

Explore Engineering – Biomedical Module

Objective

Students will be presented with a current Biomedical challenge over the course of a 3-day period. The project will focus on Biomedical instrumentation, and will require the team to design a functioning ECG. This project will incorporate fundamental Biomedical concepts such as human physiology and medical instrumentation, and will touch upon related engineering fields such Software and Electrical engineering.



To: USYD Exploring Engineering Team

Re: Novel ECG design

Dear Consultants,

Schultz & Green Med Co., is very excited to be working with your team on this upcoming project. We have been informed that the project lead and team structure of your company has recently changed hands, and as such we thought it would be wise to send a courtesy email to ensure a smooth handover.

As we are sure you are aware, your team is one of many that has been working with Schultz & Green Med Co., for close to six months now on an upcoming novel medical device. We will be visiting your university three days from now to review a variety of design applications. We are quite excited to see what your team has been working on. Based upon the results from these presentations we intend to take a product to market and to fund further research.

As you are aware if your project team is selected as the lead stakeholder, your company will receive a grant of \$100,000.

The project brief has been attached below for your convenience. We look forward to meeting your team three days from now.

Sincerely,

Dr. Alison Willard

CTO Schultz & Green Med Co.

Electrocardiogram (ECG) Design Challenge

Design Specification:

There exists a growing migration within current markets for 'self-monitoring' medical technology, with patients and individuals now being able to measure exercise levels, heart rates, sleep patterns and more. This advent in technology has raised significant concerns for the regulation and verification of these devices. [1]

Schultz & Green Med Co., has hired your team to design a reliable, non-invasive and easily fitted heart rate monitor. To ensure patient compliance this medical device should cause no discomfort to the wearer. Due to mounting pressure and immediate deadlines a prototype of this design must be manufactured and presented within the next three days.

Background Knowledge:

Your team has been supplied a SEN-11574 'Pulse Sensor', a device that works on the basis of optical pulse oximetry [2]. Oximetry is the process of measuring blood oxygen saturation [O_2], to give an indication of pulse rate. Infrared and red LEDs are shone on a thin section of the body (such as the finger or ear lobe) to give a reading for saturation. As oxygen saturation increases, a greater amount of O_2 bonds to hemoglobin resulting in a change in the infrared absorption properties of the blood. The difference in absorption from these two wavelengths can give a valid reading for the level of oxygen saturation in the blood, and hence a patient's heart rate [3].

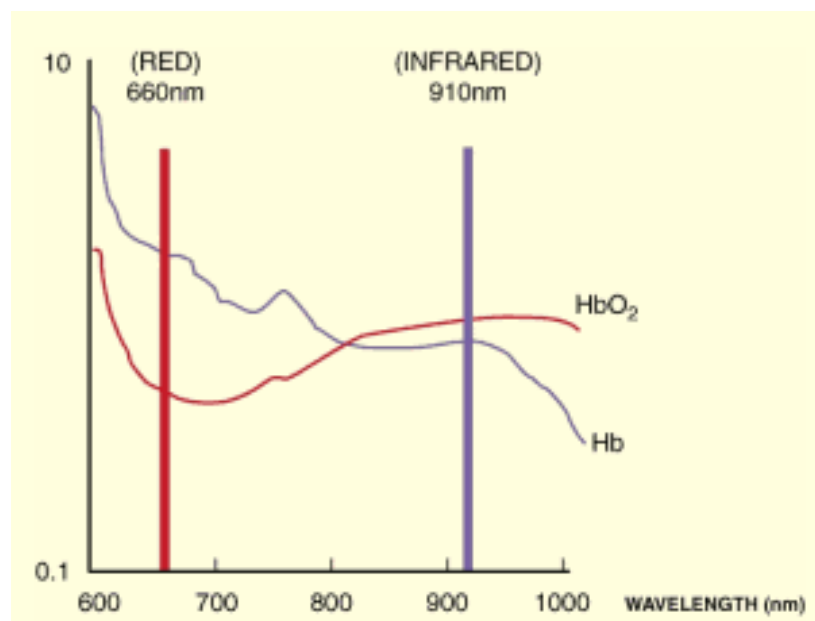


Figure 1 – Differing wavelength absorption in biological media [3]

When the electrophysiology of the human heart is measured with an ECG, a very distinctive waveform is produced. This waveform is the result of minute electrical changes in the heart, caused by the expansion and contraction of the chambers of the heart as the pump blood. This characteristic waveform is shown below:

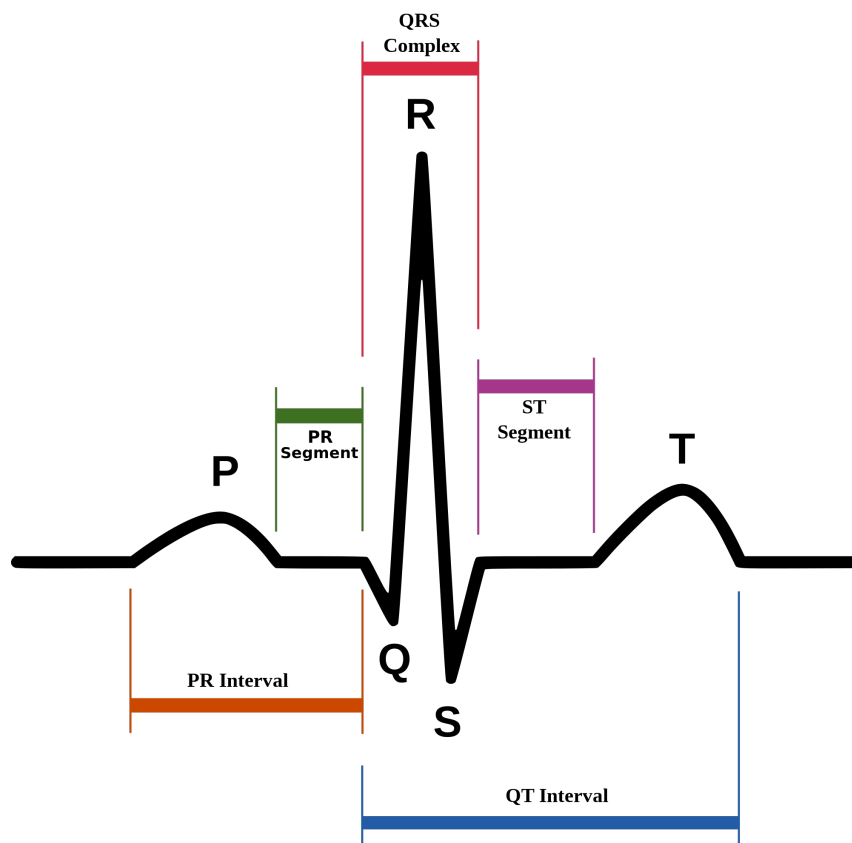


Figure 2 – Characteristic waveform of the human heart [4]

The P, QRS and T waves all correspond to different actions by the heart, and are all incredibly important medical diagnostic criteria. Capturing and analyzing these waveforms will be crucial to your team developing a reliable and accurate medical device. Due to the non-invasive nature of your team's design, pulse oximetry can be used to produce a valid representation of this ECG waveform.

Requirements:

Schultz & Green Med Co., has detailed the following requirements for the device's design and functionality:

Patient Compliance:

- Device causes no discomfort to the patient.
- Device is aesthetically pleasing to ensure patient compliance.

Hardware Considerations:

- Device produces a clear ECG waveform of the patient in real time.
- Device produces a reliable waveform across multiple patients.

Software Considerations:

- Device can detail BPM of patient.

Bonus Considerations:

- Give real time analysis of any possible cardiovascular diseases suffered by patient.
- Export ECG data to provide a long-term patient database for future reference.
- Device is able to calculate patient's blood oxygenation.

Materials:

To aid you in your design, your team has been supplied with the following materials:

- SEN 11574 – “Pulse Sensor”
- Arduino Uno
- Duct tape
- Cardboard
- Matlab and processing software

A data sheet for the SEN 11547 has been provided in Appendix 1. Similarly, code to aid in signal processing has been supplied in Appendix 2 onwards.

Presentation:

At the end of this period, your team will be required to present your findings to range of expert panelists and industry representatives. There are several factors that you should consider in your presentation, including:

- Motivation for your design
- Equipment used in design
- Demonstration of prototype
- Demonstration of team findings
- Problems faced in design, and how these problems were resolved

It may be constructive for your team to develop a simple report to aid in the presentation; this can encapsulate all the hardware and software developed in the project.

