University of Nottingham
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Individual Filter Design Coursework
-Electronic Project-

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Filter Design Coursework EEEE2046

Introduction

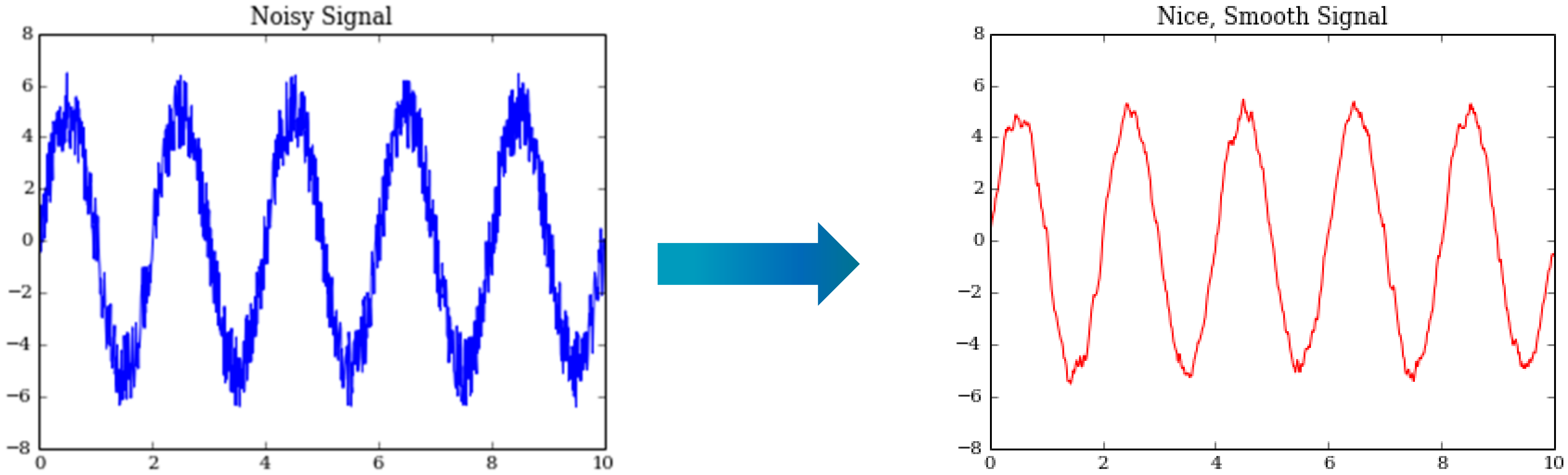
Learning outcomes

- Enhance the level of understanding in filter design specifically higher order filter.
- Appreciate issues in designing filter using different approaches
- Improve learner skills in designing course work document.

Aim

- The aim of this individual coursework is to design a higher order filter that can better attenuate the low frequency components, i.e. a **high pass filter**

- Theoretical material on filters is covered in EEEE2044: Electronic Processing and Communications module / filter section.
- Why do we filter?
- Filter are used in most of the area of Electrical and Electronic Engineering
- The signals usually corrupted with noise
- We are aiming to reduce the effect of these noises … but to perfect level



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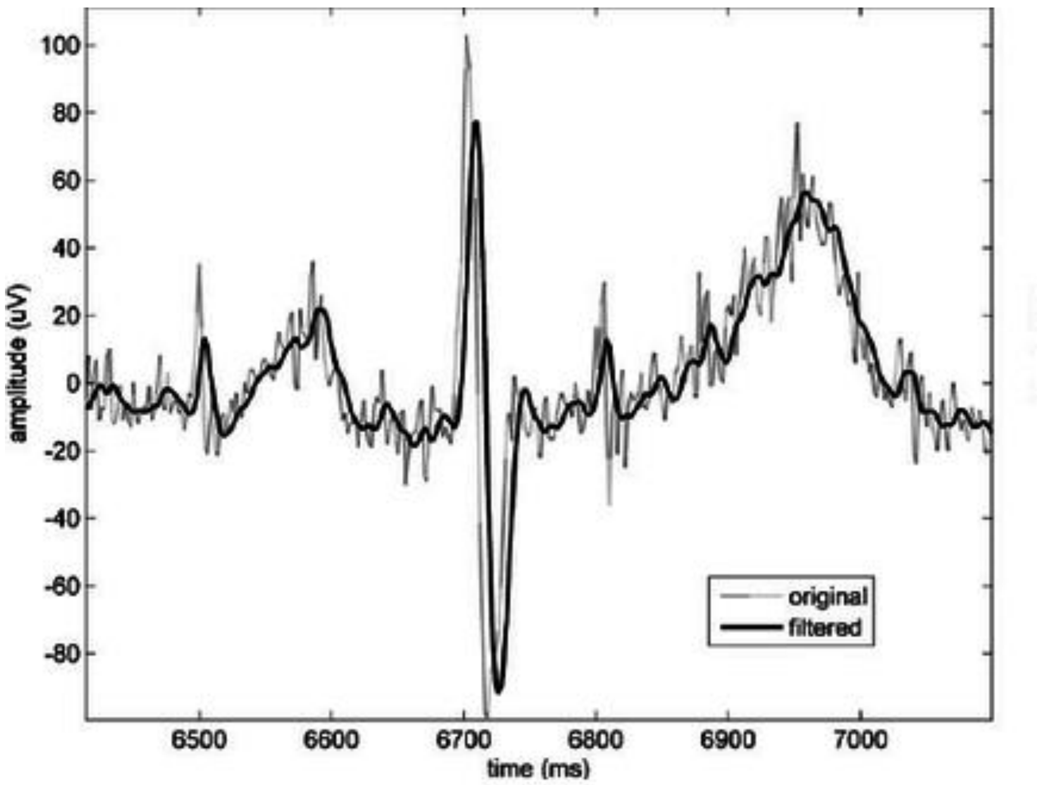


