

# Project Apollo

An open source oxygen concentrator

<http://project-apollo.org>

## Microsoft Volunteers

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[HelpfulEngineering.org](http://HelpfulEngineering.org) non-profit (19K volunteers!)

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[Quick2space.org](http://Quick2space.org) non-profit

Adi Oltean

# Project Apollo



## Why

- O<sub>2</sub> needed for ventilators, oxygen therapy
  - Typical FiO<sub>2</sub> 0.3 ... 0.5, up to 1
- Oxygen generation is a big problem in developing countries
  - No established infrastructure
  - Oxygen bottles are expensive
- People are already looking at alternative (local) ways for producing and delivering oxygen



<https://www.economist.com/graphic-detail/2021/03/09/hospitals-are-running-out-of-oxygen-to-treat-covid-19-patients>

<https://www.cidrap.umn.edu/news-perspective/2021/03/who-sounds-alarm-over-covid-linked-oxygen-crisis>

<https://apnews.com/article/oxygen-crisis-africa-latin-america-eb0d2731a8613c1ae218db7d32a227a6>

# Project Apollo

## What is it

- Goal = enabling people around the world to build the prototype ASAP
- Focus = Simplicity and speed of build
  - Simple, reliable design (zeolite-based PSA system)
  - Flexible, open source, off-the-shelf materials
  - Very low cost (aspirational target = \$200 for 15 liters/min @ 80%)
- Final goal = Enable people to iterate and publish their own designs in the community

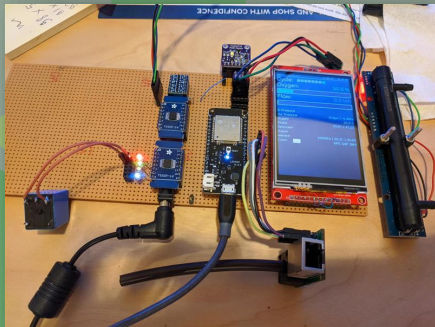


# Project Apollo v4



## Apollo v4

- Focus = medical device
  - **Safety:** detect all failure scenarios
  - **Ease of use:** User experience and maintainability. Clear, actionable error messages
  - Self-regulating: Patient sensor/data feedback loop
- Control box
  - Touch screen for diagnostic messages, medical-grade buzzer
  - Open source, modular PCB design. Works with a variety of sensors
  - **Self-tuning:** valve timing, auto-adjusts to changes in compressed air input pressure, machine learning
  - Integration with SpO2 oximeter Bluetooth sensor
  - Cloud data integration for patient monitoring
- Self-contained enclosure
  - Built-in compressor
  - Full focus on thermals, airflow, noise reduction

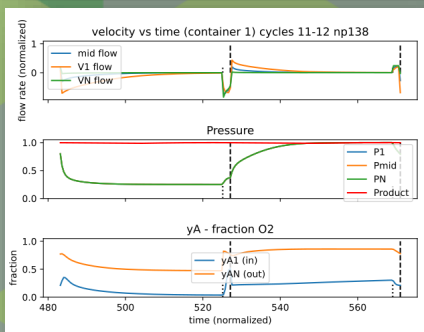


## Collaborations

- Funding: Quick2space.org
- Volunteers: Helpful Engineering, Microsoft Garage, Public Invention

## Documentation, code

<http://project-apollo.org>



# Apollo - Hack4Good Spring 2021

What we have achieved in this hackathon

- PCB schematic/layout for the valve board
  - What is it: central PCB to drive all valves and detect failures
  - What we did: finalized Friday late night!
- Prototyped integration of SpO2 oximeter sensor into Apollo code
  - What is it: Allows reading of SpO2 oxygen concentration in blood
    - Used this as a closed feedback loop to drive oxygen output
    - Important to not deliver too much oxygen!
  - What we did: prototyped and integrated Bluetooth LE code
- Project Bonsai ML simulator code
  - What is it: Uses Reinforcement Learning to self-optimize the concentrator
  - What we did: Repro previous results in a separate Azure Bonsai instance, Document simulation code
- Apollo v4 software
  - What is it: the “brain” behind the oxygen concentrator
  - What we did: Code cleanup, adding comments

