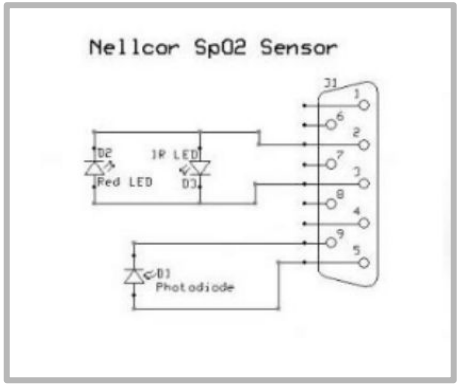
SPO2 Project

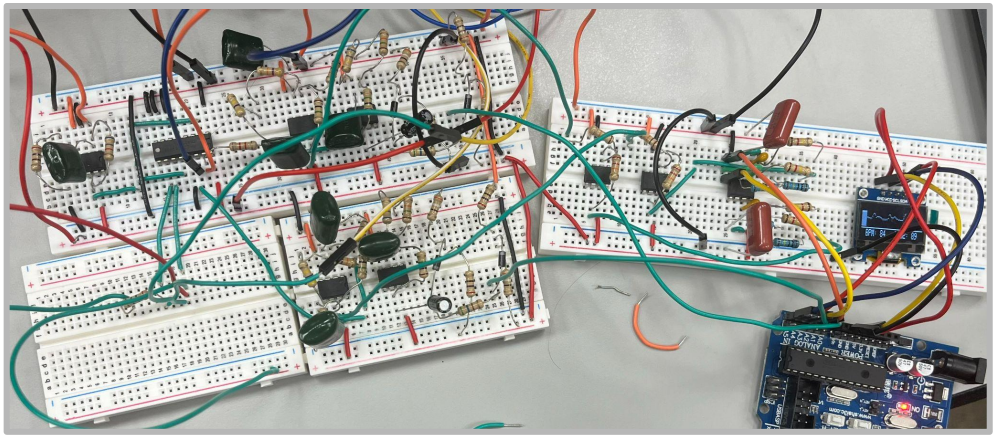
Muhammad Athar &
Jason Huang

Brief Overview

- Requirements and Constraints
- High Level Model
- Individual Subcircuits
- Arduino
- Validation