e.g. Biomedical signal

- Filtered signalled is much smoother
- Don’t over filter the signal and remove important information

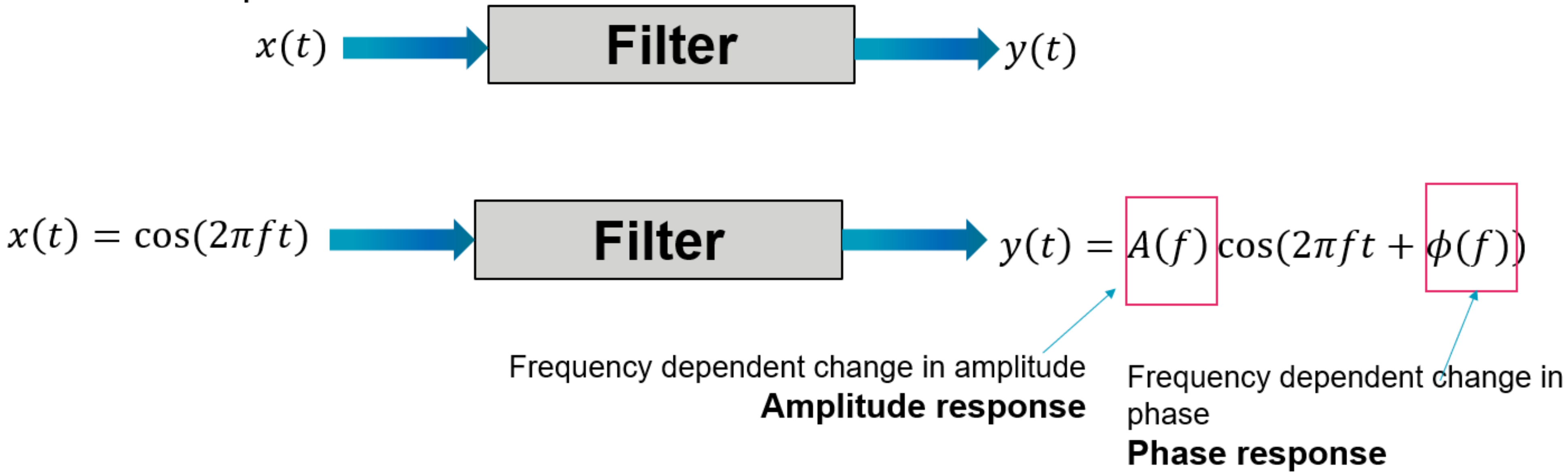
R E Gregg, S Zhou, J Lindauer and E Helfenbein, Journal of Electrocardiography, 41(1),8-14, February 2008

Key filter functions are:

Amplitude response : dependent on frequency, important to decide the type of your filter H or L pass.

