MB Logbook

21/12/2021

Ex 1

a) First determine the original signal

f		w	A	
80Hz	→	160π	0.5	$\Rightarrow$ $0.5\cos(160\pi t) + \sin(200\pi t)$
100Hz		200π	$-1i$	

For the noise

f		w	A	
210 Hz	→	420π	1	$\Rightarrow$ $\sin(420\pi t) + 0.5\sin(560\pi t)$
280Hz		560π	0.5	

Power of the signal

$$P_s = \frac{1}{2}\left(0.5^2 + 1^2\right) = 0.625$$

Power of the noise

$$P_n = \frac{1}{2}\left(1^2 + 0.5^2\right) = 0.625$$

Power of the white noise

$$\frac{P_s}{P_w} = -8\,dB$$

$$P_w = \frac{P_s}{-8dB} = \frac{0.625}{10^{-\frac{8}{10}}} \approx 3.943$$

$\therefore$ The combined noise power is

$$P_n + P_w \approx 4.568$$

The noisy signal power is

$$P_s + P_n + P_w = 5.193$$

$$\therefore SNR = \frac{P_s}{P_n + P_w} = \frac{0.625}{0.625 + \frac{0.625}{10^{-\frac{8}{10}}}} \approx -8.639\ dB$$

b)

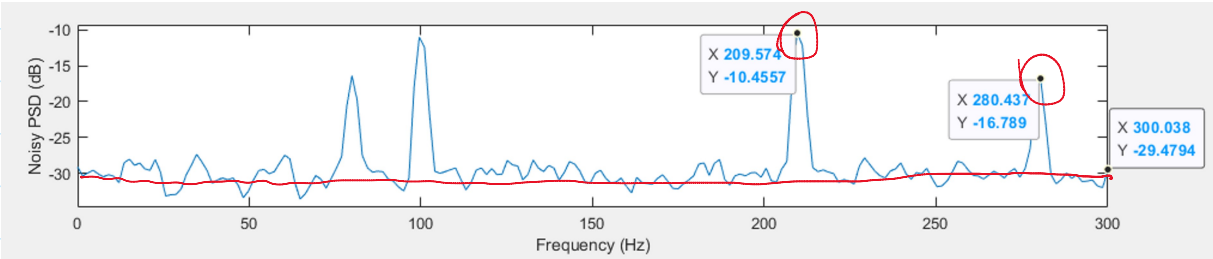
```
Pn_actual = sum(abs(x).^2/length(x))
Pv_actual = sum(abs(v).^2/length(v))
Py_actual = sum(abs(y).^2/length(y))
```

```
Pn_actual =

    0.6250


Pv_actual =

    4.6083


Py_actual =

    5.2053
```

Use the code

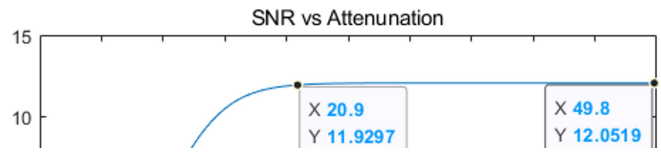
The reason of differences is that the noise is randomely generated, which will fluctuate. If we produce more noise and take the power, it will be closer to the theoretical value.

c) From the figure

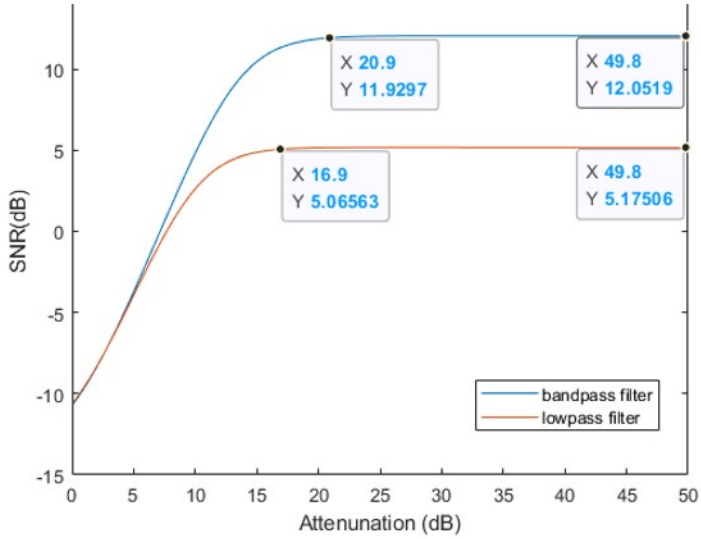


The two peaks on the right are noises.
Although the total power of the white noise is much higher than that of noises, it is spreaded over the whole spectrum, while the power of noises concentrate around certain frequences.
Therefore, the noise floor is much less than the noise power.