Appendix 1 – SEN 11574 Pulse Oximeter Data Sheet

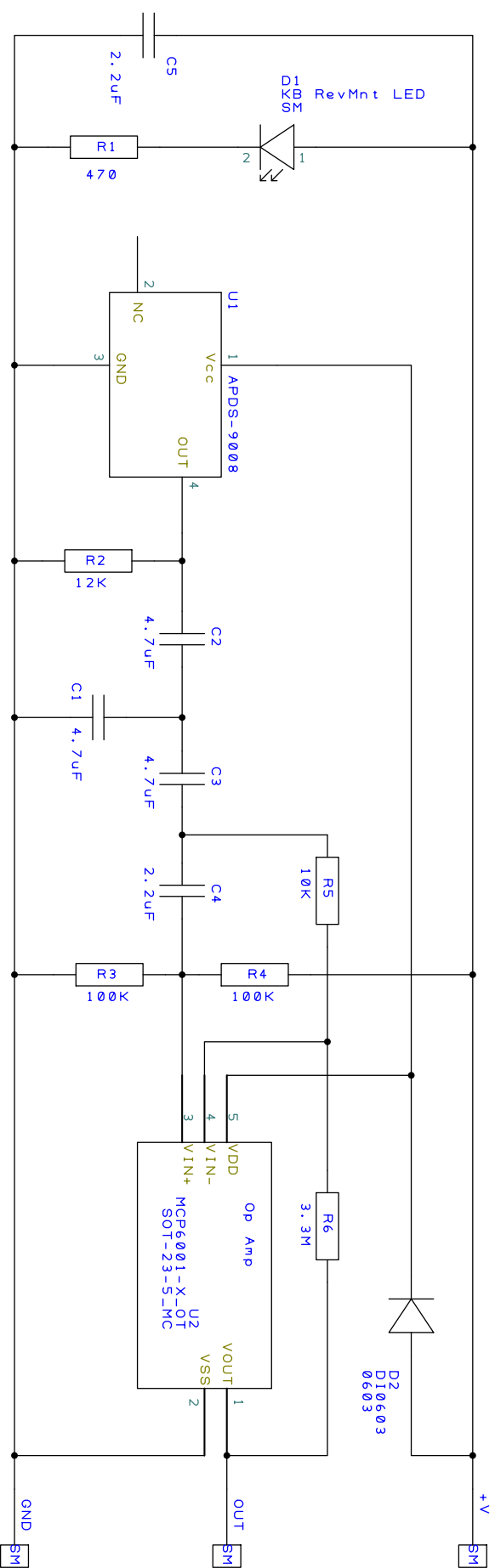


Fig 1. – PCB Schematic of SEN 11574 Sensor

Appendix 2 – Arduino System Hardware

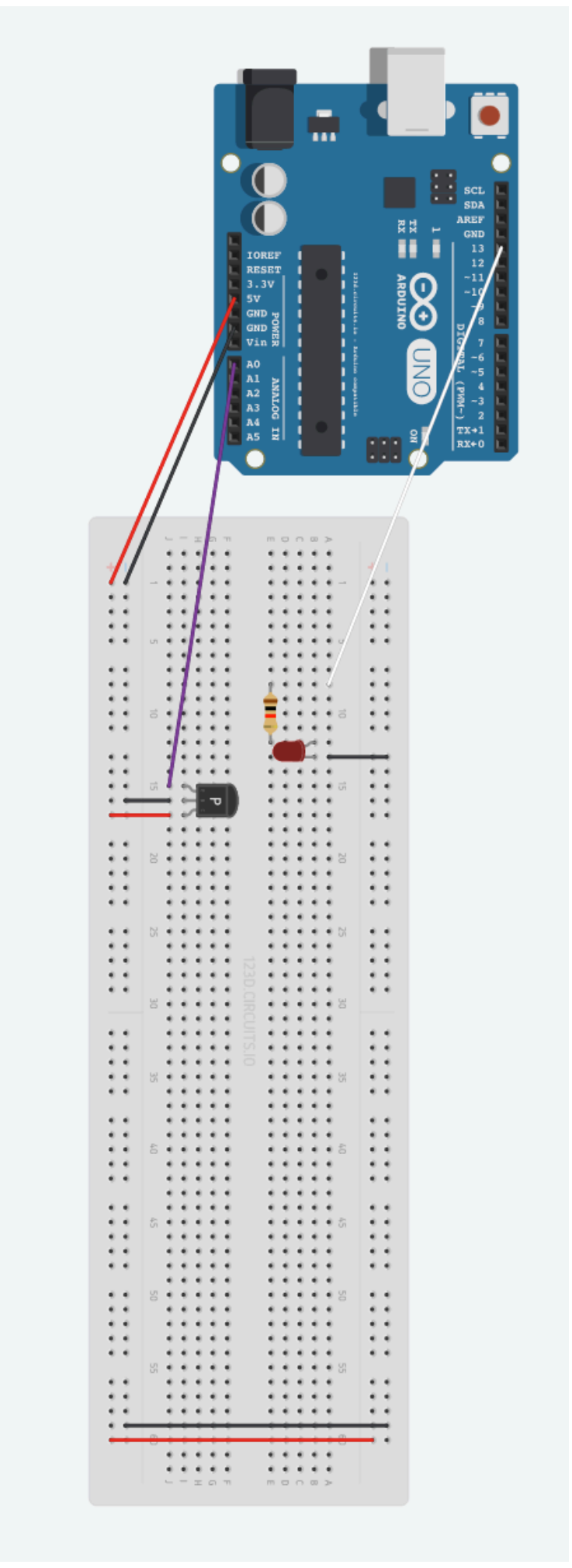


Fig 2. – Board Layout of Arduino Circuit