Phase response

- Phase response



Doppler Frequency Proportional to Speed

$$f_0 \longrightarrow f_0 + f_d \propto V$$

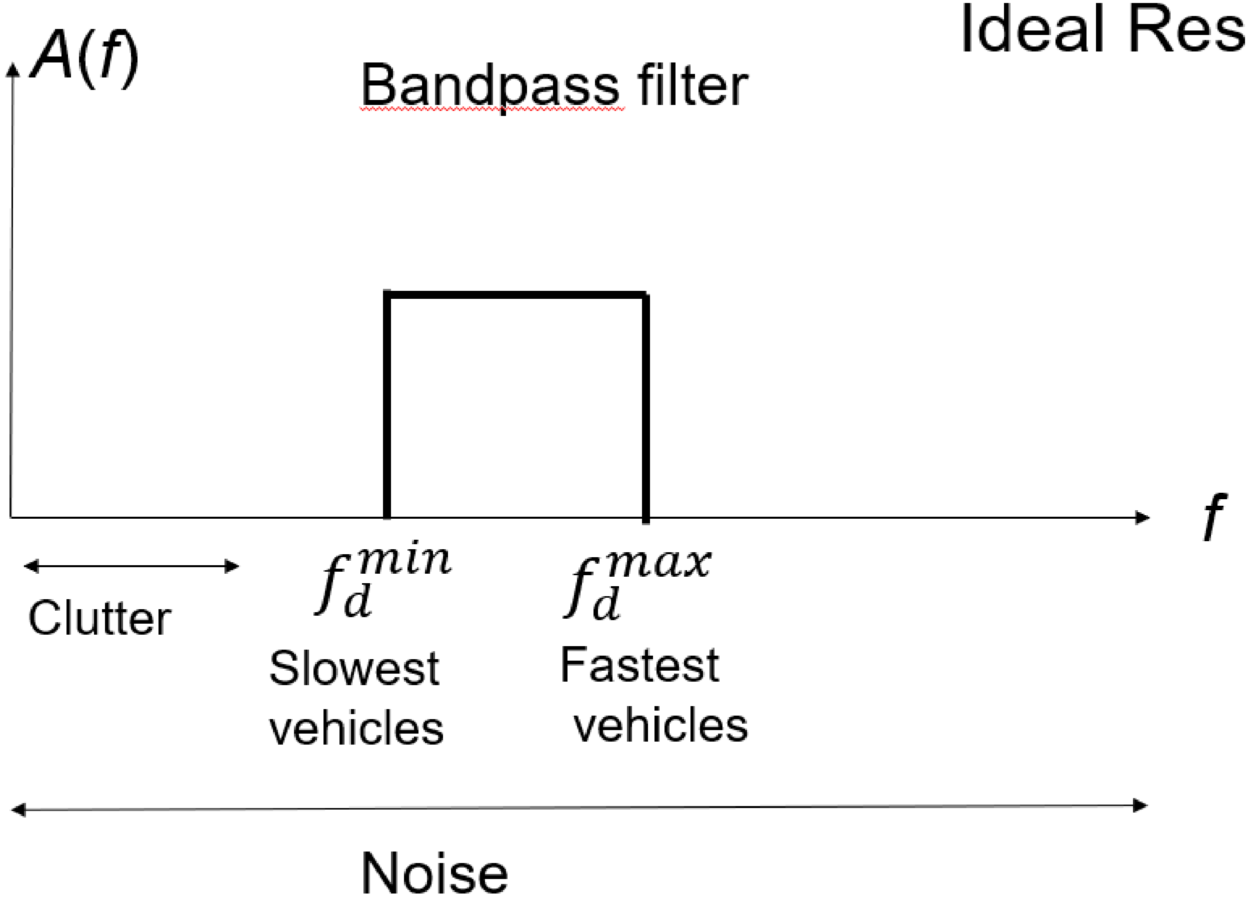
Doppler returns from cars with speeds between V_{min} and V_{max}

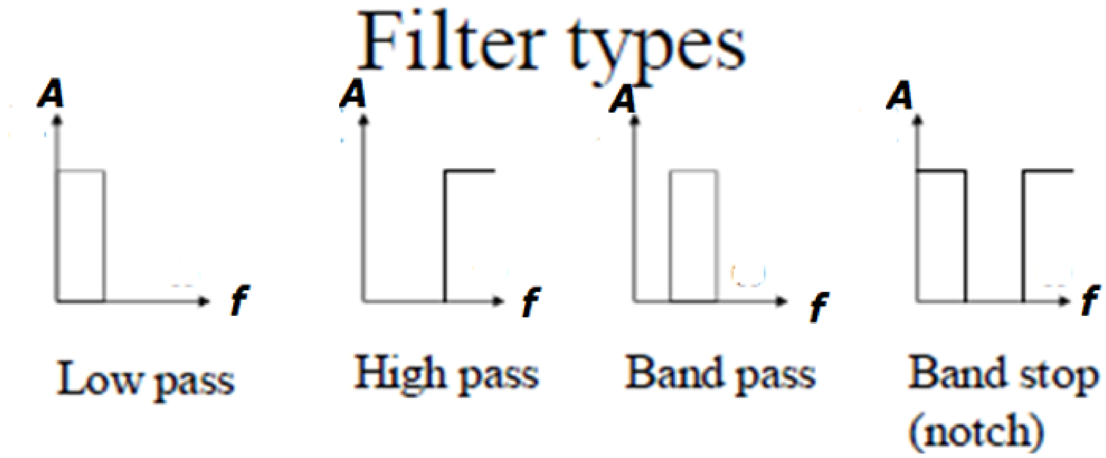
Doppler frequencies between f_d^{min} and f_d^{max}

But also returns from grass bank, trees, birds, - clutter !!!