d)



bandpass filter
80 – 100 Hz

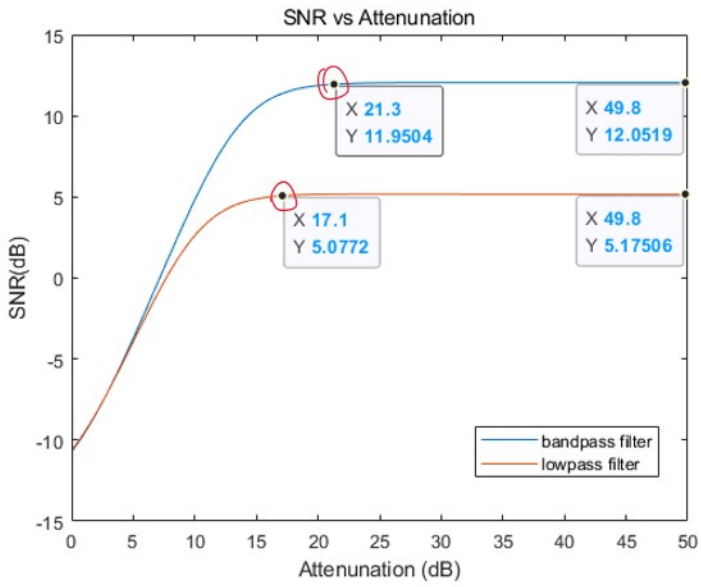


bandpass filter 80 – 100 Hz

low pass filter 0 – 100 Hz

It can be seen from the figure that the lines reach the steady state at about 5 and 12 dB attenuation respectively.

e)



At these two points, the SNR is lower by 0.1 dB than the maximum points.

∴ For

LPF : 17.1 dB

BPF : 21.3 dB

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Ex 2

a)

```
[n1,wn1] = buttord(2*ftr(1)/fs,2*ftr(2)/fs,rp,rs);
wn1
```

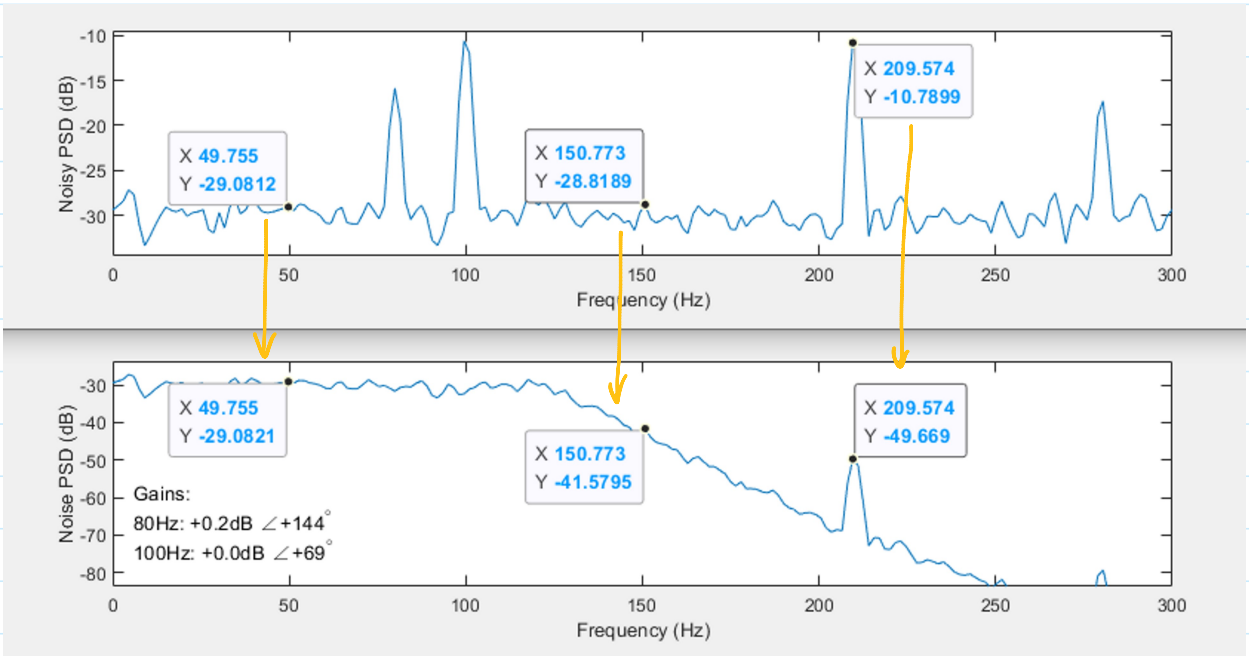
alized

```
wn1 =

    0.0642
```

∴ The unnormalized cutoff frequency is wn1 × 0.5 f_s

$= 0.0642 \times 0.5 \times 4000 = 128.4\ Hz$

b)



