Laboratory Report Task– Course Work

This section provides supplementary details on the laboratory report. This report must be submitted via the Moodle platform; however, please be advised that specific submission timelines and deadlines will be communicated by the course instructors at the appropriate time. Should you require clarification regarding the following guidelines, please do not hesitate to seek assistance.

Problem Statement: Filter Design for Biomedical Signal Acquisition System

Your team at Glasgow College UESTC Ltd. is developing high-precision neural signal acquisition systems for clinical research. Recently, a critical issue was identified in one of your electroencephalogram amplifiers: the recorded neural signals exhibit significant interference. The useful physiological signal is centred around 10 kHz ($\pm$2 kHz), capturing essential brainwave patterns for cognitive analysis. However, the signal is contaminated by two dominant noise sources: a low-frequency 100 Hz artefact, likely resulting from power line interference or electrode instability, and a high-frequency 100 kHz component, potentially caused by switching regulators or external electromagnetic interference.

To ensure reliable signal processing, it is necessary to design a filter that meets stringent performance criteria. The filter must preserve the useful signal in the vicinity of **10 kHz (having a useful bandwidth between 8 -12 kHz)** with negligible attenuation (**≤ 1 dB**) while suppressing both the **100 Hz and 100 kHz** noise components by **at least 20 dB** relative to their original amplitudes. This suppression is essential to prevent noise from obscuring subtle neural features or saturating downstream analogue-to-digital converters.

After simplification, it can be assumed that both useful and interfering components can be approximated as sinusoidal signals with the amplitude of the signal after acquisition as a 1V sinusoidal signal at f Hz frequency.

$$s(t) = \sin(2\pi f t)$$

Given these requirements, you are supposed to propose an appropriate filter architecture. A rationale for your choice should also be provided. The proposed solution should maintain signal integrity while effectively eliminating the specified interference sources.

In your report, you should exhibit:

- Figure out:
  - What type of filter do you need?
  - What cut-off frequency would you set, and what would be the order of the filter?
  - Do you need an active or a passive filter? Adopt the design method accordingly.
- Include the design of the filter and the components utilised with their specific values. Provide a rationale for the selection of the component values you use and add circuit illustrations.
- Include the simulated design and its performance using PSpice schematic and a gain plot showing that the filter performs as you expect.
- Implementation of the designed filter circuit on a breadboard. Include justification for the selection of component values, experimental data and results that show a plot of the gain of your filter as a function of frequency to demonstrate that your proposed design works.

Report Requirements

- The lab report must be a **maximum of four A4 pages** long and must be **in PDF format**. Longer submissions or submissions in other formats will **not** be accepted. A cover page is permitted and will not be counted toward the total page count.
- Margins must be larger than 1.5 cm in all four directions, recommended font Arial 11 or Times New Roman 12. **Please do not write with very small fonts**.
- The report **must have your name in English characters** on the first page and UoG/UESTC numbers (you can, of course, add your name in Chinese characters, but do not forget the English

version as well)

- **The lab report is individual**, but you can work in pairs to produce the results; however, do not submit identical reports, as this will be treated as plagiarism.
- **Structure of the report** – you may want to use the following sections and headings to structure your report.

    - *Abstract* – the abstract is a summary of your report, expressing synthetically what the problem was, what methodology you used to address it, and what the main results of your work were
    - *Introduction* – the introduction describes with some more details the problem you are asked to address and its context
    - *Methodology* – this is where you need to describe the bulk of your work, the tools you used (simulations in PSpice? Demonstrations on breadboard or PCBs?), the design procedure you followed to address the problem (why that filter structure, why those components, for example?)
    - *Results and discussion* – here you need to show and demonstrate that your proposed design works, in simulation and with experimental demonstrations
    - *Conclusions* – summarise again the problem and how you solved it (someone needs to be able to understand most of your work, reading just the introduction and conclusions)
    - *References* – if you used materials from books, research papers, or websites, you need to reference them at the end (do get in touch with GTAs/teacher if you are confused about this)

- A good report should present the circuit schematics with components chosen and their values, and both simulated and experimental results to prove that the proposed design works. You will need to write some text to justify your choices and comment on your results. Remember, this is a “real” open problem, so there is no single correct solution.
- Proposing more than one solution is encouraged, provided it does not exceed the page limits. If you address this project using additional methods, you are more likely to achieve a higher score.
- <u>Some tips for a good report</u>. Remember to:
    - Indicate the value of the components, inputs, outputs, and ground in your circuit schematics
    - Have captions for all the figures you use
    - Indicate the units of measurement in the graphs and plots you present
    - Do not just put figures and graphs with no or little text to comment on those results. Your report needs to “tell a story” and persuade the reader that by doing the lab activities, you now have a good knowledge of filters.