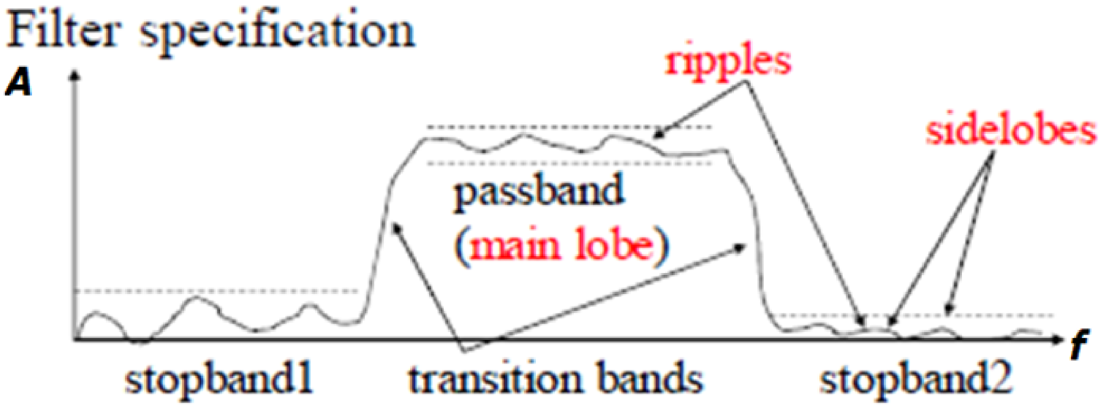
Also wideband noise affecting instrumentation

Ideal Response




Filter types
A
f
Low pass
A
f
High pass
A
f
Band pass
A
f
Band stop
(notch)

In practice……


Filter specification
A
ripples
sidelobes
passband
(main lobe)
f
stopband1
transition bands
stopband2

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Tasks 1 & 2:

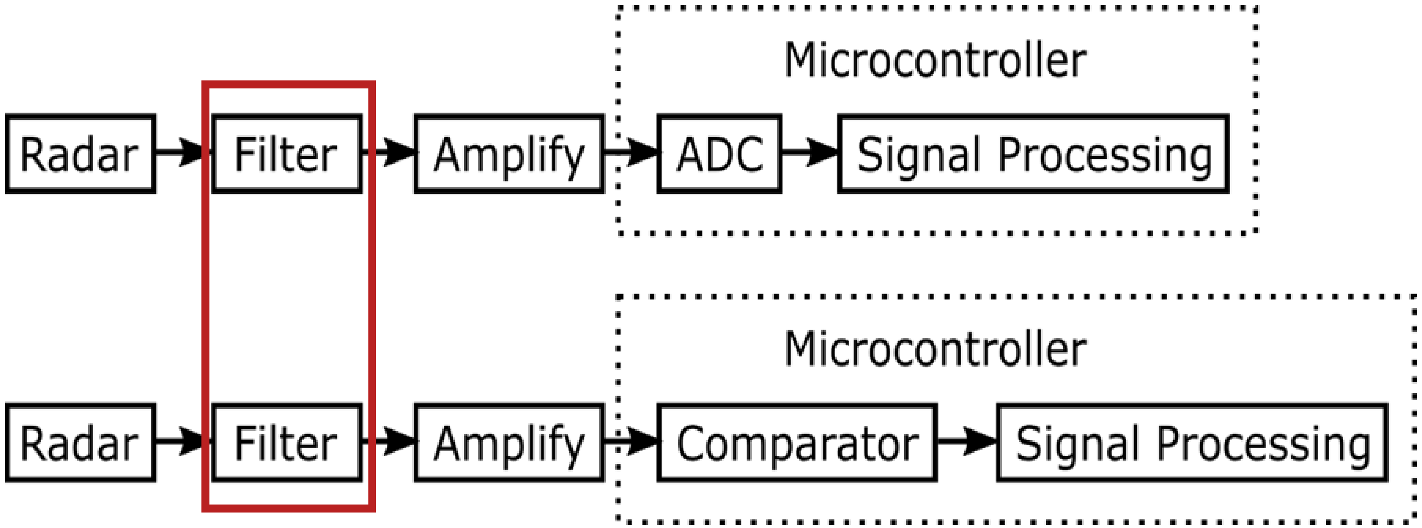
- Analogue signal conditioning -> gain and filter

Your group have designed filters for your Doppler radar system.