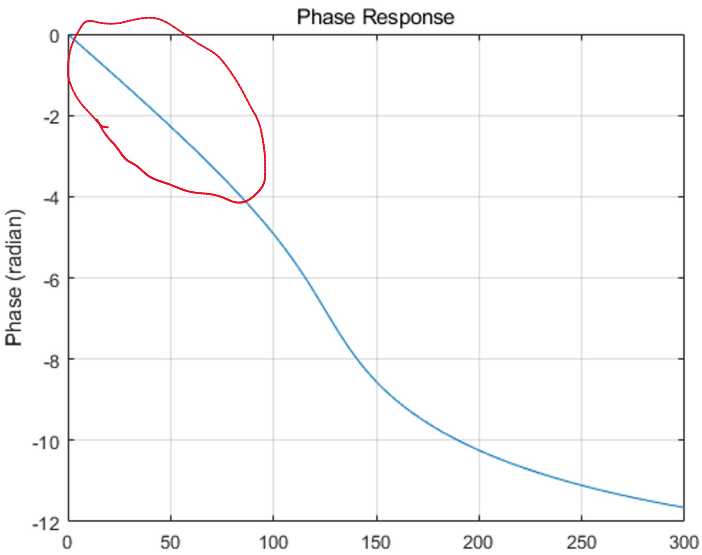
After filtering,

50 Hz : in the passband, almost doesn't change

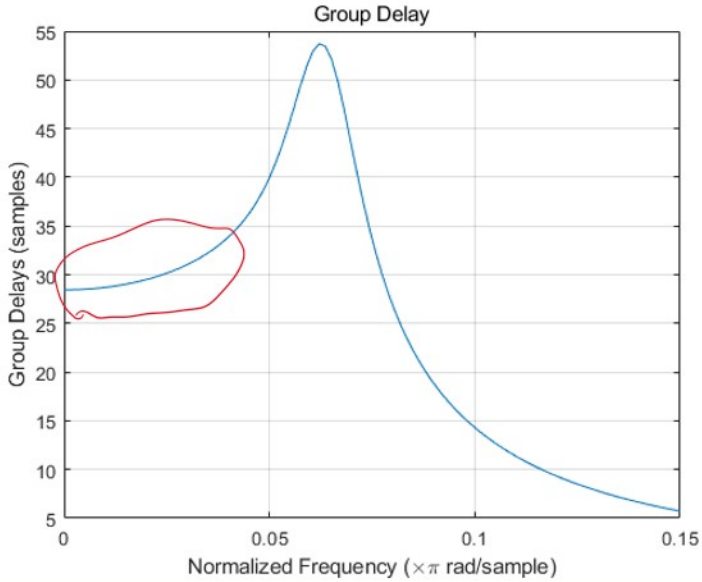
150 Hz: in the transition zone, decreased a bit

210 Hz: almost in the stop band, decreased a huge level. It is still evident since the noise power before filtering is high.

c)

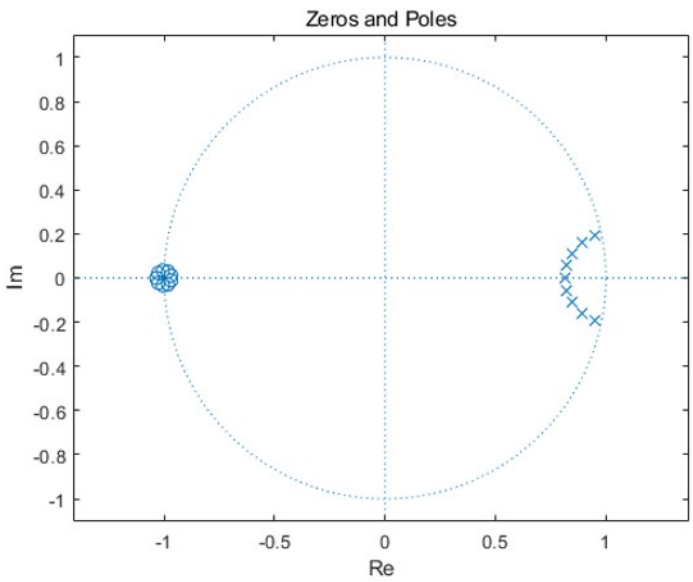


d)