SpO2 Sensor Pinout



Final Working Product

Design Requirements & Constraints

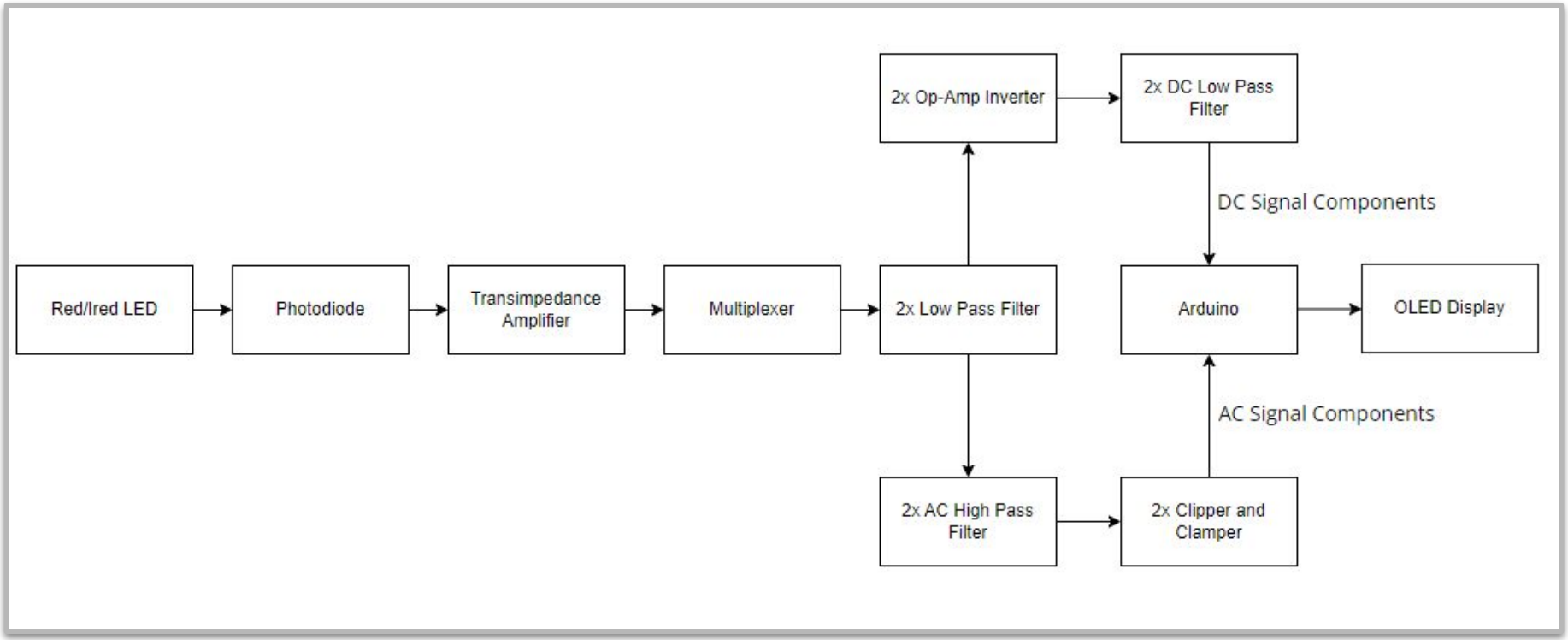
Requirements

- Display the heartbeat waveform, BPM, and % SPO2 of an individual on an OLED Display.

Constraints

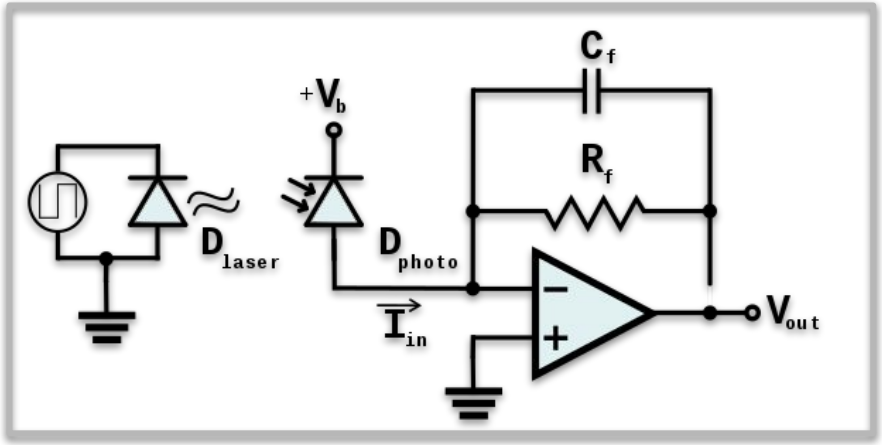
- Use of Nellcor Ds-100A SpO2 sensor, DB9 breakout board, OLED display, and CD4053BE analog multiplexer IC.
- Limit LED current to < 15mA.
- Reverse-Biased Photodiode.

