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```
% This exercise uses speksitIIR.m function from Mycourses. The function has
% to be in the same folder as this skript to work.
% You can write 'help speksitIIR' to Command Window to get information
% about speksitIIR function. Sampling frequency in both sections is 48000Hz
% Use legend() to name each magnitude response clearly.
fs = 48000;
```

## Task a)

Design digital minimum order (lowest possible order) I) Butterworth, II) Chebyshev 1, III) and Elliptic high-pass filters that fulfill specs drawn on the figure(1) and plot them to figure(1). Helpful functions: butter, buttord, cheb1, cheblord, ellip, ellipord freqz.

```
figure(1);clf
hold on
Wp = 0.5; Ws = 0.3; Rp = 3; Rs = 40; fs = 48000;

%plots here
[bOrder1, bWn] = buttord(Wp, Ws, Rp, Rs);
[bbutter,abutter] = butter(bOrder1, bWn,'high');
[h{1}, w{1}] = freqz(bbutter, abutter, [], fs); hold on;

[cOrder1, cWn] = cheblord(Wp, Ws, Rp, Rs);
[bcheby,acheby] = cheby1(cOrder1, Rp, cWn,'high');
[h{2}, w{2}] = freqz(bcheby, acheby, [], fs); hold on;

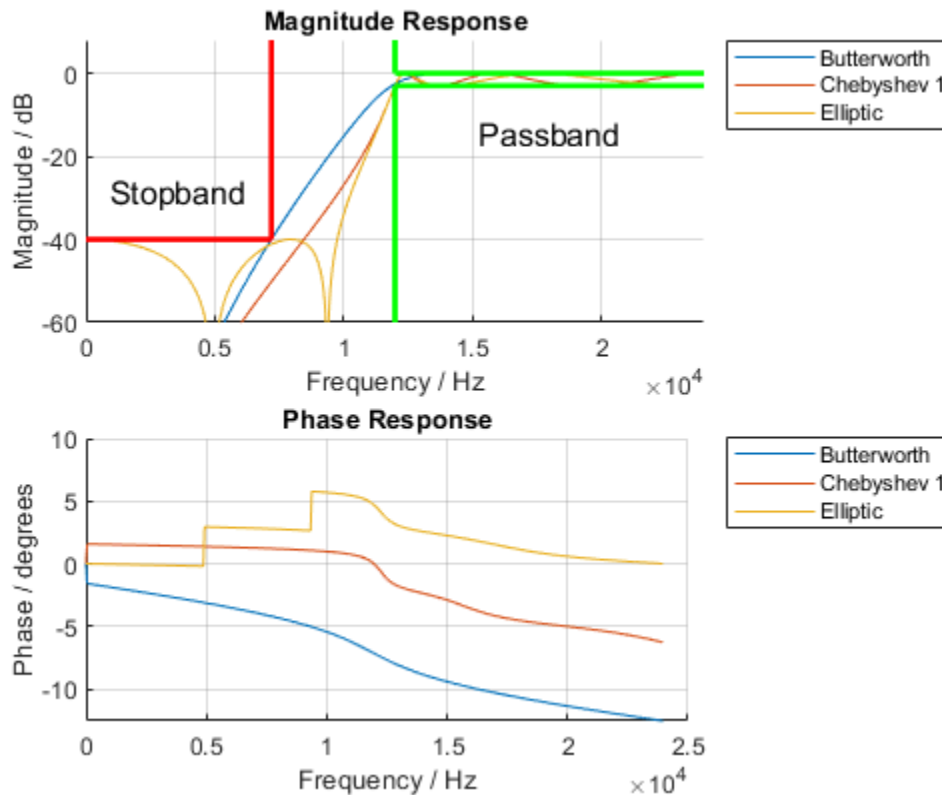
[eOrder1, eWn] = ellipord(Wp, Ws, Rp, Rs);
[bellip,aellip] = ellip(eOrder1, Rp, Rs, eWn,'high');
[h{3}, w{3}] = freqz(bellip, aellip, [], fs); hold on;

subplot(2,1,1)
hold on
for k = 1:3
    plot(w{k},20*log10(abs(h{k})))
end
speksitIIR(0.5, 0.3, 3, 40, 'high', 48000);
title('Magnitude Response')
legend('Butterworth','Chebyshev 1','Elliptic','Location','NorthEastOutside')
xlabel('Frequency / Hz')
ylabel('Magnitude / dB')
hold off
grid on
subplot(2,1,2)
```

```

hold on
for k = 1:3
    plot(w{k},unwrap(angle(h{k})))
end
title('Phase Response')
legend('Butterworth','Chebyshev 1','Elliptic','Location','NorthEastOutside')
xlabel('Frequency / Hz')
ylabel('Phase / degrees')
hold off
grid on

```



## Task b)

Design digital minimum order (lowest possible order) I) Butterworth, II) Chebyshev 1, III) and Elliptic band-pass filters that fulfill specs drawn on the figure(2) and plot them to figure(2). Helpful functions: butter, buttord, cheb1, cheblord, ellip, ellipord freqz.