Appendix – Remote experiment

Experimental Procedures

Step 1: Access the lab computer remotely.

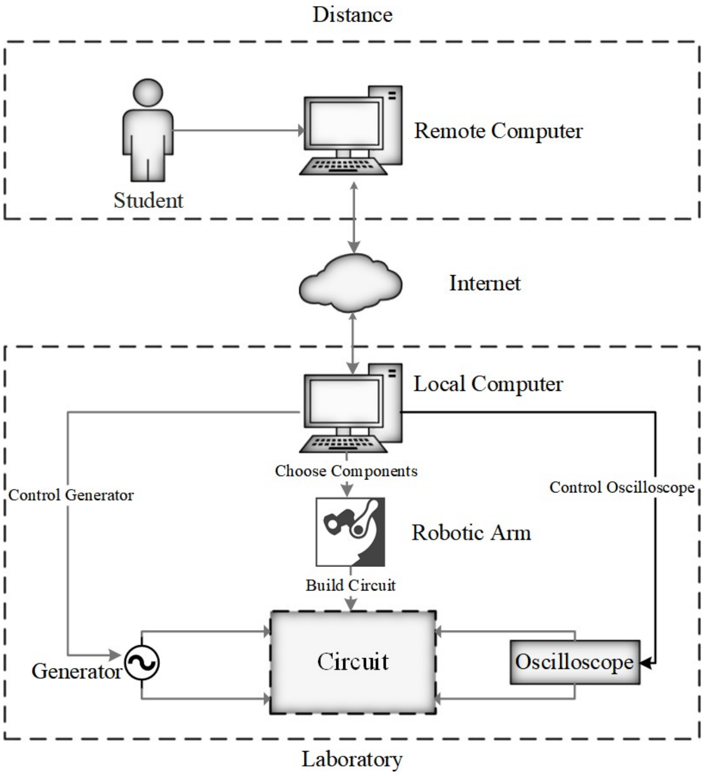
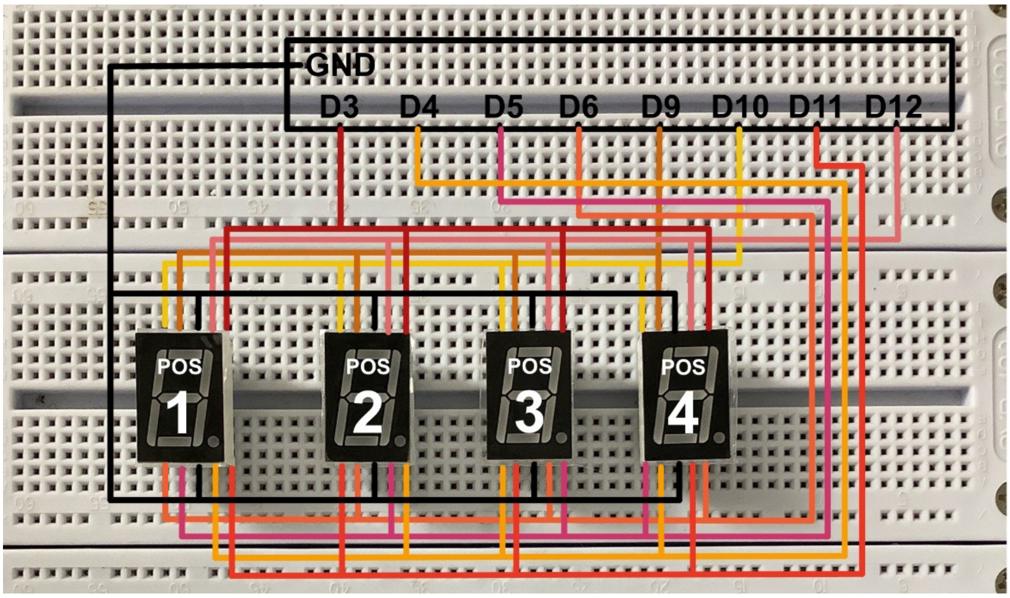


Figure 1 Concept of remote lab

Step 2: Choose the position to place the 7-segment display in *LabAS_7-segments*. Then build the circuit.



