An Electro-optical Sensor to Measure Pulse Rate

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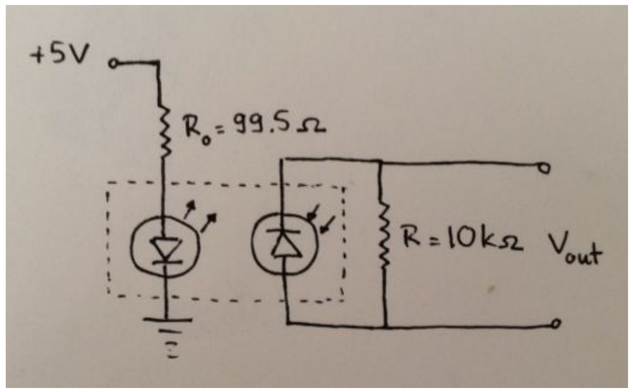
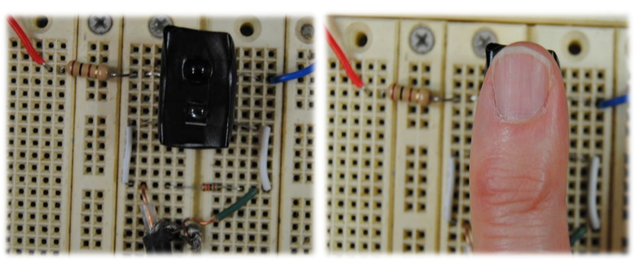
Pulse

Heart rate and blood oxygen measurements provide an important indication of an individual's fitness and medical condition. A widely-used device known as a pulse oximeter uses an optical method to continuously and non-invasively make these measurements. The method is based on the fact that absorption of red and near-infrared (NIR) light differs significantly between oxyhemoglobin and its deoxygenated form. Heart rate can be measured by a simpler optical sensor that uses a single light source to detect the change of blood volume at the fingertip for each heartbeat. This method is called photoplethysmography (PPG).

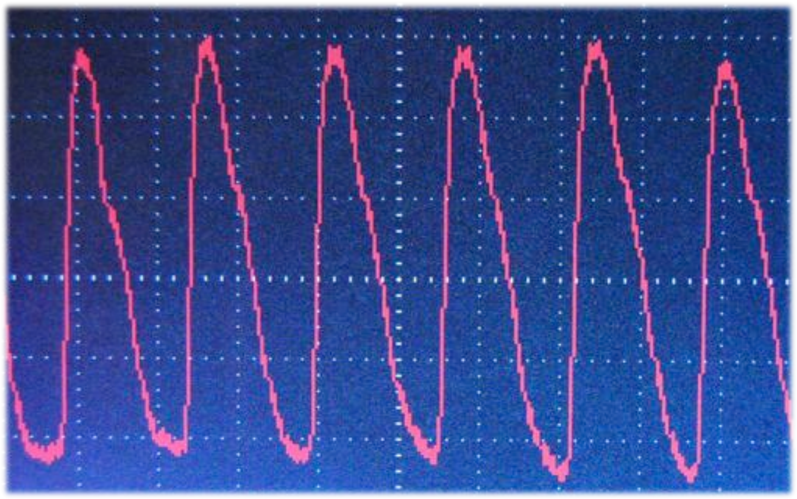
Our Sensor



The sensor was designed to have a NIR LED (850 nm peak wavelength) as an emitter and a photodiode mounted side-by-side to detect light reflected from a finger tip. In order to provide stability and avoid noise detection from room light, foam and black tape were made to surround these elements. A 10kΩ resistor was connected across the photodiode to convert current to output voltage, which was fed to the commercial pre-amplifier (PAR Model 113) from 0.3 Hz to 10 Hz. The pulse signal was captured and displayed on the oscilloscope OWON PDS6062S.