High Level Model

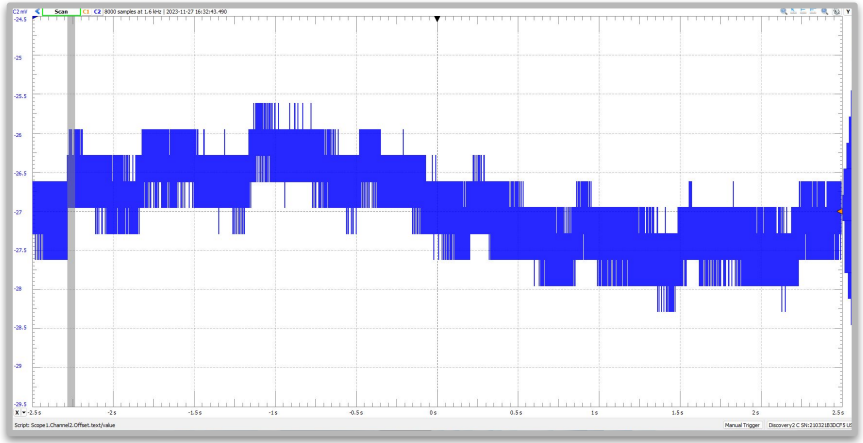


Transimpedance Amplifier

- Converts photodiode-produced current from alternating LEDs (500hz) into voltage.
- Gain = R_f = 6.8k
- Output is the input to **MUX**.



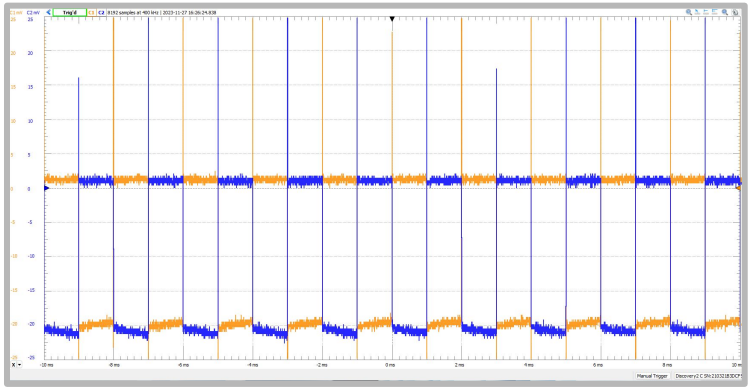
TIA Schematic



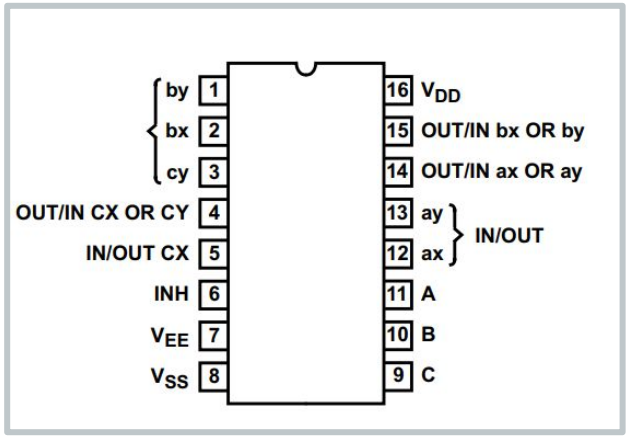
TIA Output

Multiplexer

- 3x 2-1 Multiplexers
- Splits the circuit into Red & Infrared Sections.
- Alternate signals at 500 Hz