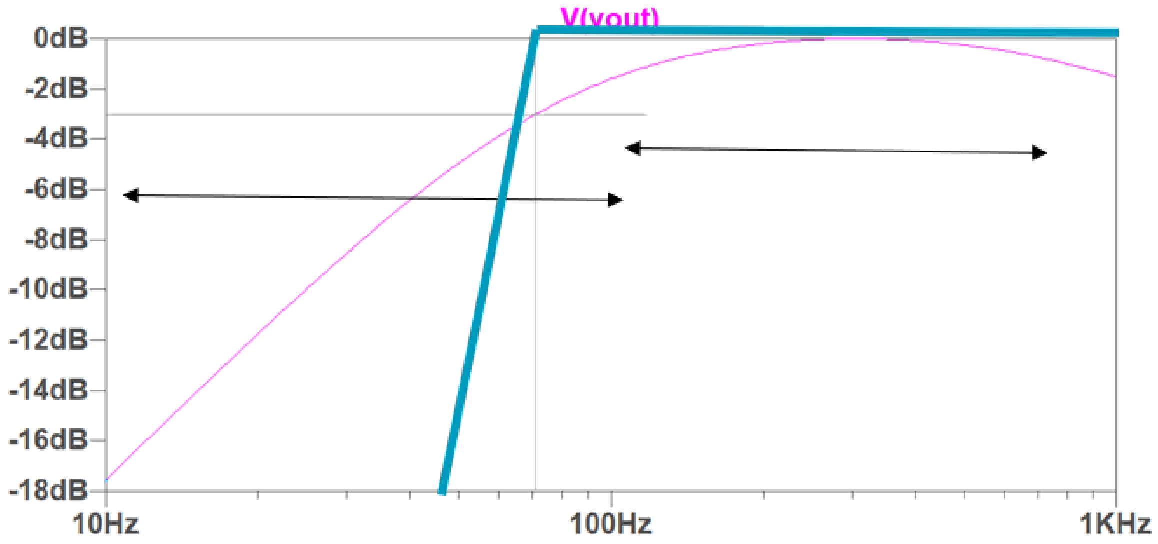
As you may have seen with your experimental results – these filters are less than ideal.

The purpose of the filter design coursework is to:

- Build upon your experiences in the laboratory to consider an improved system.
- Apply and link theoretical work you've done in EEEE2044: Electronic Processing and Communications with the experimental work in your project.



So far, you have designed a filter with the following response



Non-ideal response because:

- Not a flat response in the passband
- Some unwanted frequencies passed by the filter

The aim of this coursework is to make the low frequency response sharper – high pass filter

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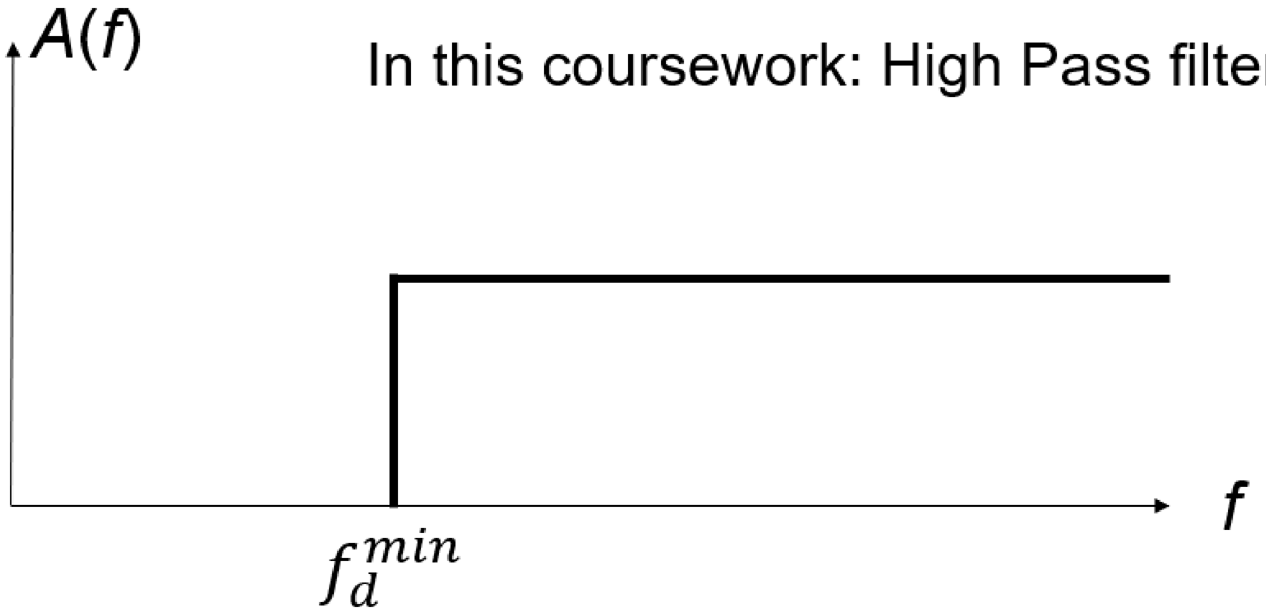
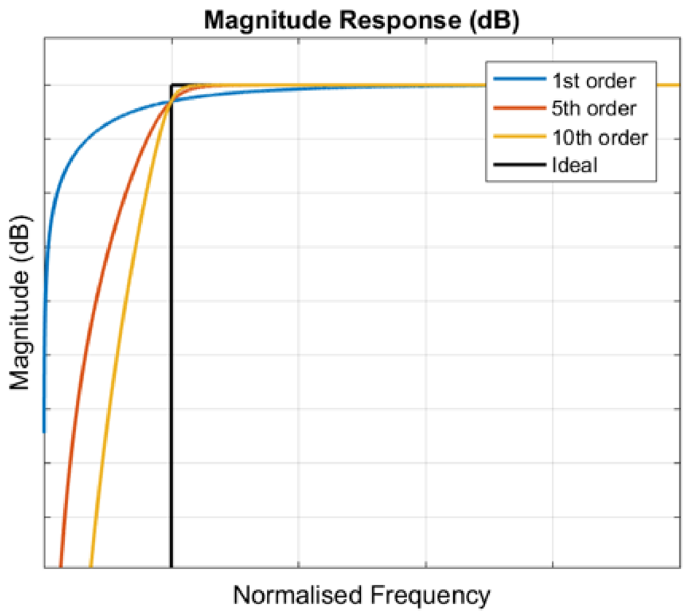


