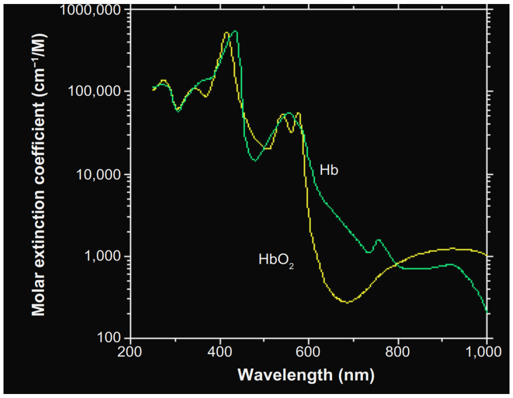
7Pulse Ox Wearable, open/free source designs by Josh Brewster



Band Design

The wearable band is a simple, thin pulse oximeter and motion-sensing band, designed to be rechargeable and to sample from the bottom of the wrist for optimal signal. Two designs are outlined: custom and canned. The custom design provides state-of-the-art results.

Design 1: Custom, More Reliable Pulse Ox, Cheapest Possible

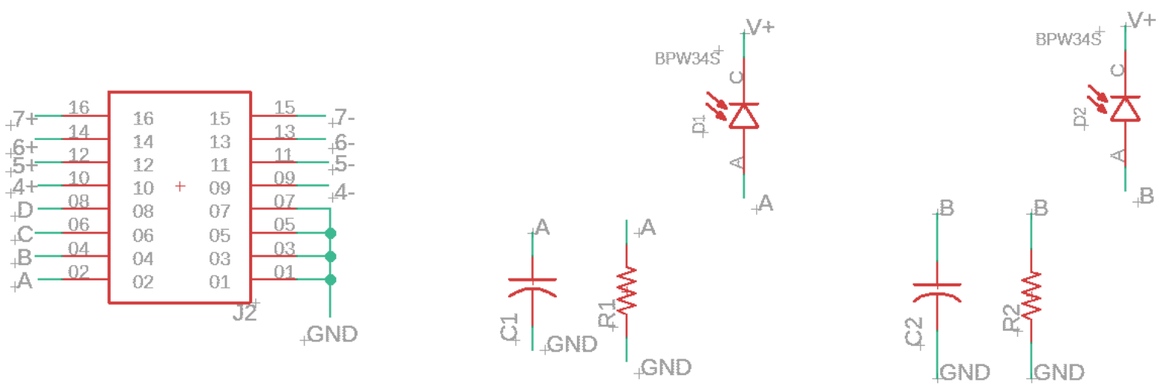
This design aims to provide a more reliable pulse oximeter using custom components.

Hardware Specs

- **Microcontroller**: nRF52/53 BLE 5 controller
- **ADC**: ADS131M02 2-channel 24-bit simultaneous sampling sigma-delta ADC
- **Photodiodes**: 2 BPW34S high sensitivity photodiodes with a simple low pass filter circuit
- **LEDs**:
  - 1 660nm Red LED (e.g., XZM2MR55W-3 by SunLED) Domed LEDs are better (narrower light cone)
  - 1 840-880nm IR LED (e.g., XZTHI55W-3 by SunLED)
- **Accelerometer**: MPU6050 3-axis accelerometer (or a more current alternative)
- **Magnetometer**: QMC5883L 3-axis magnetometer (ideal for fall detection)
- **Battery**: Rechargeable LiPo battery port, small battery to fit in the case
- **Charging**: USB Type-C with TVS diodes for safety compliance
- **Buttons**: Small On/Off push button, plus 2 additional programmable buttons (e.g., for support or alert)
- **Sampling**: Bottom of the wrist (like over the artery/vein)
- **Optional**: Audio speaker for alarms (needs amplifier chip, e.g., MAX98357A)

Firmware Specs

- **Operating System**: Zephyr or Arduino (Zephyr is more advanced, but both are suitable for basic hardware)
- **Communication**: Bluetooth 4 or 5 (nRF52 has BLE5)
- **Power Profile**: Low power consumption (nRF is better for this)
- **Sample Rate**: The minimum is 250Hz on the ADS131, we can use a moving average firmware-side or BLE can handle the data in real time, we've tested plenty. Otherwise averaging to 125Hz, 75Hz, or 50Hz would be fine.
- **Data Streaming**: Stream raw LED data; use canned heart rate and SpO2 algorithms for pre-made PPGs with selected LEDs and PDs
- **Filters**: Preferably avoid hardware filters (e.g., for DC); more can be done with raw data without them



This is an ADS131M08 configuration, with 2 of 4 photodiodes shown, we use a simple RC filter and ground the negative input on the sigma delta ADC. 1MOhm R and like 220pF C (need to double check cap value)

Hardware resources, includes nRF and peripheral quotes:
https://github.com/joshbrew/nRF5x-Biosensing-Boards

BOM samples:
E.g BT840
https://docs.google.com/spreadsheets/d/1_HJGfFERPbjsfyVsvAEBeEDxsZvMkjib/edit?usp=sharing&ouid=115019542711496588778&rtpof=true&sd=true

