Final Project
Graphical Display with Pulse Oximeter

Project Report for ENGE250
Electrical Circuit Analysis
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The construction of this project consisted of two main components, the pulse oximeter circuit, and the graphical output circuit, shown in fig. 1. The pulse oximeter utilized three different operational amplifiers, one acted as a voltage offset which shifted the input DC signal by ½ of the initial voltage. This was to ensure that the input signal that was to be amplified remained at a positive voltage consistently. The other two amplifiers acted as a lowpass filter. This was necessary because the input signal has quite a lot of noise at the higher frequencies, and the only frequency that is needed to pass through should be at the frequency of a heartbeat. The input signal was generated by passing a light through a tester's finger and measuring the voltage change due to altered light levels with a light dependent resistor. This works because as the volume of blood passes through the finger during a pulse, the light is obstructed and can be detected. After the signal has been filtered by the amplifiers, the output voltage is then passed onto the second half of the project circuit, the graphical output. The graphical output is comprised of a line of resistors that compose a simple voltage divider circuit with two potentiometers at the start and end, four operational amplifiers, and another line of four LEDs with resistors which act as a visual output. The basic principle behind this circuit is that each of the nodes across the voltage divider are passed into one terminal of the amplifier, and the pulse signal is passed into the other terminal. The op-amps then behave as a simple comparator circuit, and clip to their maximum value once the input voltage exceeds the voltage from the divider. Each amplifier output is then passed through a LED. The potentiometers change the voltage range of the comparator inputs to account for the variability of the input voltage based on varying light levels. All this combined act very similarly to a simple Analog to Digital converter circuit, but instead the output is sent to the four LEDs. This simple yet powerful circuit is used in the medical field to both measure a patient's heart rate and can be adapted to measure the blood oxygen levels of a patient. Both uses demand that the signal being measured is accurate and low noise. The lowpass filter, described above, does this by using a capacitor to cutoff frequencies that exceed the charge and discharge rate time required of the capacitor. Otherwise, the capacitor would act as an open circuit, which is what prevents the high frequency noise from passing through the circuit.

This experiment demonstrates the practical use of several basic electrical components and shows how the use of electrical engineering circuit design methods can produce a useful and accurate measurement device. Some of these fundamental components are operational amplifiers, resistors, capacitors, light emitting diodes, and light dependent resistors. Some basic circuit analysis and design features that were seen in this experiment were voltage divider, active filtering, and comparator circuits.