MUX Output



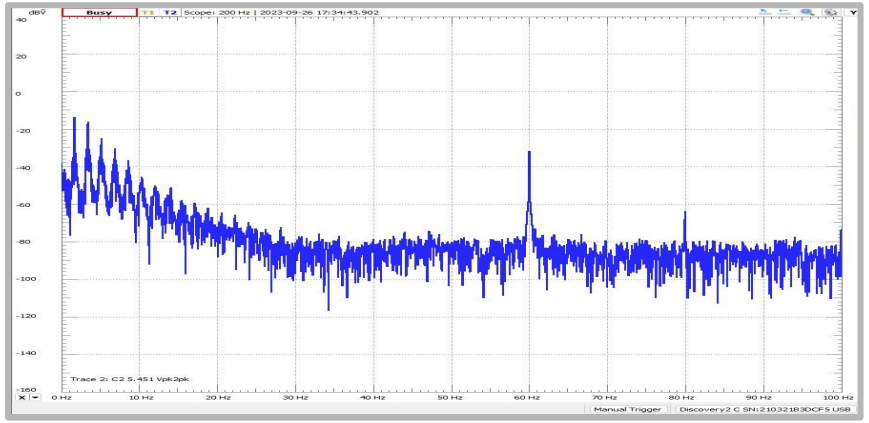
MUX Schematic

INPUT STATES				ON CHANNEL(S)
INHIBIT	C	B	A	
CD4051B				
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	X	X	X	None
CD4052B				
0		0	0	0x, 0y
0		0	1	1x, 1y
0		1	0	2x, 2y
0		1	1	3x, 3y
1		X	X	None
CD4053B				
0	X	X	0	ax
0	X	X	1	ay
0	X	0	X	bx
0	X	1	X	by
0	0	X	X	cx
0	1	X	X	cy
1	X	X	X	None

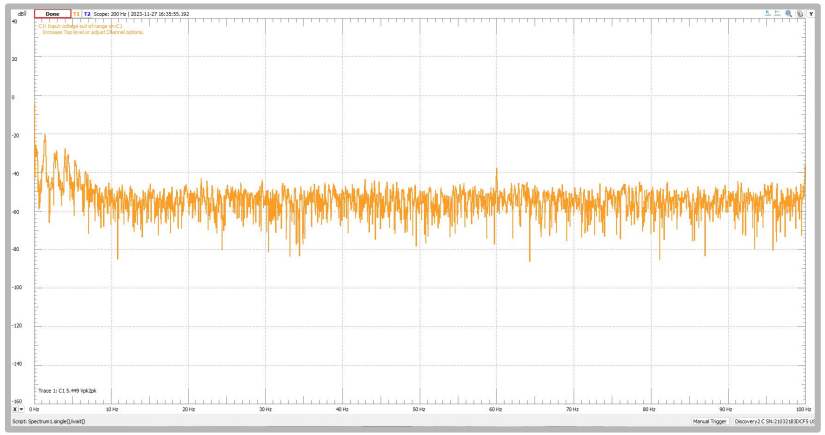
MUX Truth Table

AC Filtration Circuit

- **LPF** (Reduces Signal Noise)
  - Break Frequency @ 5 Hz.
    - 0.67 Hz < f < 2 Hz.
  - Gain = 50.
  - Keeps Harmonics.
  - Attenuates 60hz human noise.
- **HPF** (Centers Signal)
  - Removes any DC offset.
    - Break Frequency @ 0.5 Hz.
  - Gain = 60.
  - Only passes heart-rate frequencies.
  - Output is the input to **Clipper & Clamper Circuit.**



