Biomedical Electronics Project-LAB: Optical Plethysmography design

General instructions

With this project, you will demonstrate the skills acquired through this subject and how you collate knowledge and skills acquired in previous studies (i.e. Mathematics, computing etc.) to produce and demonstrate a fully functional device.

1. For the purpose of this assignment, refreshers for topics that are assumed as known such as the Fourier Transformation and the use of Matlab are provided, please look at the vUWS location: *"Biomedical Electronics/Assessment Zone/Applied Project (40%), Practical (30%)/ Training material"*

   This two-parts assignment is part of your assessments for this course. The two separate submission deadlines are specified in the schedule of activities and is your responsibility to submit by the due date. 40 Marks will be assigned in total, and these will be transformed into a percentage of your final grade as per Learning Guide. For this project you will use the "Lab in a Box" platform, please consult the relevant tab on vUWS for purchase/details about this platform.

   Hints:

   i. Words can explain things, but figures can be worth thousands of words. Use plenty of figures

   ii. Figures are useless without a proper caption, without axis labelling and well visible lines: before importing any figure in your document, edit it to make sure that the lines are at least 2px, that there is a legend (if many plots share the same axis) that axis labels are specified and visible (where is possible use 12pts font). Pictures of instruments' screens/computers will be not accepted and not considered to award marks

Design specs:

Design and test a digital (Arduino based) output light plethysmography sensor capable to a) detect the pulsatile blood waveform in your finger (https://en.wikipedia.org/wiki/Photoplethysmogram); b) measure the pulse rate and output this in beat per minutes refreshing the value at least every 5 seconds.

You must use the LDR sensors and LEDs available in the Lab in a Box. If you want to use your own, you will need to submit a brief statement explaining the reason why you should be allowed this advantage; approval is granted by the teaching team and decision is final.

You can only use LM741 and/or TL081/2/4 as amplifier for this project. Your choice must be declared and argued.

As light sensor, you are free to use the LDR or the LED (yes a LED can be used as light detector for specific light colour see: https://makezine.com/projects/make-36-boards/how-to-use-leds-to-detect-light/ and . https://www.sparkfun.com/news/2161). Your choice must be declared and argued.

BPM extraction can be either hardware or software. Your choice must be declared and argued.

Please note: in this project you are competing with your peers, as part of this assignment you will need to submit a video of you presenting/demoing your project/circuit. The aim of this presentation is to convince the project managers (teaching team) to select your project/circuit for manufacturing.

1) With this assignment you will demonstrate your engineering skills; the skills acquired during this course and capability to work unsupervised.
2) You are going to build up the skills to fulfil this project during the lectures and tutorials, submission of milestones is devised to match the skills acquired.

3) It is expected that this project will take approximately 10 hours of work during the semester, at least 5 hours will be spent in class where members of the teaching team will be able to assist you with your queries and design issues.
4) For this project you will be trained into the use of the instruments/software packages used in this unit for approximately 4 hours during the semester. It is expected that you dedicate at least as much of your own time exercising the skills acquired.
5) The project milestone submissions are due in class (see detailed schedule of activity) please read the submission requirements in advance and prepare any material required in advance where necessary.
6) All the tutorials are functional to the preparation of this assignment and its submission.

Milestone 1: You are required to answer a brief vUWS quiz, the questions are "file response" type, please prepare PDF documents beforehand. This milestone is normally due in week 9/10/11 of the teaching term, please note that deadline may change to reflect progresses of the class, changes of the deadline will be timely advertised and pinned into the project tab.

vUWS questions for Milestone 1 (25 Marks):

Q1 (10 Marks): For this project you are free to design using either a bottom-up or a top-down approach, to answer this question prepare a design brief (max 1500 words) explaining your design strategy and the principle of functioning of the entire circuit and accompanying software. It is expected that the document will have (at least) the following sections (use headings):

1) Design principle and strategy (5 marks)
2) Principle of functioning and circuit section pictures with explanations (3 marks)
3) Arduino and any other accompanying software explanation and well documented code (2 marks)

Q2 (10 Marks): For this project you are expected to verify the circuit (or individual parts of it) via simulations before physical implementation. Please prepare an implementation brief (max 500 words) containing any simulation and the obtained results. It is expected that the document will have (at least) the following sections (use headings):

1) The circuit diagram (Multisim/Partsim or any simulator of your choice) with the simulation results that crosscheck with the assigned specs and with the design strategy outlined in Q1 (5 marks). The simulation results must show without doubts that your simulated circuit can fulfil the assigned specs. Tidiness and easiness of reading the image will be key in getting good marks. Hint: import the data from the simulation in Matlab/Excel to produce a proper plot and add proper caption/legend/labels.
2) The virtual breadboard implementation showing without doubts that you have simulated the circuit assembly including the Arduino software (5 marks)

Q3 (5 Marks): For this project you are expected to produce a manufacturable circuit, for this submission you will prepare a Printed Circuit Board (PCB) that you can manufacture at school (please inquiry with the lab managers for manufacture specs and deadline). Please prepare a manufacturing brief containing the:

1) PCB schematic.
2) The PCB design, your PCB must be single side, and use through-hole components (copper side must be on bottom layer), use short wire bridge on the components side as required, include the 2D design of your board, not a 3D rendering.
3) The bill of materials.

Milestone 2: Circuit demo (15 marks) normally due in week 13/14.

Produce and upload a professional demo for the implemented circuit. Prepare a up to 10 minutes video presentation showing the circuit is operation, the video must show your webcam ON (you can use a virtual background) and must contain at least one picture of the physical breadboard/PCB you have produced/assembled with the student ID. It is expected that the video presentation is structured as following:

1) Brief introduction of the project design (you can use the screen share function in Zoom), for this section you can use slides or the documents you produced for Milestone 1.
2) Show and explain the physical implementation. In this section it is expected that you show and explain the picture with the implemented physical circuit.
3) Real demo showing (screen sharing) the data stream acquired by the Arduino

Hints:

1) The three sections for this presentation can be recorded in separate sessions and when you are happy assembled together as single video.
2) Be professional, you are presenting your work to the project manager.

3) If your circuit despite all of your efforts does not work, this Milestone can be used to explain the engineering principles behind the fault tracing and the engineering steps you have applied to rectify the design, it is assumed that the only reason why you have not been able to implement the rectifications devised to be the limited time constraint of the teaching term.