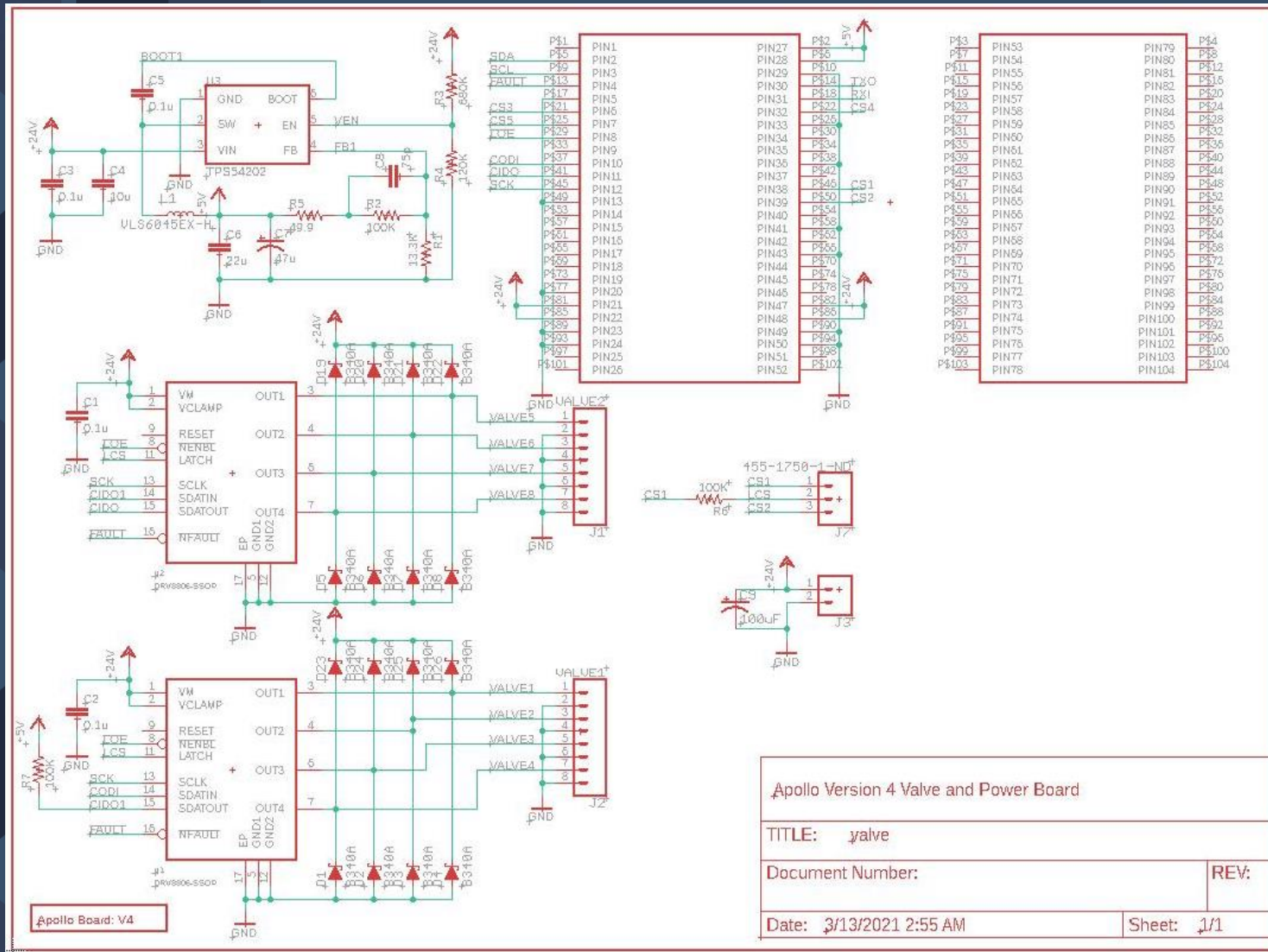


# Apollo v4: Bluetooth SpO2 sensor

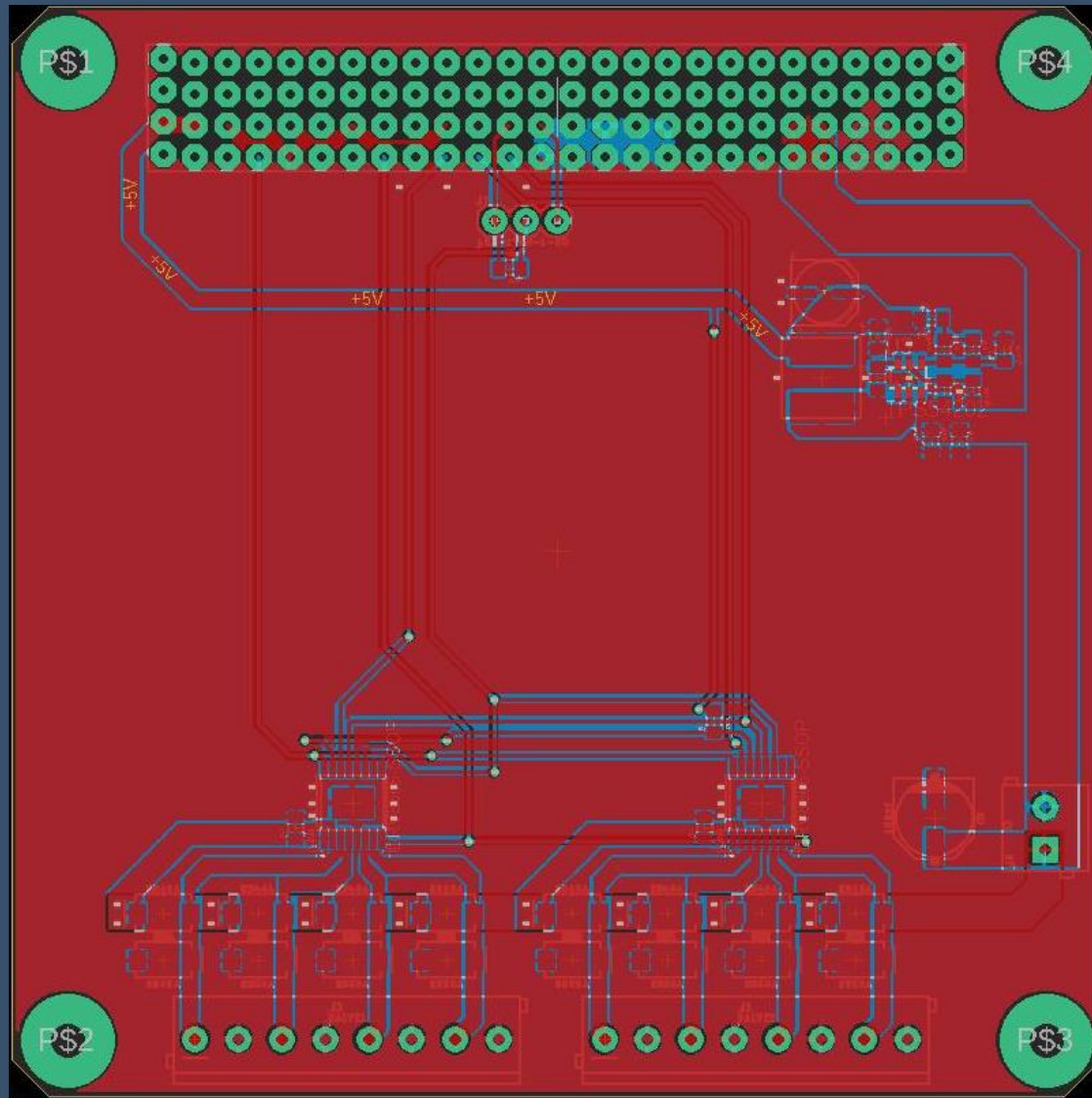
```
COM3
entry 0x400806b4
Scanning...
Found BerryMed Oximeter
Forming a connection to 00:a0:50:c2:48:46
- Created Bluetooth client
- Connected to Target Bluetooth server
Trying to get service..... received reply.
- Found the Oximeter service
- Found Oximeter data characteristic
We are now connected to the BLE Server.
Waiting for user... Pulse : 108 bpm SpO2 : 99%
Pulse : 108 bpm SpO2 : 99%
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# Apollo v4: valve board schematic