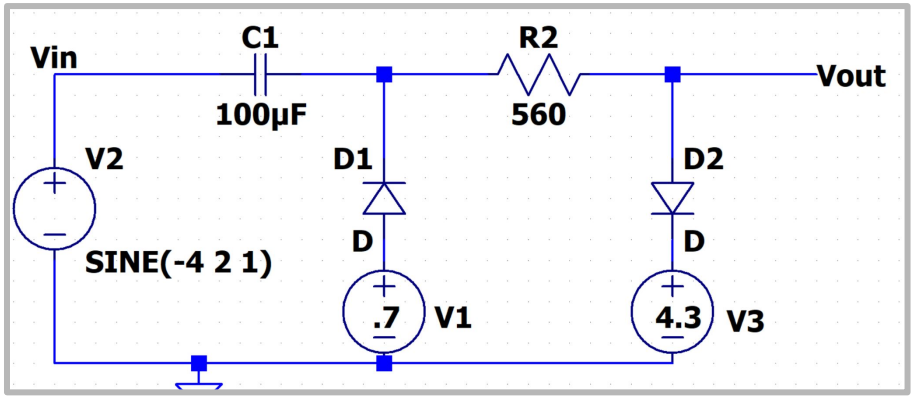
Spectrum before AC Filtration



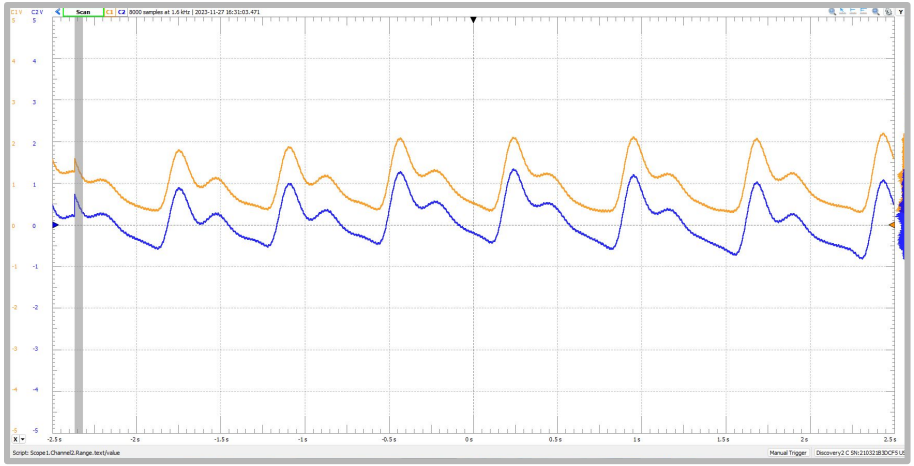
Spectrum after AC Filtration

Clipper & Clamper

- Clipper shifts signal above 0V
- Clamper clamps signal at +5V
- Safeguards the Arduino
- Output is the input to **Arduino**



