BIOE457
Final Project

PULSE OXIMETER

Lab schedule (attendance is mandatory for all meeting times; 25% will be deducted for each unexcused absence):

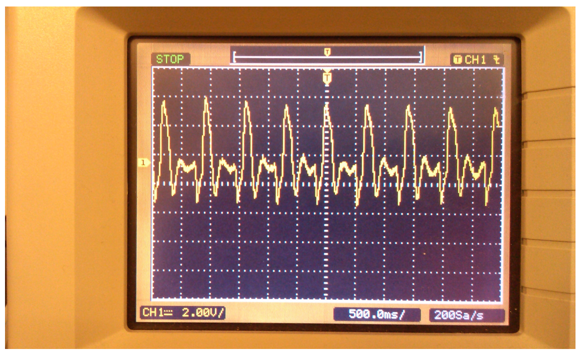
Friday, 4/24	Section 1: 9:00 – 10:30 Section 2: 11:00 – 12:30
Friday, 5/1	Section 1: 9:00 – 10:30 Section 2: 11:00 – 12:30
Monday, 5/4	Section 1: 2:00 – 3:15
Wednesday, 5/6	Section 2: 2:00 – 3:15
Friday, 5/8	Section 1: 9:00 – 10:30 Section 2: 11:00 – 12:30

Groups can deliver the final demonstration during any of the times above.

Materials:
Arduino Uno
Red LED and photodiode in finger clamp
IR LED and photodiode in finger clamp
(4) 741 Op amps
(2) 47 Ω resistor
(5) 10 MΩ resistors
5 MΩ resistor
(4) 2.2 MΩ resistors
(2) 1 MΩ resistors
470 kΩ resistor
(2) 10 μF capacitor
(2) 100 nF capacitor
(4) 270 pF capacitors
DC power supply
Function generator
Oscilloscope
Electronic prototyping board (breadboard)

Principle of pulse oximetry

A pulse oximeter measures the oxygen saturation of hemoglobin in the blood. Today's pulse oximeters utilize the absorption of blood at red (~660 nm) and infrared (~935 nm) light. Reduced hemoglobin has higher optical absorption than oxygenated hemoglobin at 660 nm, while oxygenated hemoglobin has higher optical absorption than reduced hemoglobin at 935 nm. Both red and infrared light have good penetration into tissue, and thus are well-suited for probing the oxygen content of blood within tissue. The use of both wavelengths allows for the correction of various measurement fluctuations. Furthermore, the measurement is taken during pulsation, as during pulsation the amount of arterial blood at the measurement site increases significantly. The image below, taken from an oscilloscope, shows the amplified signal from a photodetector in pulse oximetry; the pulses show the additional absorption due to pulsating arterial blood.



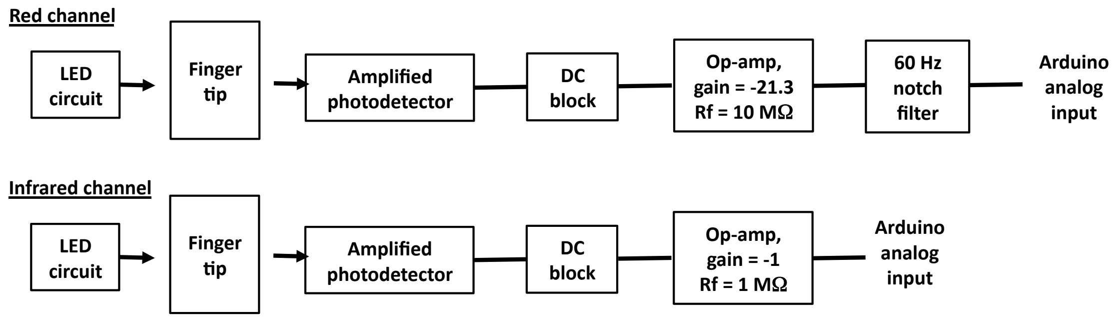
To determine the oxygen saturation, the ratio of the absorption in the red to the absorption in the infrared is computed and compared to a look up table that was compiled from a high number of volunteers (unfortunately we don't have a the time and resources to calibrate your final projects, so we won't be able to use the project to measure your blood oxygen saturation).