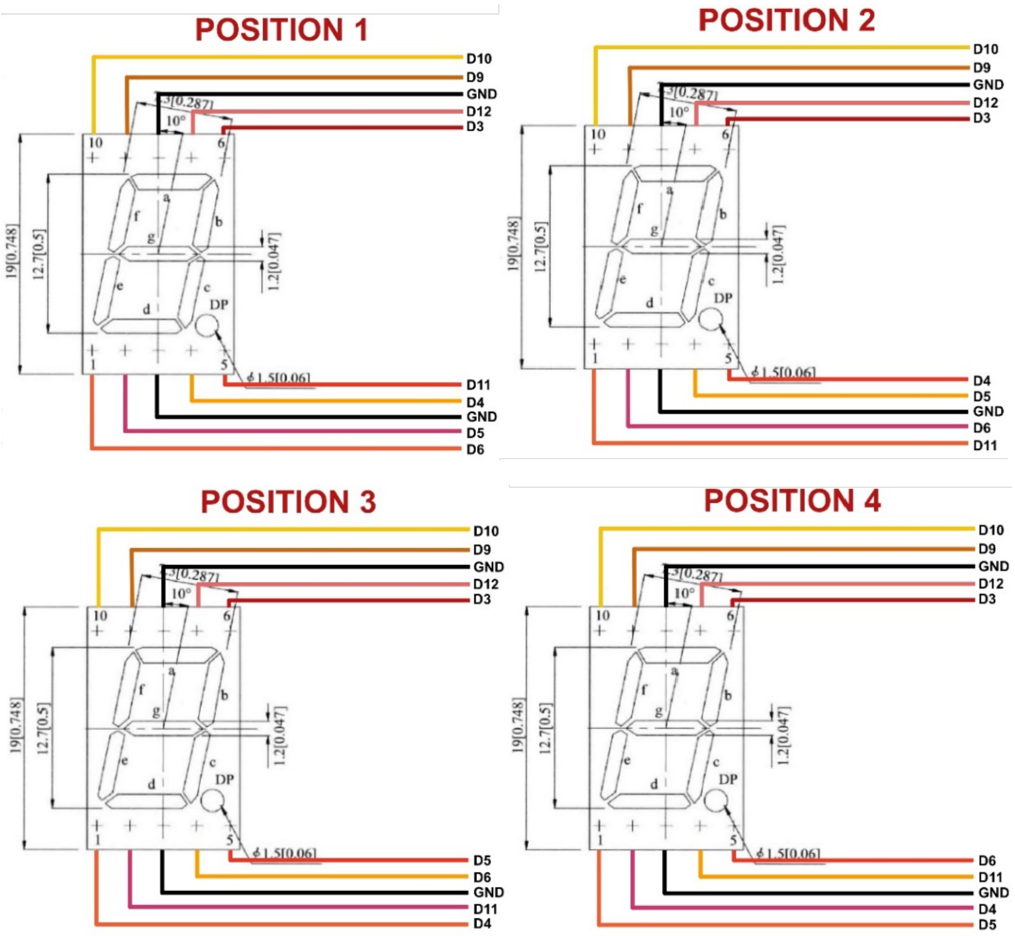


Figure 2 Pin connection diagram of 7-segment display

Step 3: Based on your table to determine the hexadecimal values required to produce the digital 0-9 on the seven-segment display, modify the code above to count from 0-9.

Step 4: (optional) When the display counts from 0-9, show the decimal point simultaneously with the odd number.

Step 5: Reset the circuit in *LabAS_7-segment*.

Step 6: Understanding simulation experiment.

Step 7: Complete the questionnaire.