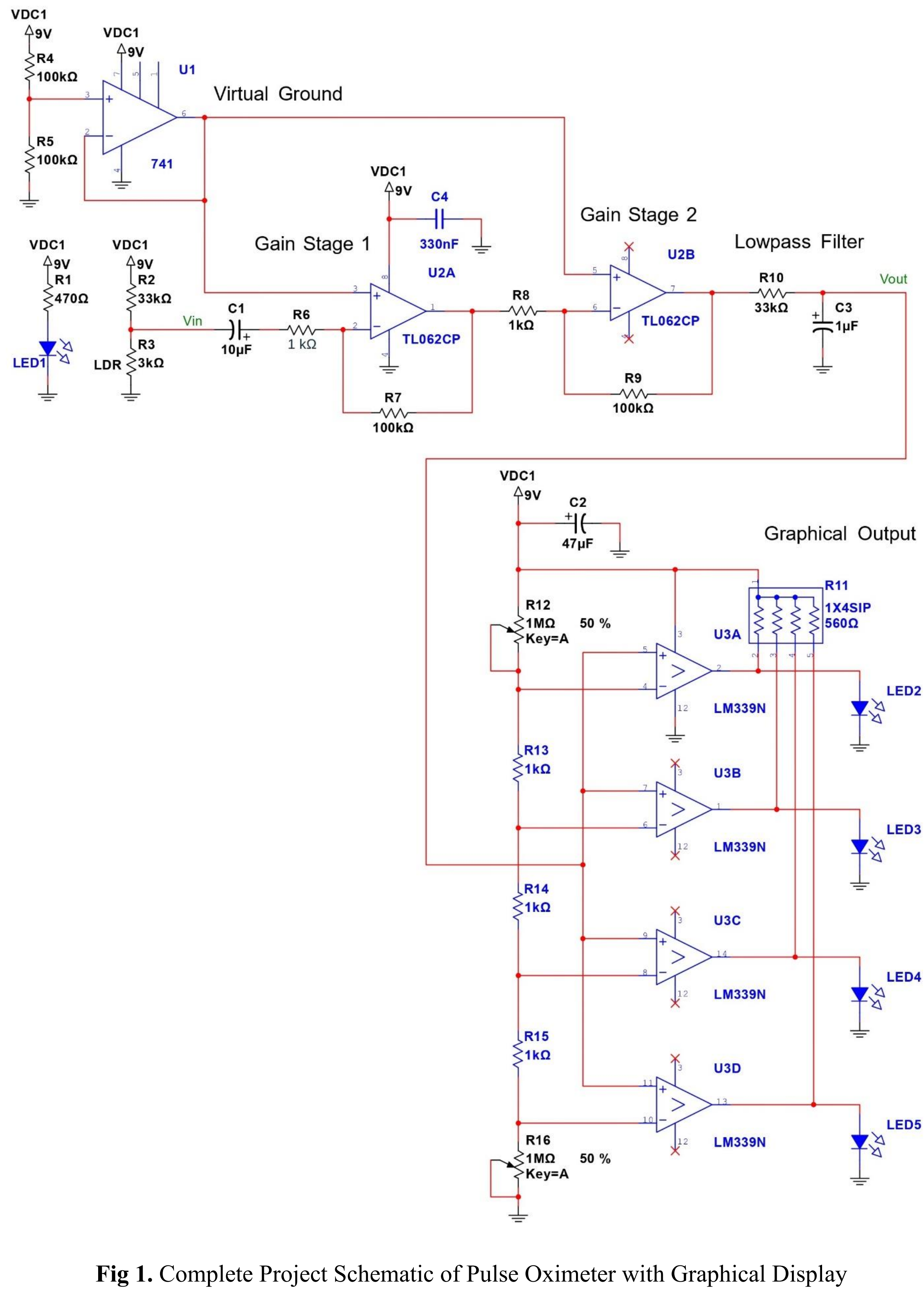

Fig 1. Complete Project Schematic of Pulse Oximeter with Graphical Display

Table 1. Measured and expected gain and cutoff frequency determined during the experiment.

	Gain Stage 1 $(\frac{V}{V})$	Gain Stage 2 $(\frac{V}{V})$	Overall Gain $(\frac{V}{V})$	f_{3dB} (Hz)
Measured	9.10	113	958	6.25
Expected	10.0	100	1000	4.82
Percent Error (%)	9.00	13.0	4.20	29.7