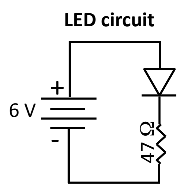
Assignment description

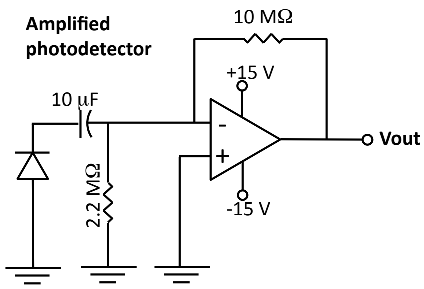
In this project, your team is to assemble a pulse oximeter circuit using your Arduino and the components provided. In addition, you are required to coordinate MATLAB and Arduino code to do the following: (i) record the signals from the pulse oximeter circuit, (ii) plot both channels (identify the red and IR channel in a legend) in real time (refresh the graph every 10 seconds), (iii) display the number of counted peaks every 10 seconds, (iv) display the average pulse rate every 10 seconds, and (v) display the ratio of the absorption of infrared light over the absorption of red light every 10 seconds. After completing all of the requirements below, you are to demonstrate your system to the instructor or your TA.

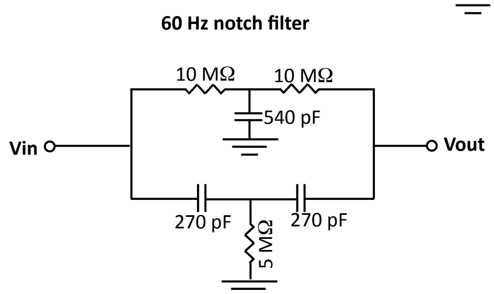
It is recommended that you work on the hardware and software parts simultaneously in subgroups; however, each member is expected to understand the details of both parts.

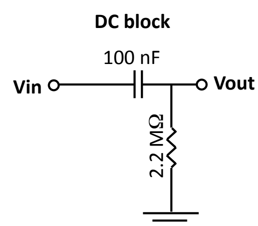
Pulse oximeter system diagram and circuit components











Detailed assignment

1. Assemble the circuit blocks above to form the correct system (both channels). You must present your circuit to the instructors during your demo. Points are allocated for the neatness of your circuit. Wires should be as short as possible, and leads on components should be clipped such that they plug onto the surface of the proto-board. Power and ground strips should be utilized appropriately.

2. Characterize the notch filter. Using the function generator, input a 1 Vpp sinusoid and record both the input and output voltage with the oscilloscope for frequencies between 10 Hz and 110 Hz (record values for every 5 Hz between 10 Hz and 110 Hz, and record values for every 1 Hz between 55 Hz and 65 Hz). ***Plot Vout/Vin.***

3. Using the oscilloscope, display and record the pulse of both channels using the circuit above. Set the time axis for 500 ms/div. ***Include the image in your report.***

Arduino

1. Build a sketch, from samples used throughout the semester, to acquire two analog voltage signals from your circuit. Continuously provide this data to MATLAB.

Matlab

1. Build a Graphical User Interface (GUI) in MATLAB to house axes and other components necessary for the following tasks. HINT: See “GUIDE” in the MATLAB documentation.

2. Measure the signal from each channel and plot the signals in real time. Clear the graph every 10 seconds and begin the plot again. HINT: Be aware of the method you use to continuously update your plot. If your plot does not appear to be plotting in real time, there may be a better way. Be sure to identify the red and infrared channels in a legend.

3. Locate peaks associated with a pulse in both channels, compute and display the average pulse rate every 10 seconds. That is, record data for 10 seconds; at the end of the time window, compute the total number of peaks and the average pulse rate and display both values. HINT: You do not need to manually write code to locate the peaks.

4. Compute and display the average ratio of the infrared absorption peak over the red absorption peak. That is, record data for 10 seconds; at the end of the time window, compute the average ratio and display it.

In your report, include a screen shot showing the plotted data, the pulse rate, and the ratio.