At low frequencies, the phase shift is small, hence the group delay does not vary much.

e)



This filter has 9 orders

9 zeros, 9 poles

hence need 18 multiplications per sample.

$$\frac{\prod_{i=1}^{9}(s-z_i)}{\prod_{i=1}^{9}(s-p_i)}$$

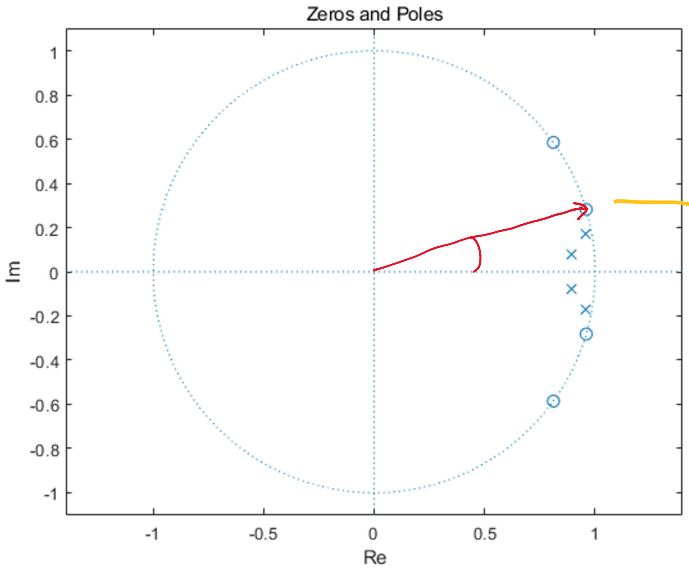
28/12/2021

Ex3

```
[n,wn] = ellipord(2*ftr(1)/fs,2*ftr(2)/fs,rp,rs);
[b,a] = ellip(n,rp,rs,wn);
z = filter(b,a,y);
[snr,ax,e,v] = mb1_snrtone(z,xfa,fs);
snr
```

```
snr =

    4.0202
```