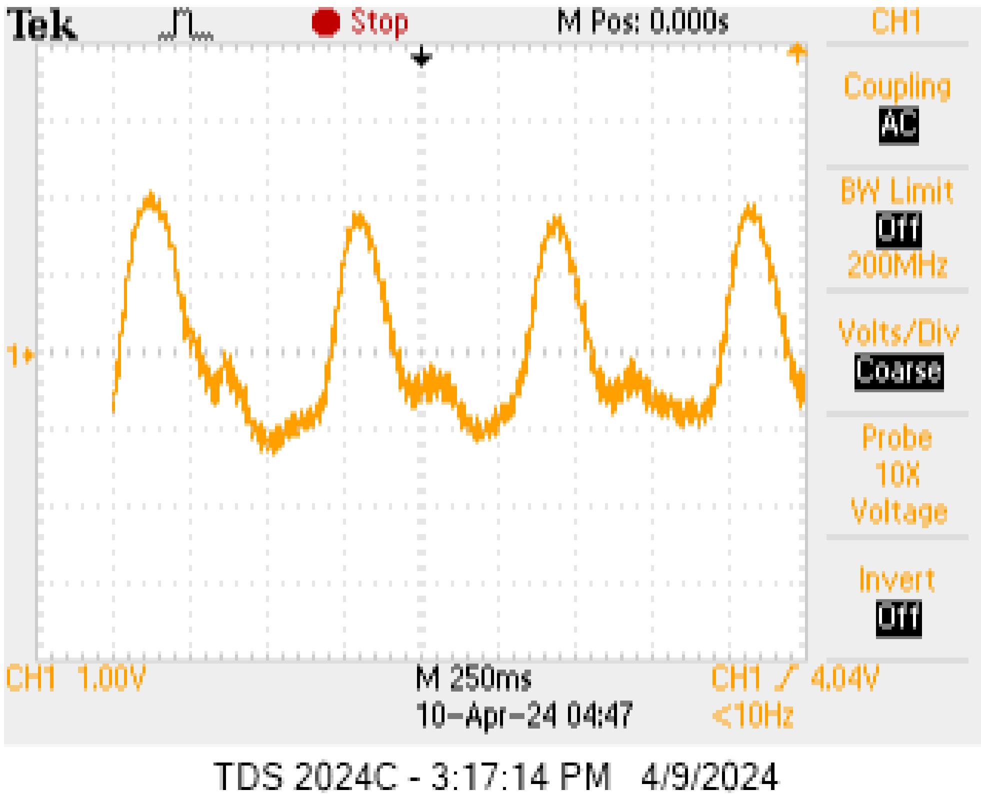

Fig 2. Oscilloscope measurement of PPG heartbeat

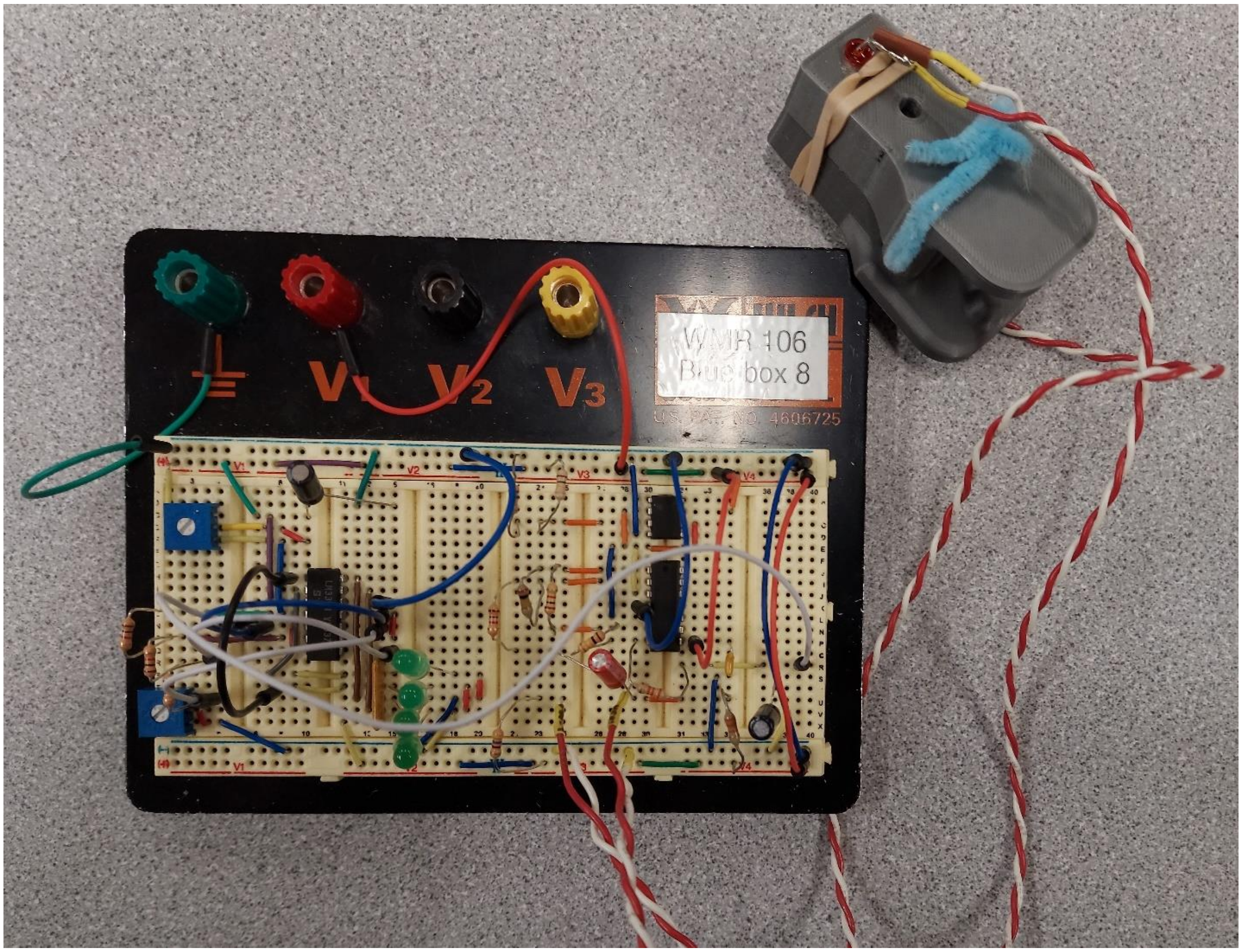

Fig 3. Photo of breadboarded circuit

Overall, this circuit functioned as intended as a pulse oximeter with a LED display, however there were some changes that would improve the design. One of these is to use a darker color for the 3D printed finger reader. The finger reader used in this experiment was bright orange, and light noise from the room was observed to effect the output heavily. The circuit that was soldered used a darker plastic for the reader and the signal was much more resistant to noise pollution. Another change that was made during experimentation was changing R6 from a 10 kΩ resistor to a 1 kΩ resistor. This was necessary to increase the gain of the signal coming from the LDR, so the output signal had enough amplitude to light up all the LEDs in the graphical output section of the circuit. The final adjustment that might improve the design is to print some knobs for the potentiometer adjustment. The “tuning” of the potentiometers was arduous and difficult to find the right threshold, so adding something to help make fine adjustments would speed up the process.