1

```
% define parameters
wp = 0.2*pi;
ws = 0.4*pi;
Rp = 1;
As = 20;
T = 2;
Fs = 1/T

OmegaP = (2/T)*tan(wp/2);
OmegaS = (2/T)*tan(ws/2);

[cs,ds] = afd_butt(OmegaP,OmegaS,Rp,As); %butterworth filter design in
 continuous domain
[b1,a1] = bilinear(cs,ds,Fs); %butterworth continuous to discrete

figure(1);
freqz(b1,a1);
title('Frequency Resp of Butterworth 1st approach');
```

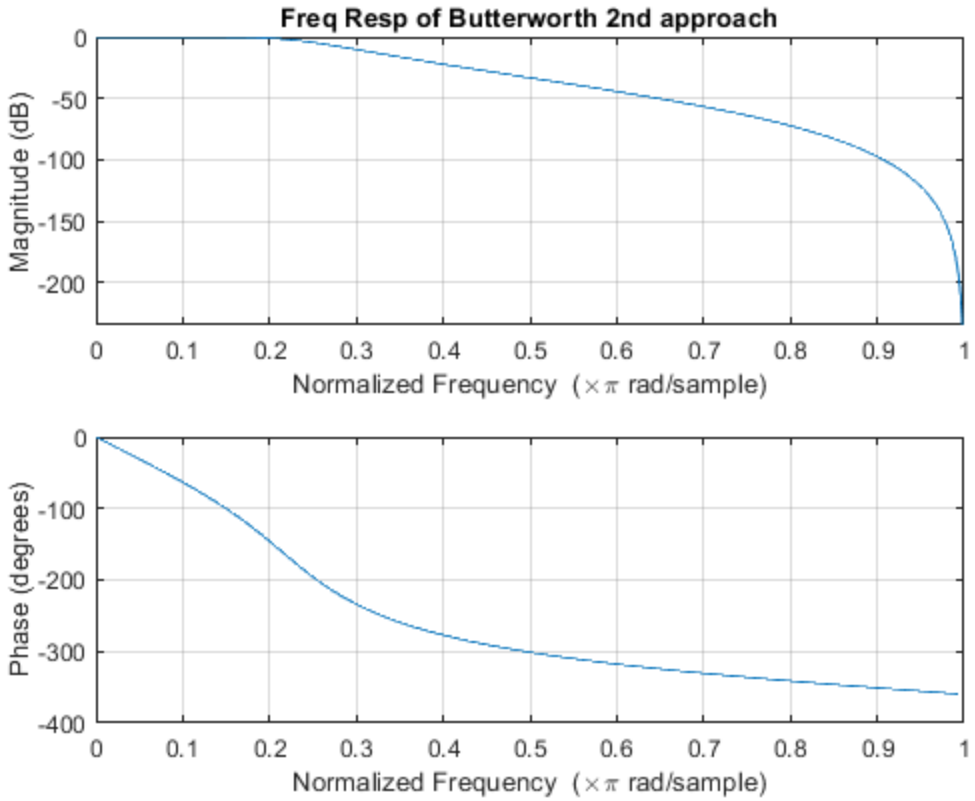
```
Fs =

    0.5000


*** Butterworth Filter Order =  4
```