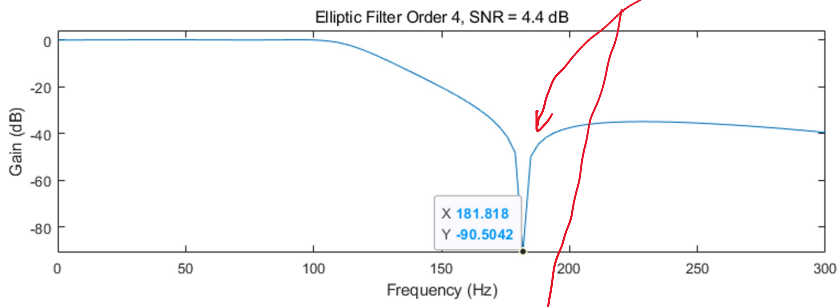
$\therefore$ SNR is 4.0202

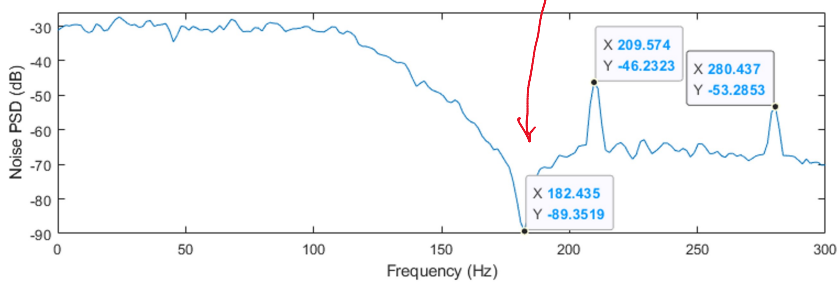


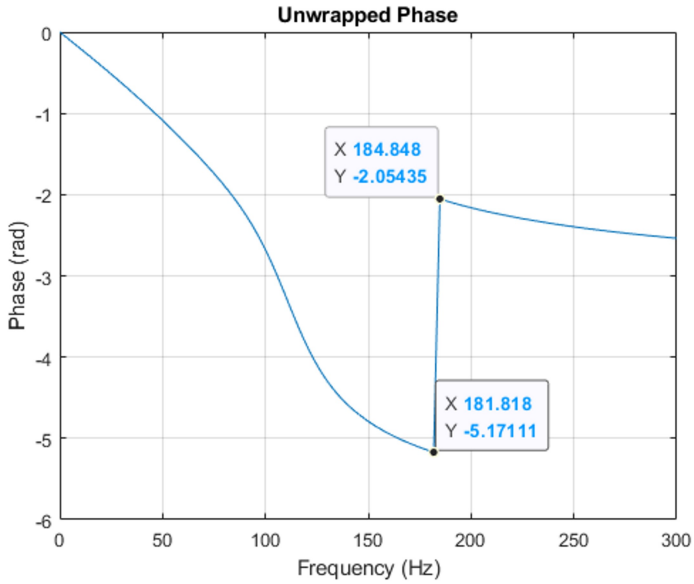
This angle is $\theta \approx 0.286$

$\therefore \frac{\theta}{2\pi} \cdot f_s \approx 182.1$ Hz

This refers to the lowest gain







181.818 is where the first zero occurs.

4 zeros
4 poles $\Rightarrow$ 8 multiplications

Advantage: ① The Elliptic filter has lower order $(9 \to 4)$ than Butterworth filter.

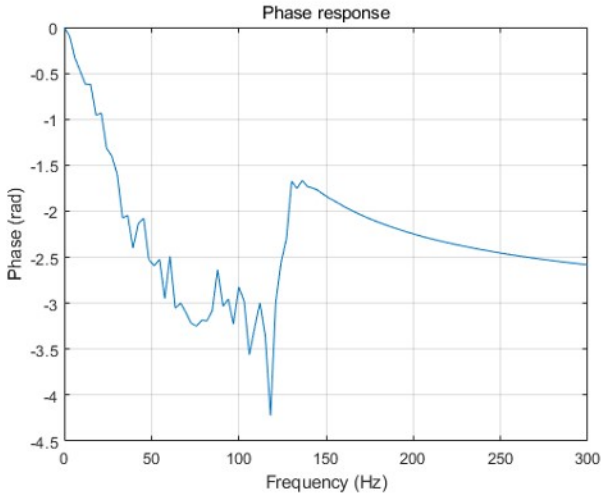
② Narrower transaction band

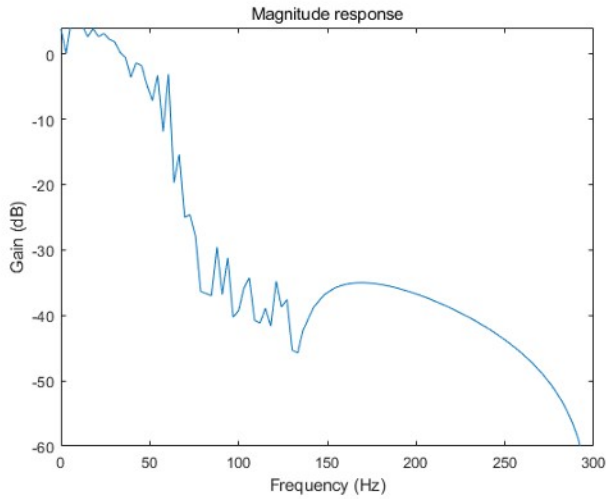
Disadvantage: The performance in the stop band is not as good as Butterworth filter.

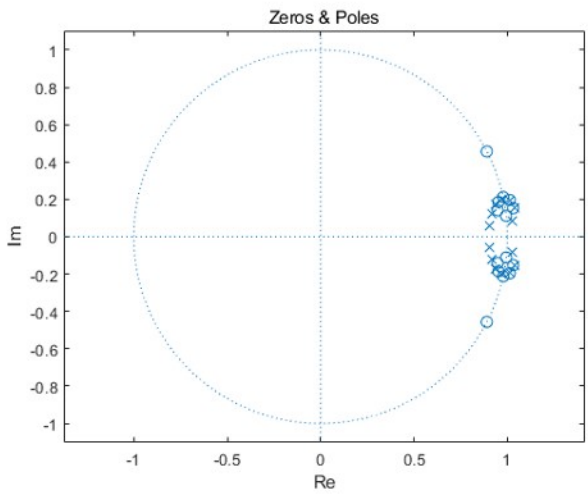
2/1/2022

Ex 4

Direct implementation:



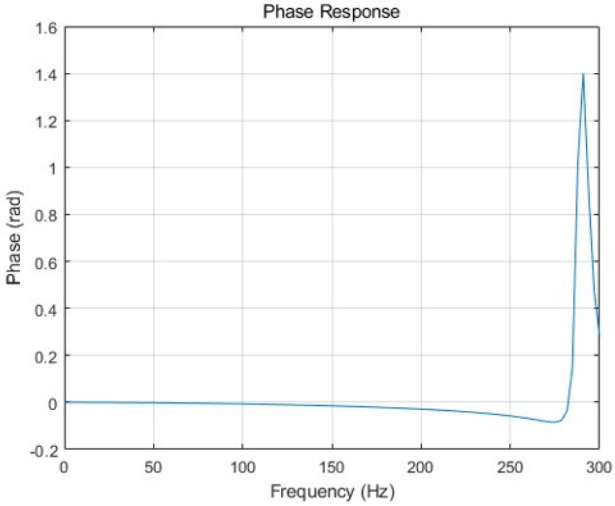


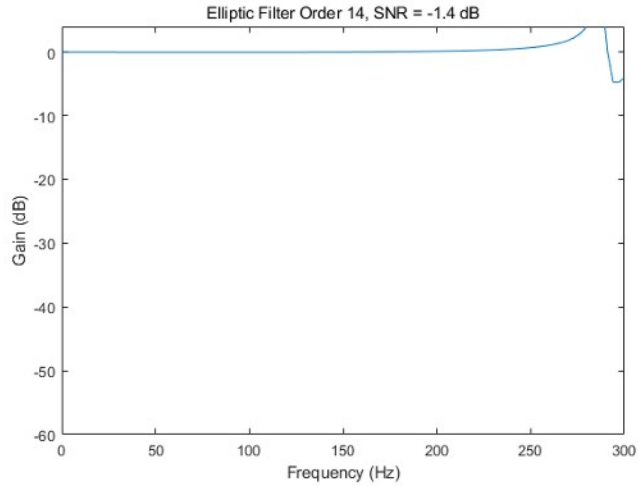


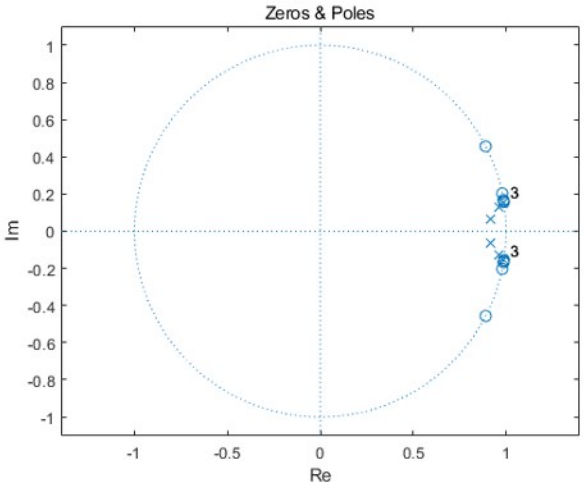
PSD is fail to plot

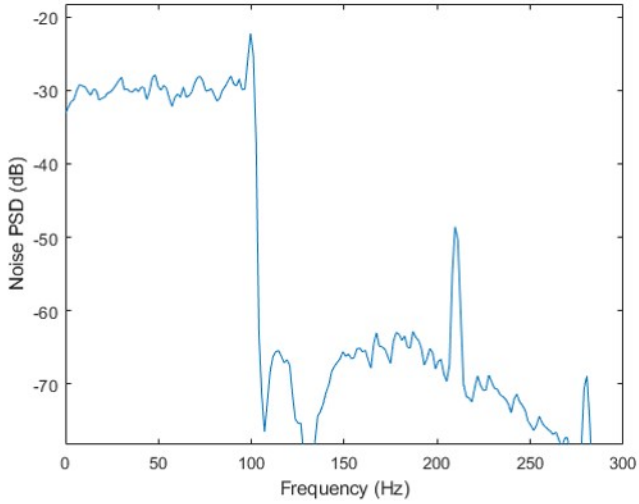
The elliptic filter has some problems

Stable implementation









It is obvious that with this implementation, the elliptic filter works quite well.