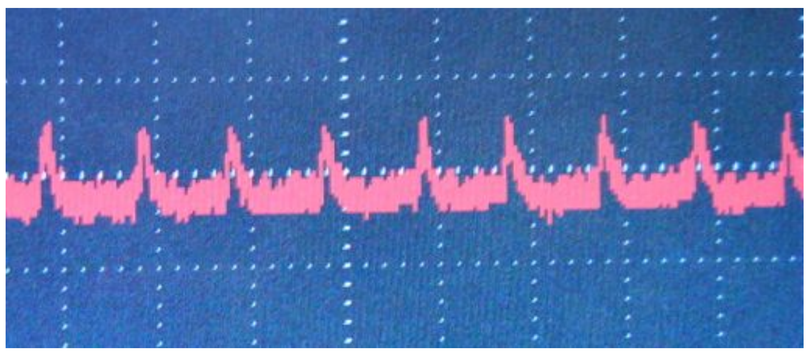


Detected Pulses



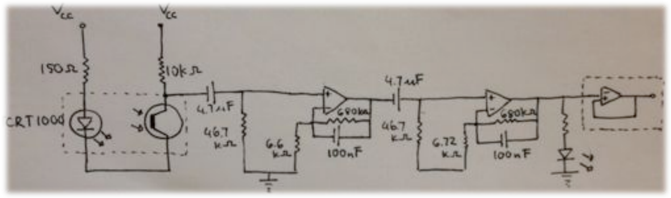
Dr. Noé's pulse on the oscilloscope: 78 bpm, 1.0 V/div, Gain = 100

My pulse on the oscilloscope: 74 bpm, 200 mV/div, Gain =500.

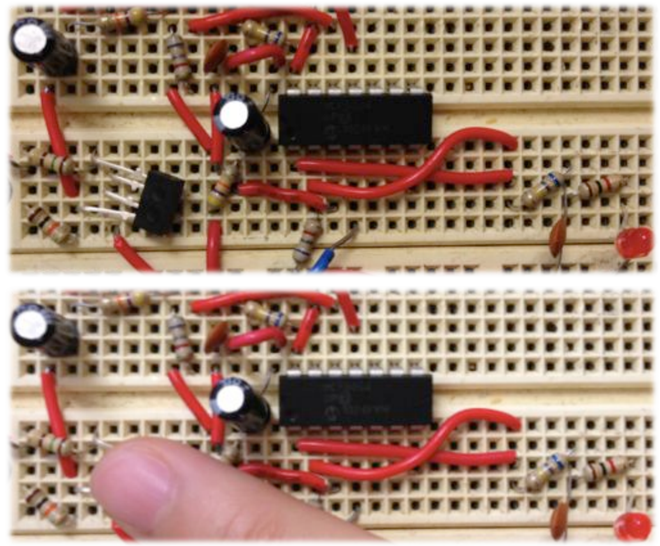


Yuning's on the oscilloscope: 61 bpm, 500 mV/div, Gain =500.

The circuit and Future Plan



Band-pass filter with (0.7 - 2.4 Hz) Total Gain:206[1]



When heartbeat is detected, LED light flashes. In the fulture we would like to see the result of the signal passed through this circuit using our designed sensor on the oscilloscopes. A recently found paper "Analysis of Reflectance Photoplethysmograph sensors" [2] experimented the effects of light of different wavelength and source-detector distance on the reflected output signal.

They concluded that even though, red light is mainly used in pulse oximeter. Its reflectance signal is generally not observable because reflected light only travels a short distance in reflectance approach. In the figure above, yellowish green light of peak wavelength at 571nm wit 2-mm emitter-detector distance gave the most optimal results. We would lie to reproduce this experiment in the future as well as the design of a potable sensor, which can be used for different part of the body such as neck, ear lobes, etc…

Observations

Testing candidates like myself , who have poor blood circulation, appeared to have rather noisy signals. The applied finger pressures also vary the output signal. It was found that when much pressure is applied, blood circulation seems to be blocked causing the output signal to be very noisy or nothing at all.

Reference

[1] www.electronics-tutorials.ws
[2] Huang F, Yuan P, e.g. (2011) "Analysis of Reflectance Photoplethysmograph sensors", http://www.waset.org/journals/waset/v59/v59-241.pdf
Thank you Prof. Tom Allison for the use of the oscilloscope.