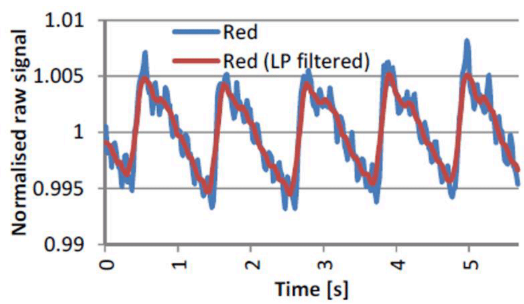
E.g. BT40
https://docs.google.com/spreadsheets/d/1iG1TCaeJnqPSEQdyyh46KBVxkoCE-ekg/edit?usp=sharing&ouid=115019542711496588778&rtpof=true&sd=true

Another BT40 BOM (high overages though, not that necessary)
https://docs.google.com/spreadsheets/d/1nfP5cUY5rJFIu8GrZoNSI9P1zyI8ZTMB/edit?usp=sharing&ouid=115019542711496588778&rtpof=true&sd=true
E.g BT832 cheap nRF52 option (note BT832A is the nRF52810, very small memory)
https://docs.google.com/spreadsheets/d/1Iq_YZKACqgZNz5KGheo3KygyKR9DUOsgQVpr5Snjju0/edit?usp=sharing

https://docs.google.com/spreadsheets/d/1RUImk_B_wu3TRTACJXpPSCaapPaiVIjje_XyH6pws34/edit?usp=drive_link Peripheral stuff (not all directly relevant, just dev board sourcing, potential cheap route for sensor prefabs)

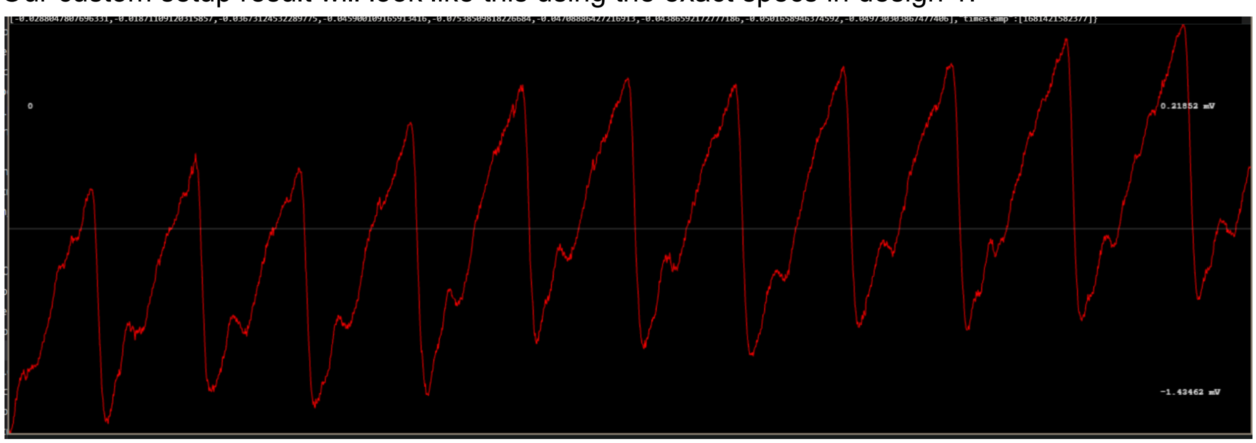
This firmware will work out of the box for either design if we use nRF52 or 53, the boards just need a redesign for a tighter integration of chipsets.

Output Expectations:



Pulse oximeter data is a wave like this. We compare two wavelengths as means to assess blood oxygen content, and more.

Our custom setup result will look like this using the exact specs in design 1:



This is unfiltered at 250Hz, the minimum sampling rate on the ADS131 without using global chop, but note this is state of the art quality PPG data, This is not a normal level of detail and signal cleanliness and we did not have to use any special configuration on the ADC.

More sampling data gives us more to diagnose and filter. Design 2 would be unprecedented quality for a low cost design and reflects our more up to date work. Realistically it should cost the same as the first design for physical hardware.

Design 2: Cheapest Possible, Bottom of the Barrel BLE Streaming Pulse Ox

This design focuses on cost-efficiency with pre-made pulse oximeter units.

Hardware Specs

- **Microcontroller**: ESP32 or nRF52/53 Bluetooth (Fanstel chips are cheap nRF options)
- **Pulse Ox Unit**: MAX30102/5 or other pre-made pulse ox units that are cheap in bulk
- **Accelerometer**: MPU6050 3-axis accelerometer (or a more current alternative)
- **Magnetometer**: QMC5883L 3-axis magnetometer (ideal for fall detection and motion artifact removal)
- **Battery**: Rechargeable LiPo battery port, small battery to fit in the case
- **Charging**: USB Type-C with TVS diodes for safety compliance
- **Buttons**: Small On/Off push button, plus 2 additional programmable buttons (e.g., for support or alert)
- **Sampling**: Bottom of the wrist (like over the artery/vein)
- **Optional**: Audio speaker for alarms

Firmware Specs (largely the same as design 1, just different sensor AFE)

- **Operating System**: Zephyr or Arduino (Zephyr is more advanced, but both are suitable for basic hardware)
- **Communication**: Bluetooth 4 or 5 (nRF52 has BLE5)
- **Power Profile**: Low power consumption (nRF is better for this)
- **Sample Rate**: 50Hz-100Hz (50Hz is acceptable, 100Hz is better; nRF can pack samples into ~30 sample packets)
- **Data Streaming**: Stream raw LED data; use canned heart rate and SpO2 algorithms for pre-made PPGs with selected LEDs and PDs
- **Filters**: Preferably avoid hardware filters (e.g., for DC); more can be done with raw data without them