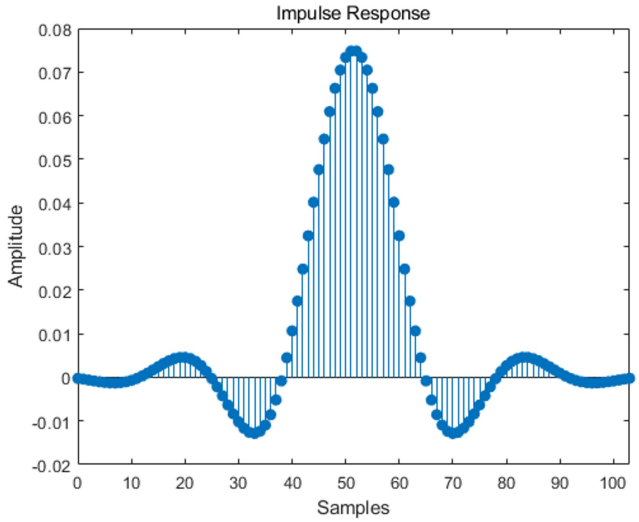
3/1/2022

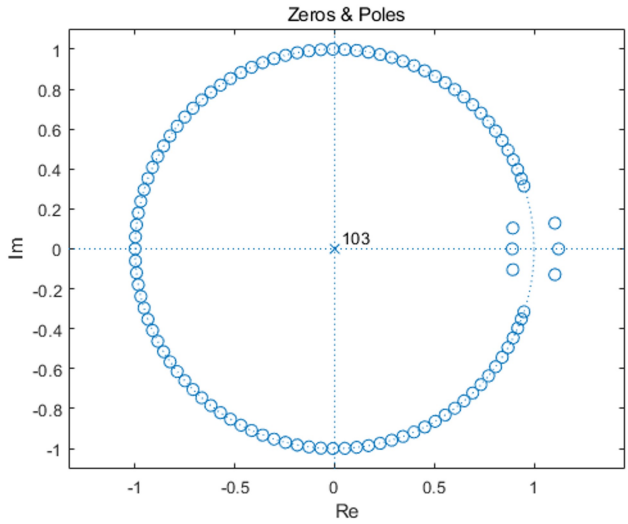
Ex 5

```
[n,wn,beta,ftype]=kaiserord(ftr,a,dev,fs);
n
```

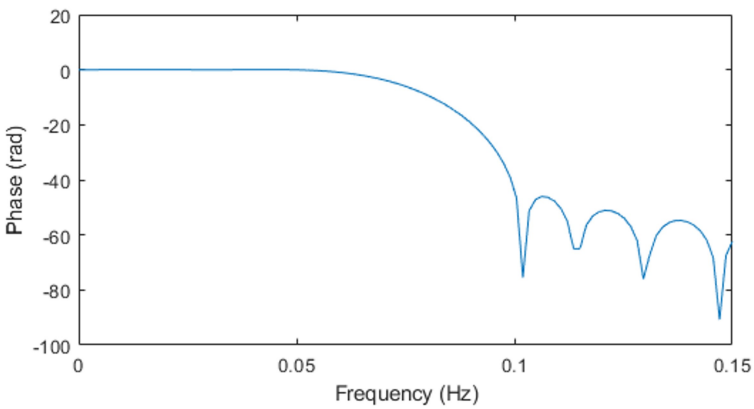
```
n =

   103
```

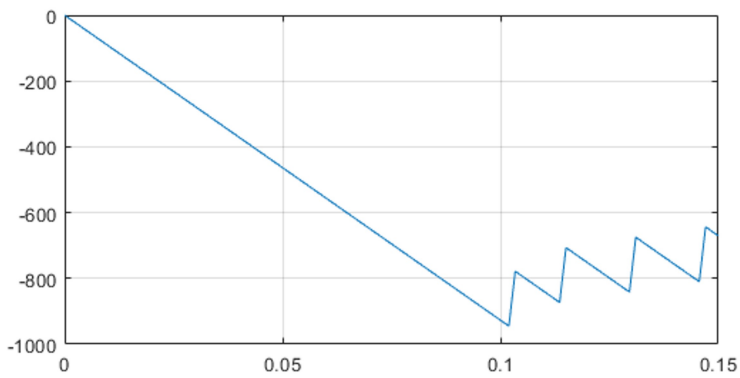
Using this function, the order can be found under SNR = 4.0202





By plotting the Magnitude & Phase reponse:





Advantage:

The phase response is linear, the poles are at the origin hence its stability is high

Disadvantage: the order is extremely high (103)