# Apollo v4: valve board layout





# Conclusion

- Key items developed/prototyped
  - Valve board, SpO2 sensor, Apollo software, Apollo ML simulator stack
- Next steps
  - Finalize Apollo v4 in the next 3-6 months
  - FDA emergency use approval
- Thanks
  - Microsoft Hack4good community
    - for helping create the context for amazing work
  - Helpful Engineering.org non-profit
    - Community of 19,000 engineers going strong
    - Help from QA/RA volunteers from the medical industry helping with regulatory compliance
    - Help with FDA certification of the upcoming device
  - Quick2space.org
    - support/funding for materials

Thank you!

# Project Apollo v2 (previous work)

Published one year ago

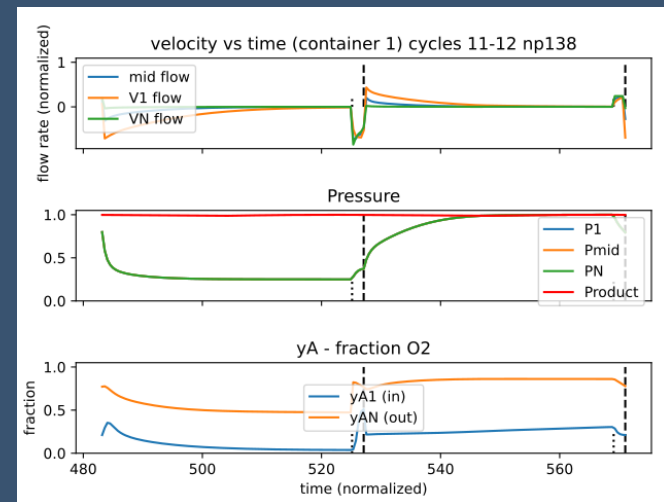
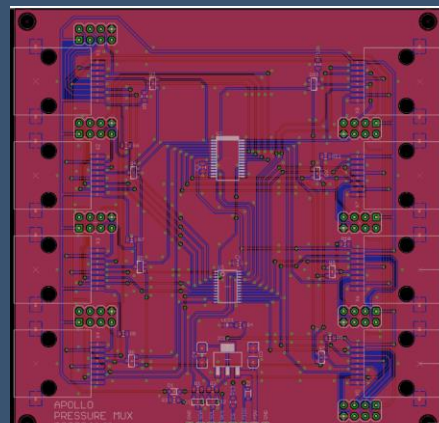
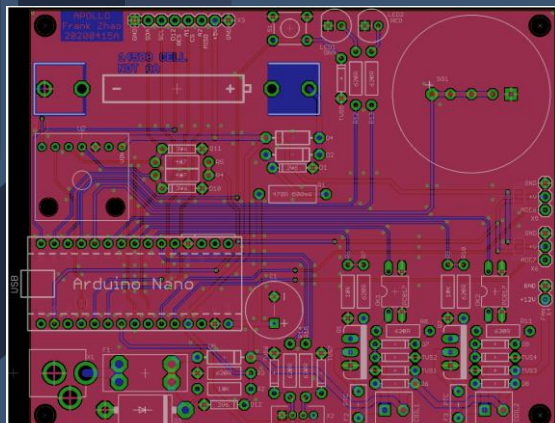
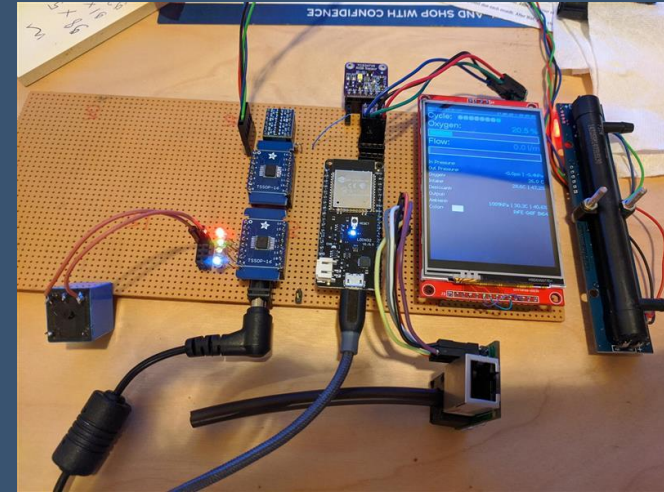
- Oxygen concentrator prototype using household materials
- Build instructions - [documentation](#)
- \$260 material cost – [BOM](#)

Multiple iterations/variants have been built

- O2 concentration 45 ... 70%, 5 lpm



# Apollo v4 (previous work)



<http://project-apollo.org>