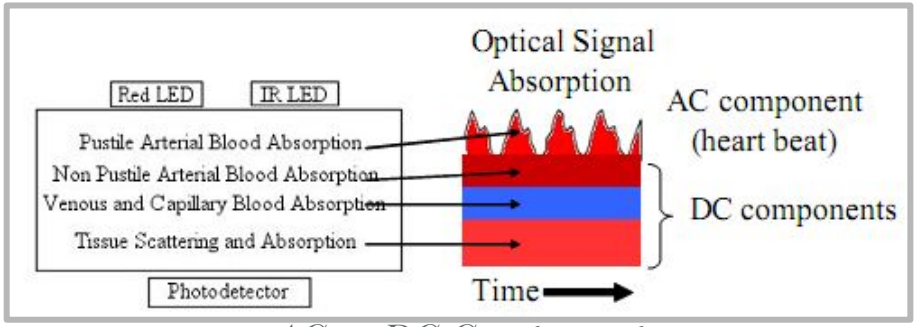
Clipper & Clamper Schematic



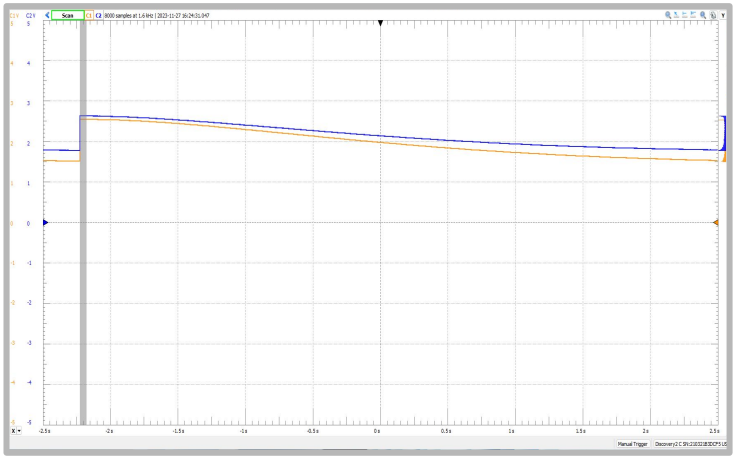
Input vs Output

DC Circuit

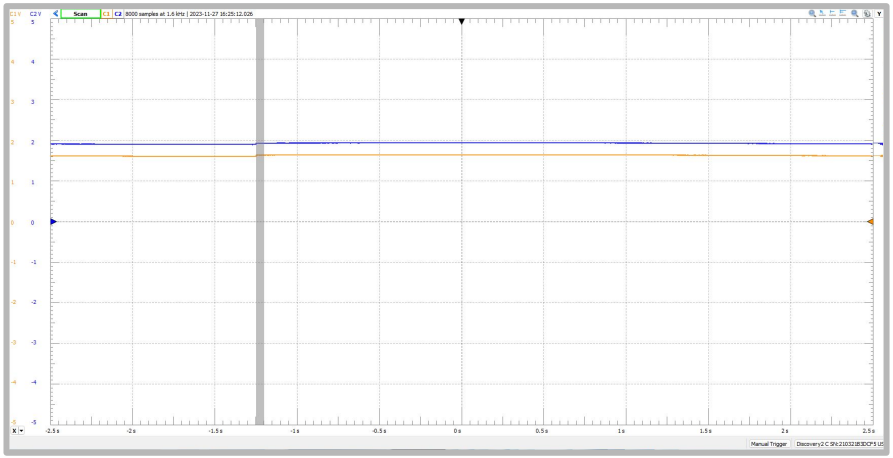
- Passes only 0hz.
- Stems from AC LPF.
- Required to compute R.
- DCRed & DCIred are outputted.
- Output is an input to **Arduino**.



AC vs DC Components



Discharging DC



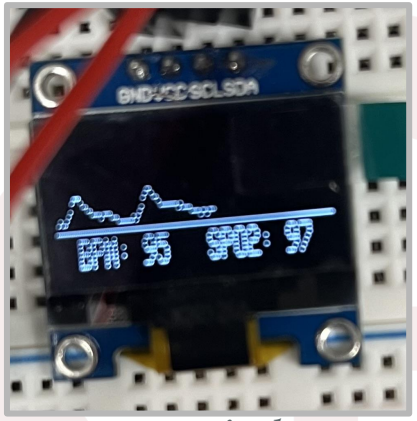
DC Output

Arduino

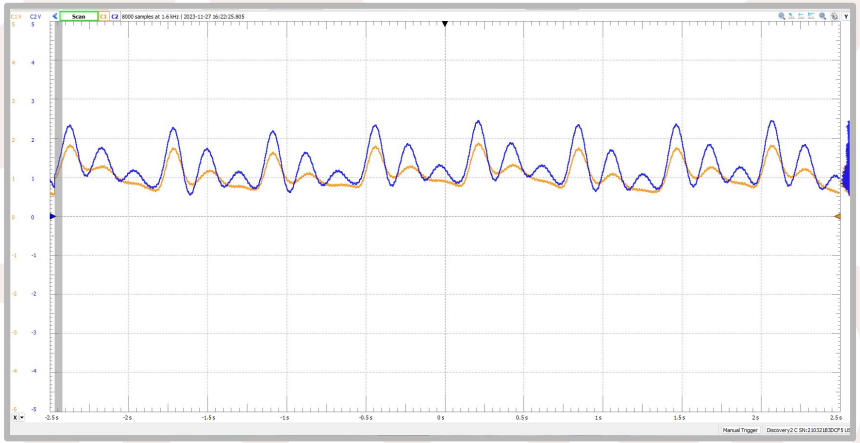
- Reads the AC & DC output components.
- Computes R & % SpO2.
  - % SpO2 = 110-25R
- Outputs to **OLED Display**
  - Heartbeat Signal
  - BPM (beats per minute)
  - % SPO2

$$R = \frac{AC_{red}}{DC_{red}} \Big/ \frac{AC_{ired}}{DC_{ired}},$$

R equation



OLED Display



AC Inputs to Arduino

Validation Tests

- Comparisons between Nellcor Ds-100A and Commercial SpO2.
- BPM and waveform are consistent.
- SpO2 value is close, with minimal margins of error.
  - 80-100%
- Overall, it fulfilled the requirements under the given constraints!

Nellcor vs Commercial Sensor

Thanks For Listening!