103 poles & zeros: 206 multiplications

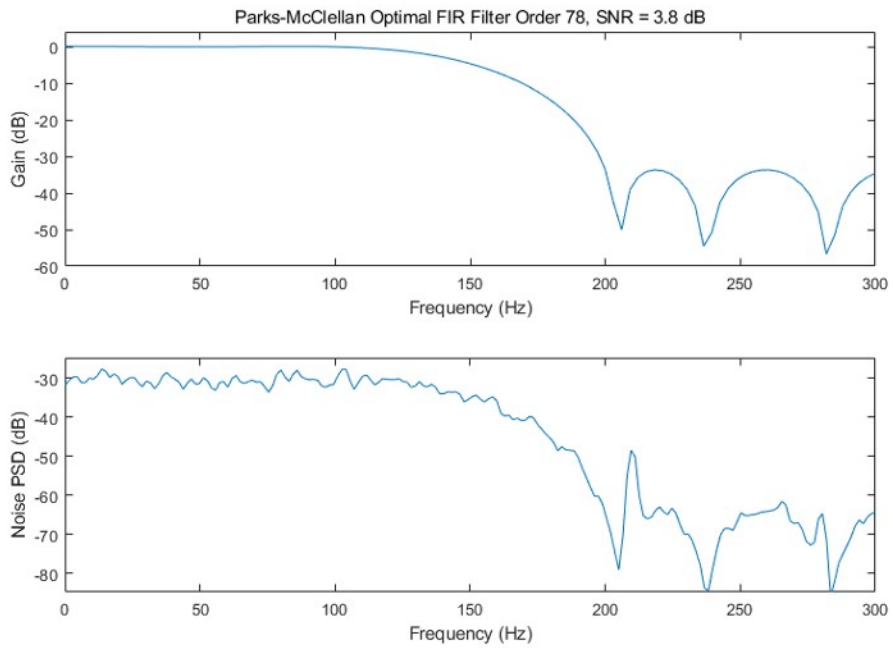
↓ actually

103 multiplications

Because of its symmetricity, half of multiplications can be ignored.

6/1/2022

Ex 6

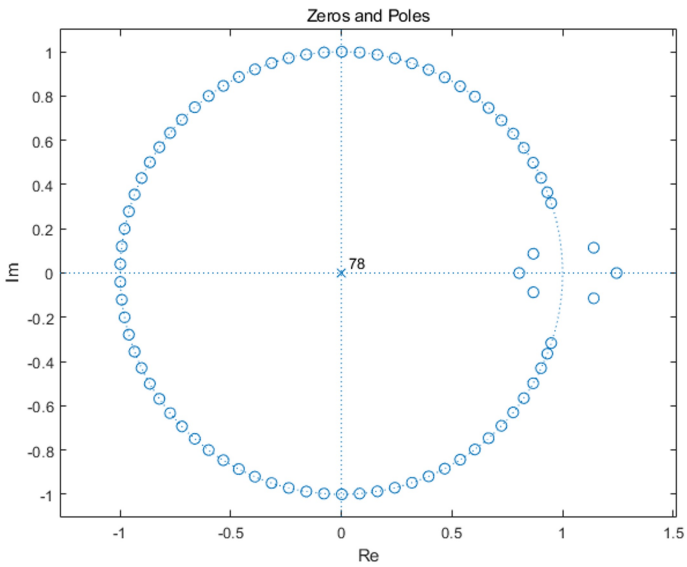


With 78 order (103 → 78), the same SNR is reached.

8/1/2022

Ex 7

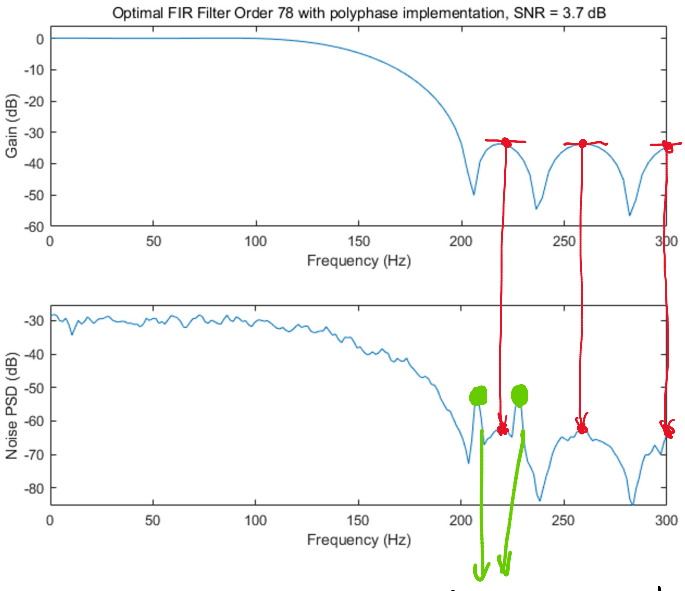
Nyquise frequency 2000 Hz $\longrightarrow$ $K = \frac{2000}{150} \approx 13$



∵ There are 78 zeros and poles & $K = 13$ & symmetricity

$$\frac{78+78}{2} \times \frac{1}{K} = 6$$

multiplications



→ These peaks are caused by the zeros of the filter.

These 2 peaks are caused by noises.