```

figure(2);clf
hold on

%plots here
fs = 48000; Wp = [0.5 0.7]; Ws = [0.3 0.8]; Rp = 1; Rs = 40;

%plots here
[bOrder2, bWn] = buttord(Wp, Ws, Rp, Rs);
[butter,abutter] = butter(bOrder2, bWn);

```

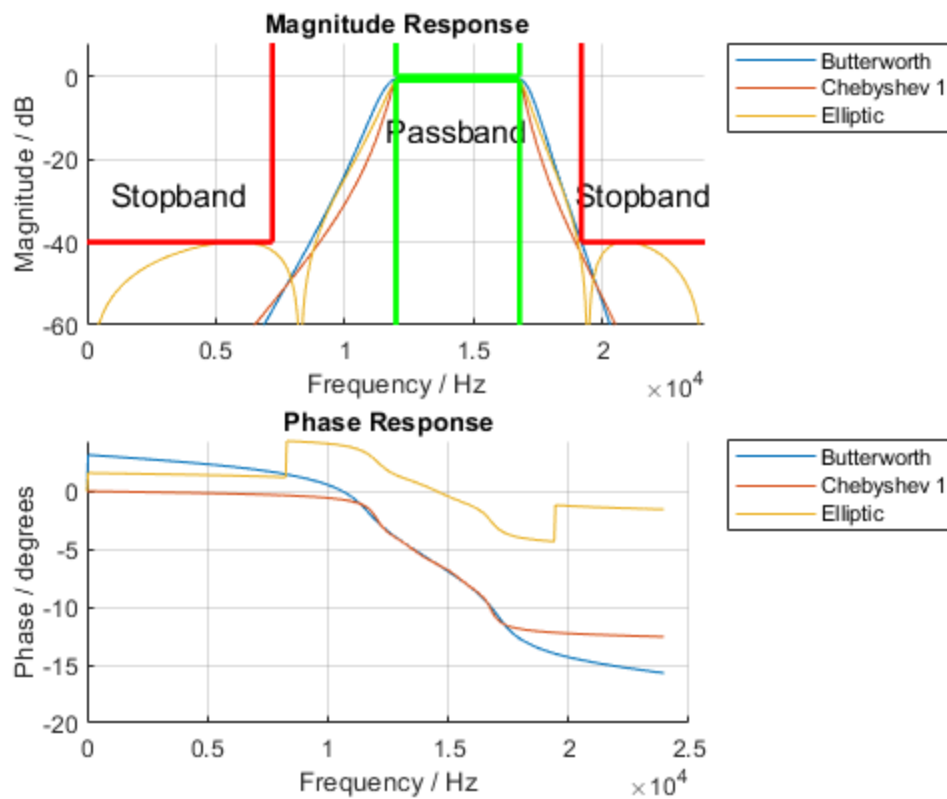
---

```
[h{1}, w{1}] = freqz(bbutter, abutter, [], fs); hold on;

[cOrder2, cWn] = cheblord(Wp, Ws, Rp, Rs);
[bcheby,acheby] = cheby1(cOrder2, Rp, cWn);
[h{2}, w{2}] = freqz(bcheby, acheby, [], fs); hold on;

[eOrder2, eWn] = ellipord(Wp, Ws, Rp, Rs);
[bellip,aellip] = ellip(eOrder2, Rp, Rs, eWn);
[h{3}, w{3}] = freqz(bellip, aellip, [], fs); hold on;

subplot(2,1,1)
hold on
for k = 1:3
    plot(w{k},20*log10(abs(h{k})))
end
speksitIIR([0.5 0.7], [0.3 0.8], 1, 40, '', 48000);
title('Magnitude Response')
legend('Butterworth','Chebyshev 1','Elliptic','Location','NorthEastOutside')
xlabel('Frequency / Hz')
ylabel('Magnitude / dB')
hold off
grid on
subplot(2,1,2)
hold on
for k = 1:3
    plot(w{k},unwrap(angle(h{k})))
end
title('Phase Response')
legend('Butterworth','Chebyshev 1','Elliptic','Location','NorthEastOutside')
xlabel('Frequency / Hz')
ylabel('Phase / degrees')
hold off
grid on
```



## Task c)

What are the orders of each filters and what differences: butterworth, chebyshev 1 and elliptic filter have?

bOrder1  
bOrder2  
cOrder1  
cOrder2  
eOrder1  
eOrder2

*bOrder1* =

7

*bOrder2* =

6

*cOrder1* =

5

---

`cOrder2 =`

`4`

`eOrder1 =`

`4`

`eOrder2 =`

`3`

*Published with MATLAB® R2021b*