B. Normalized Butterworth

part 2

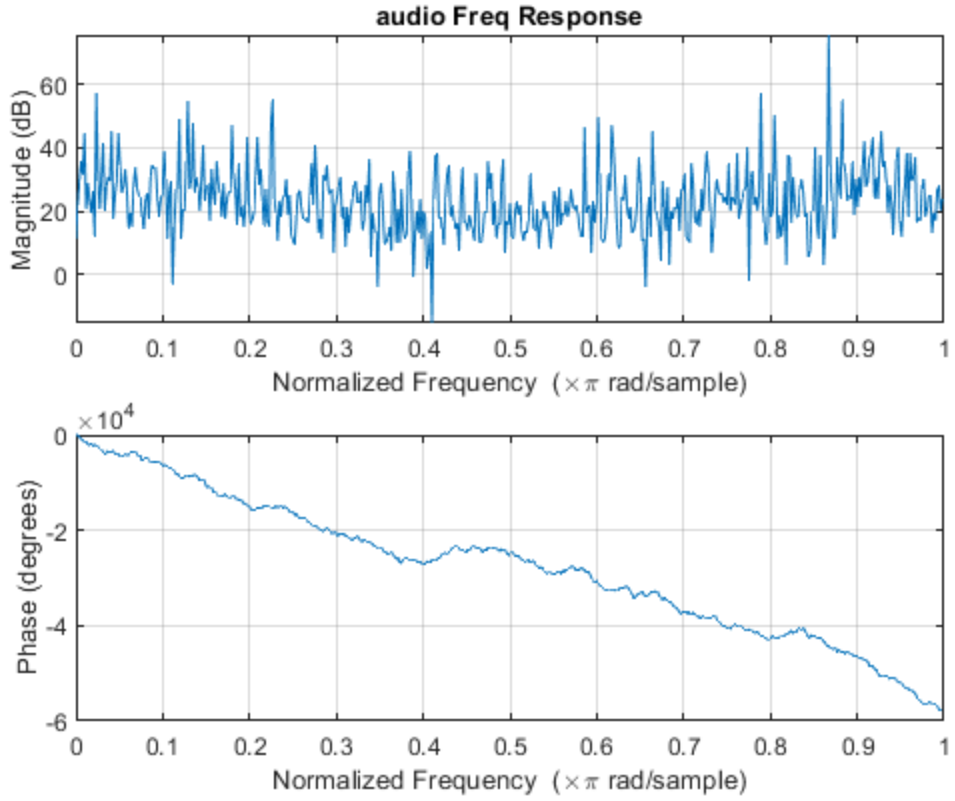
```
OmegaP = (2/T)*tan(wp/2);
OmegaS = (2/T)*tan(ws/2);
N =ceil((log10((10^(Rp/10)-1)/(10^(As/10)-1)))/(2*log10(OmegaP/
OmegaS)));
OmegaC = OmegaP/((10^(Rp/10)-1)^(1/(2*N)));

wn = (2/pi)*atan((OmegaC*T)/2);
[b2,a2] = butter(N,wn); %butterworth direct design in discrete domain

figure(2);
freqz(b2,a2);
title('Freq Resp of Butterworth 2nd approach');
```