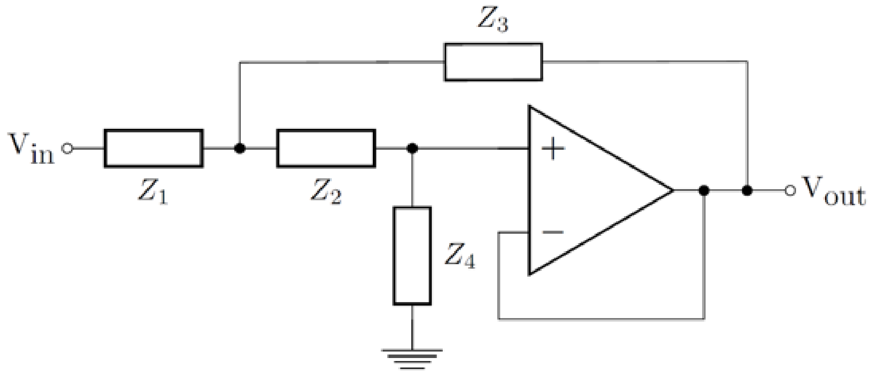
Again this response is ideal

The more components, the sharper the response

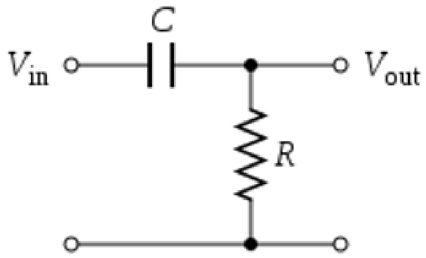


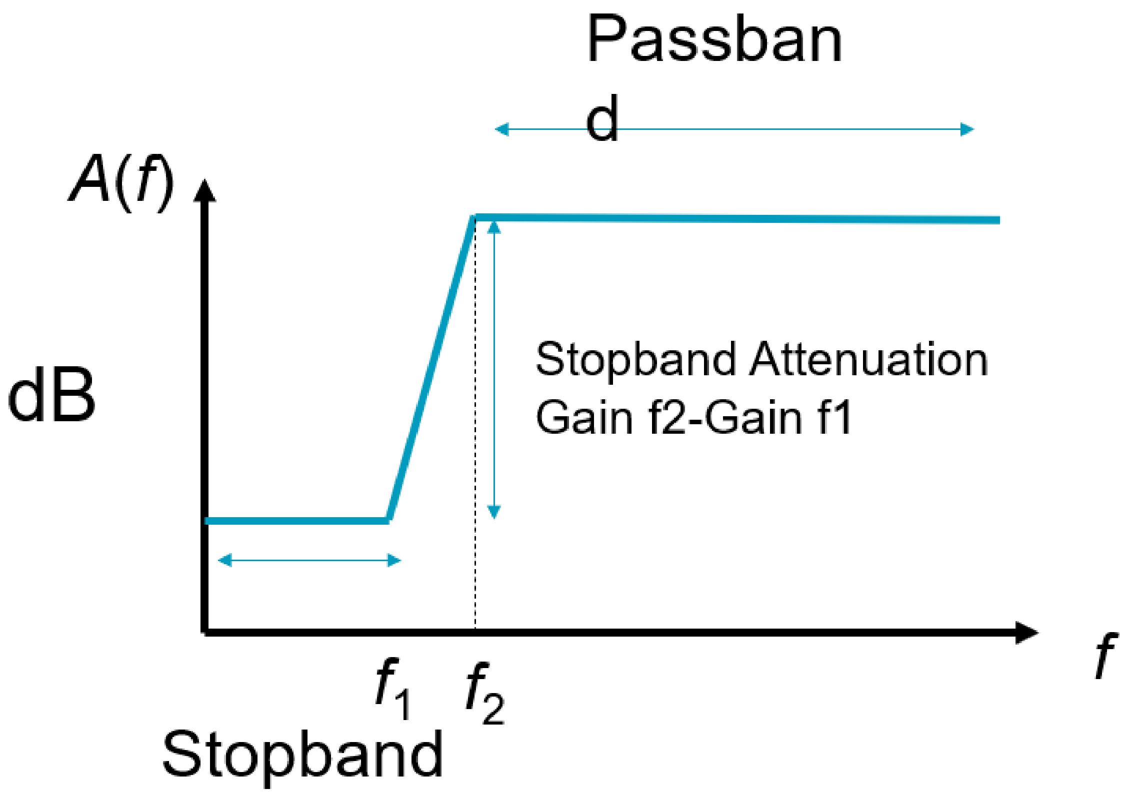
e.g. Third Order = Cascade First Order followed by Second Order