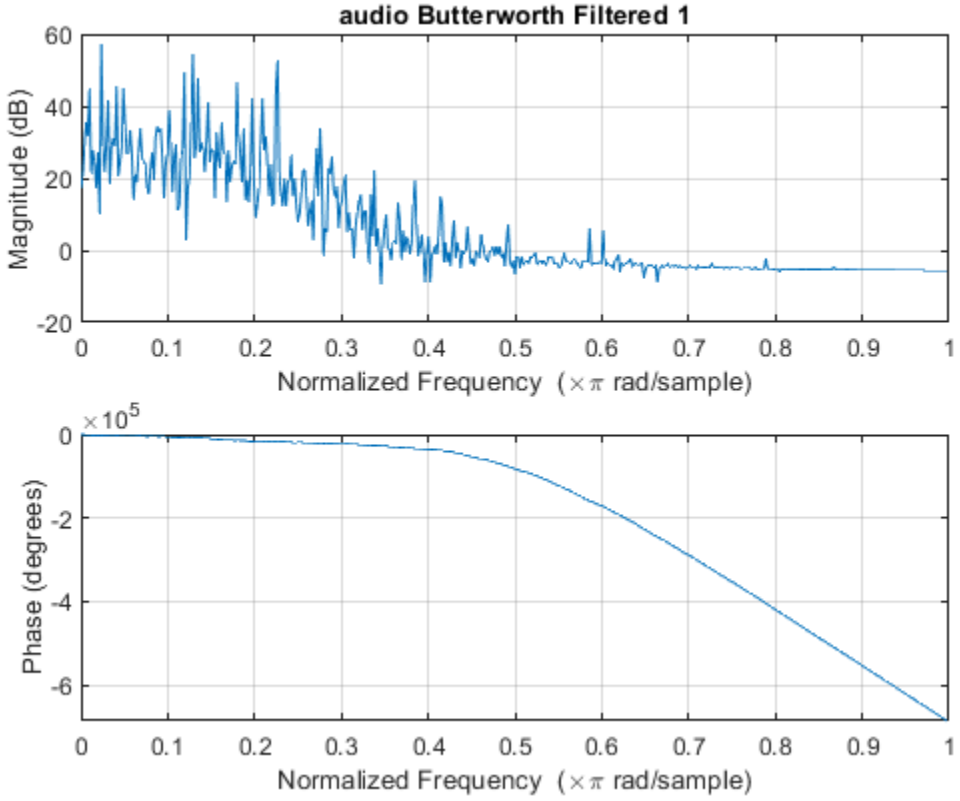


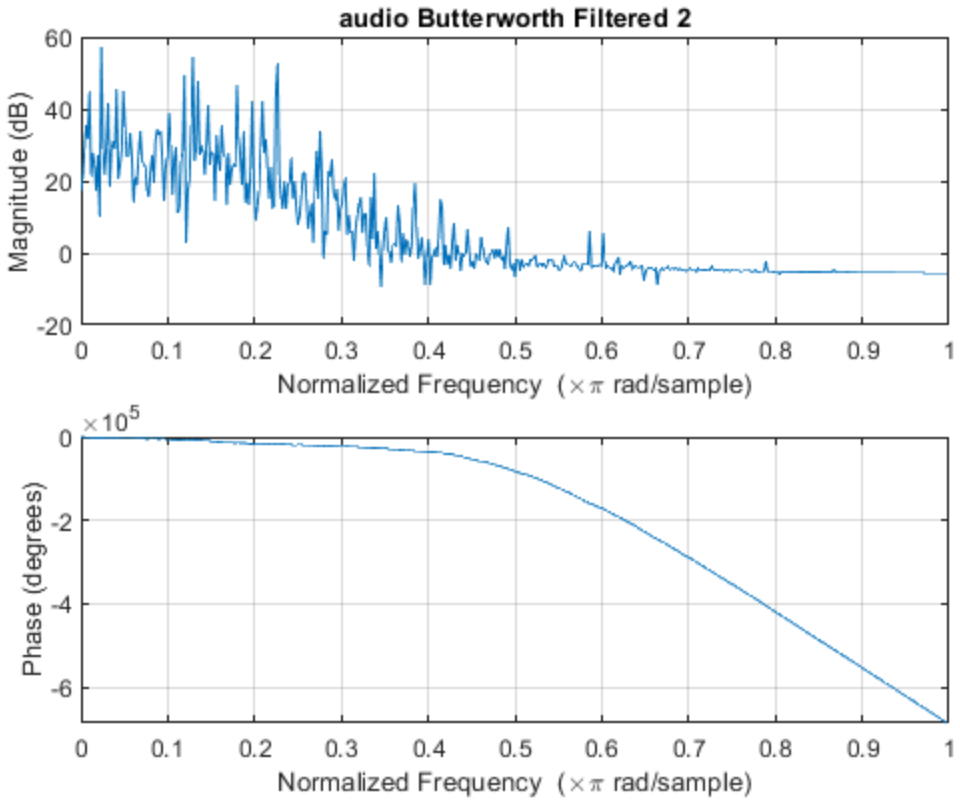
C.Filtering

part 3

```
[audio , Fs] = audioread('HW3_Q2_multi_tone.wav') ;
audio = (audio)' ;                      %transposing audio file

figure(3);
freqz(audio);
title('audio Freq Response');

filtered_audio1 = filter(b1,a1,audio); %first methof filter on audio
 file
figure(4);
freqz(filtered_audio1);
title('audio Butterworth Filtered 1');

filtered_audio2 = filter(b2,a2,audio); %second method filter on audio
 file
figure(5);
freqz(filtered_audio2);
title('audio Butterworth Filtered 2');
```


audio Freq Response
Magnitude (dB)
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Normalized Frequency (×π rad/sample)
×10^4
Phase (degrees)
0
-2
-4
-6
Normalized Frequency (×π rad/sample)


audio Butterworth Filtered 1
Magnitude (dB)
60
40
20
0
-20
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Normalized Frequency (×π rad/sample)
×10^5
Phase (degrees)
0
-2
-4
-6
Normalized Frequency (×π rad/sample)



Butterworth Function

```
function [b,a] = u_buttap(N,Omegac) %%copy butterworth design function
 from the book
[z,p,k] = buttap(N);
p = p*Omegac;
k = k*Omegac^N;
B = real(poly(z));
b0 = k;
b = k*B;
a = real(poly(p));
end
function [b,a] = afd_butt(Wp,Ws,Rp,As)
if Wp <= 0
error('Passband edge must be larger than 0')
end
if Ws <= Wp
error('Stopband edge must be larger than Passband edge')
end
if (Rp <= 0) || (As < 0)
error('PB ripple and/or SB attenuation ust be larger than 0')
end
N = ceil((log10((10^(Rp/10)-1)/(10^(As/10)-1)))/(2*log10(Wp/Ws)));
fprintf('\n*** Butterworth Filter Order = %2.0f \n',N) ;
OmegaC = Wp/((10^(Rp/10)-1)^(1/(2*N)));
```

```
[b,a]=u_buttap(N,OmegaC);
end
```

Published with MATLAB® R2020b