Second Order: Sallen key filter



First Order Section





The steeper the transition between Passband and Stopband, the higher the order of the filter
*f*1: end of the stop band
*f*2: frequency corresponding to beginning of pass band : 3dB freq

Need to use a minimum order satisfying design specification to avoid using unnecessarily large number of components

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The coursework task will lead you through a number of design steps and ask you to write up your findings.

In EEEE2044, we will be discussing filters in more detail and provide you with a more comprehensive overview of filter design.

If, after completing the coursework you think your filters in the project can be improved, I recommend that you do not change your circuit at this late point (unless you are having major issues with your signal input to the microcontroller) and instead be prepared to discuss improvements in your viva.

Submission

- 1. A written document that contains calculations for your filter design and the other written components asked for.
- 2. A zip file containing the LT Spice schematic files for your designs.

- **Deadline is 23/11/2022 at 3pm**

Page limit

- Absolute maximum of 10 pages (including all tables, charts, references etc.) Cover page not included.
- Anything over the page limit will not be read/marked
- Marking Rubric : Coursework Assessment Criteria

https://moodle.nottingham.ac.uk/mod/resource/view.php?id=5926784

Report structure

- 1- Introduction: background, filter types, advantages, and disadvantages..
- 2- Filter circuit design calculations and description.
- 3- Results: Simulation results
- 4- Discussion
- 5- Conclusion (optional)
- 6- References
- 7- Appendix (optional).

Report structure

IMPORTANT

- No screenshots for calculations/ no mobile photos
- No handwriting in your report / including using ipad or any similar devices.
- For equations: use word (or any other software)→ insert symbols→ equation→ insert new equation.
- For tables: use word (or any other software)→ insert table → or draw table
- No results figures or calculations in Appendix

Task 1

- Carry out research into different filter characteristics and their applications. Provide a description of the advantages and disadvantages of each of Butterworth, Chebyshev and Bessel filter designs and include examples of where these filters can be found in real life products.
- No Wikipedia references
- Use IEEE numbering as a reference style

Task 2

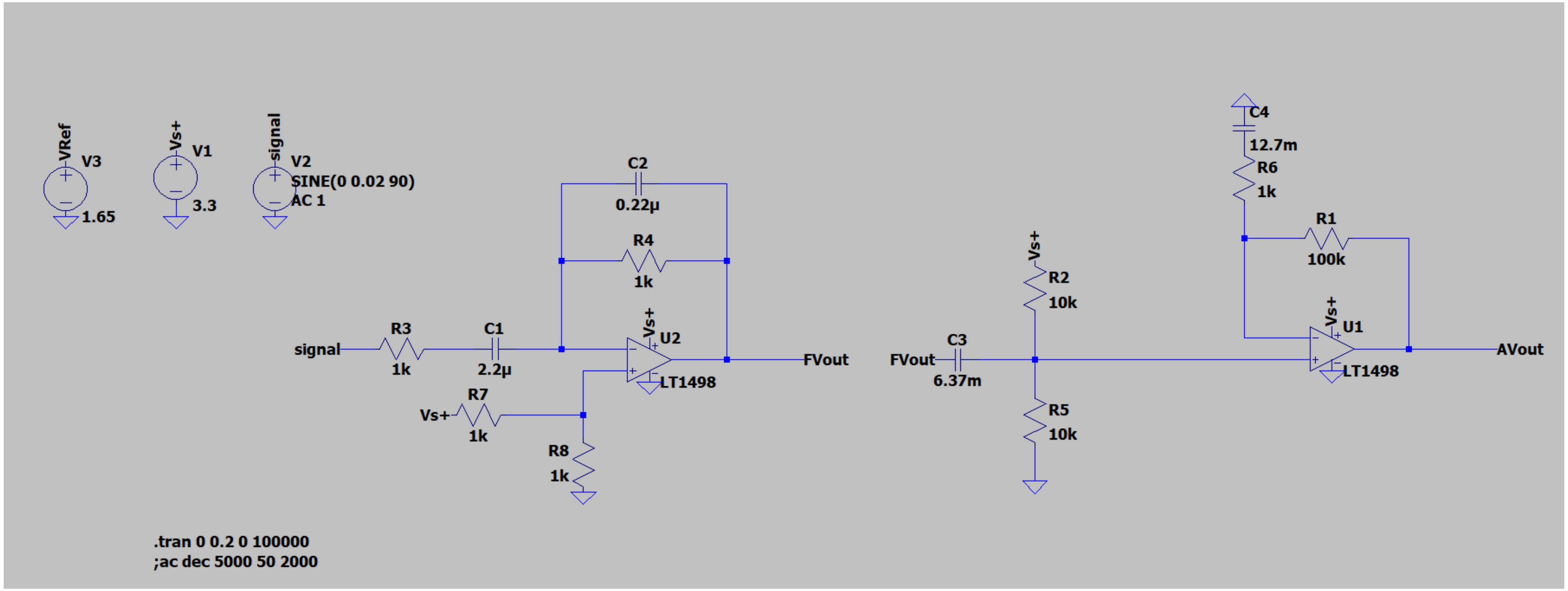
- Design and simulate a high pass Butterworth filter using the Sallen Key topology, to meet the following specification:

- Gain: 1
- Pass band: 100+(use your student ID last 2 digits)Hz
- Stop band: 50Hz
- Stop band attenuation: 30dB

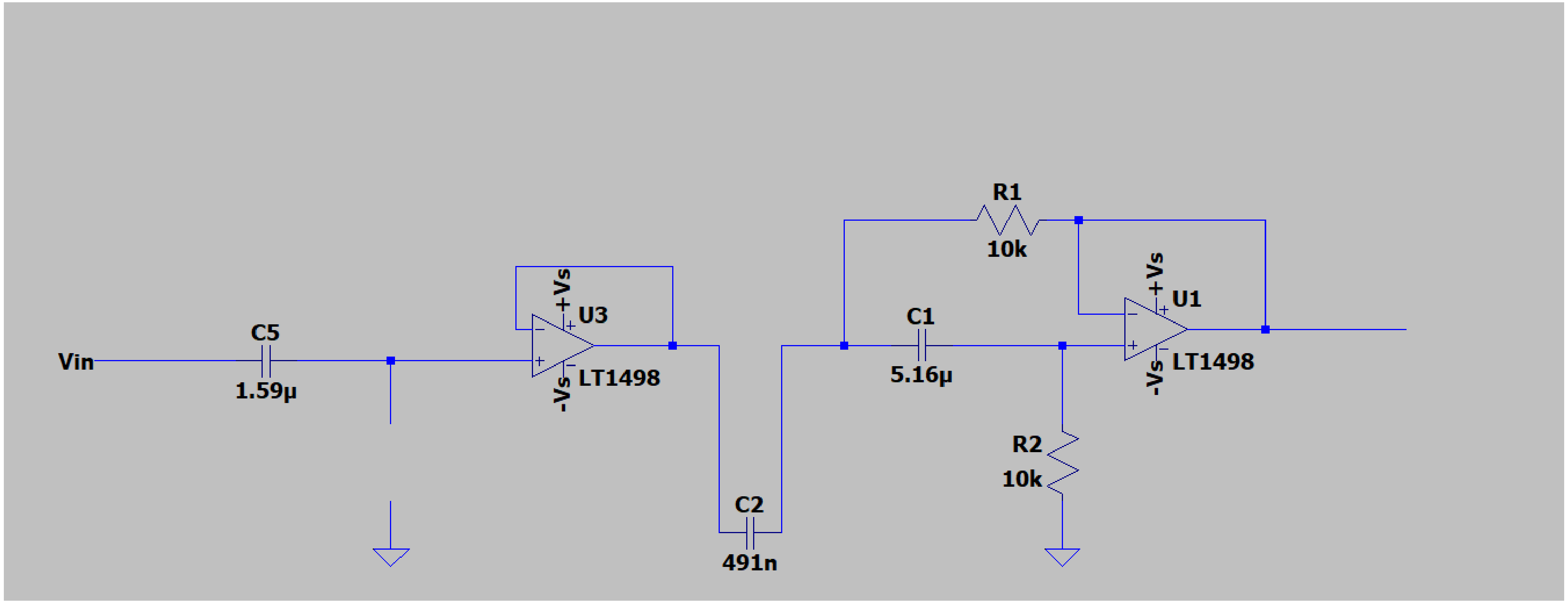
Task 3

- Create a new copy of your design that uses resistor and capacitor values that are readily available. Resistor and capacitor values are typically available in so-called “E” ranges.

Good design- example

- 

Poor design- example

- 

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Thank you