



Open source platform to measure physiological signals in a classroom setting



Urs Utzinger^{#+}, Carmella Ocaya⁺, Muad Alsayar[#], Alec Newman^{*}, Daniel Capana[#], Michael Morrett^{\$}

The University of Arizona ⁺Biomedical -, ^{*}Biosystems -, [#]Electrical and Computer -, ^{\$}Mechanical - Engineering utzinger@arizona.edu

ECG & Impedance

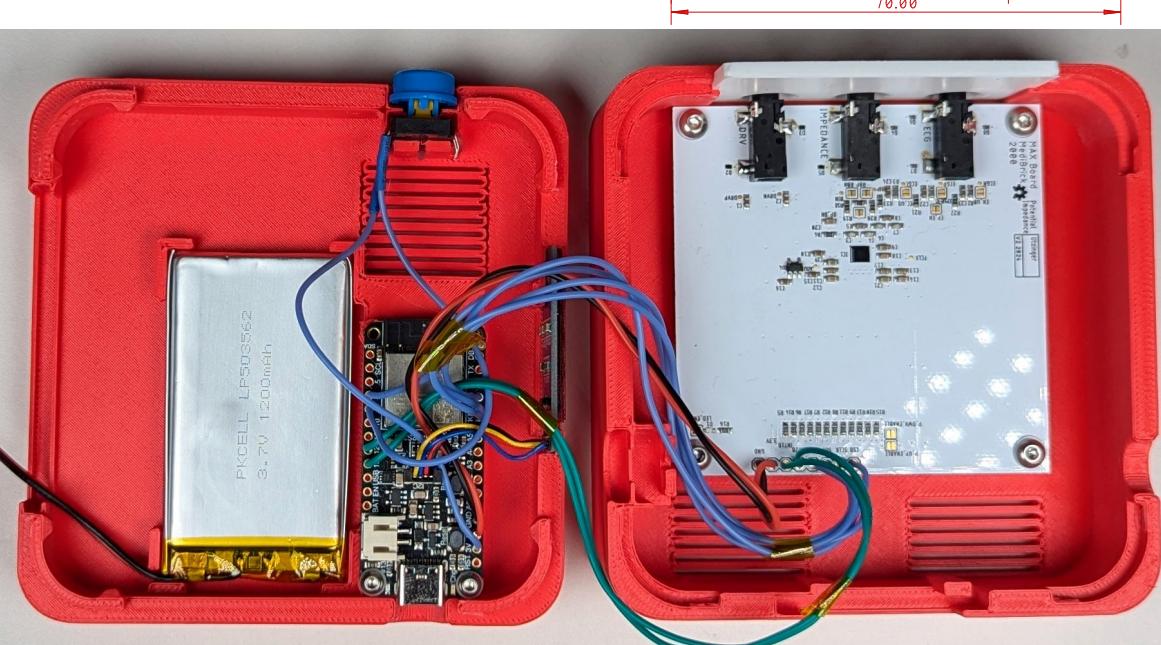
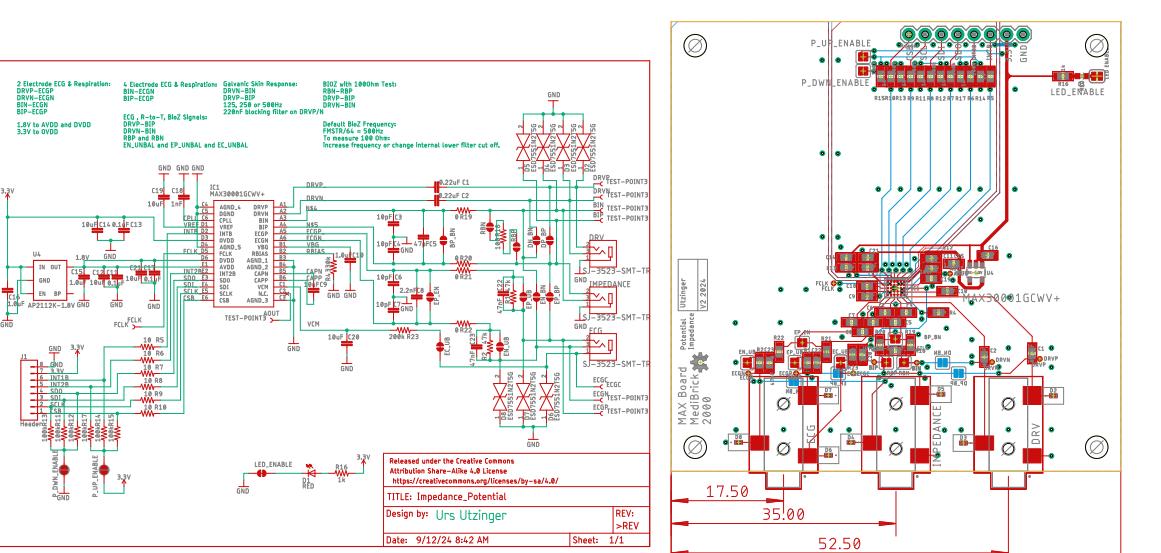


Material Costs approx. \$110

The ECG & BIOZ MediBrick uses the Maxim MAX30001G analog front end. It can measure:

- Bipotential
- ECG (waveform)
- R-R Time (heart rate and heart rate variability)
- Bioimpedance
- Impedance at single and multiple frequencies 5k..100kHz
- Respiration rate
- GSR (galvanic skin response, stress level)
- EDA (electro dermal activity)

A comprehensive driver capable of single and spectroscopy readings is under development.



Stethoscope & Bloodpressure



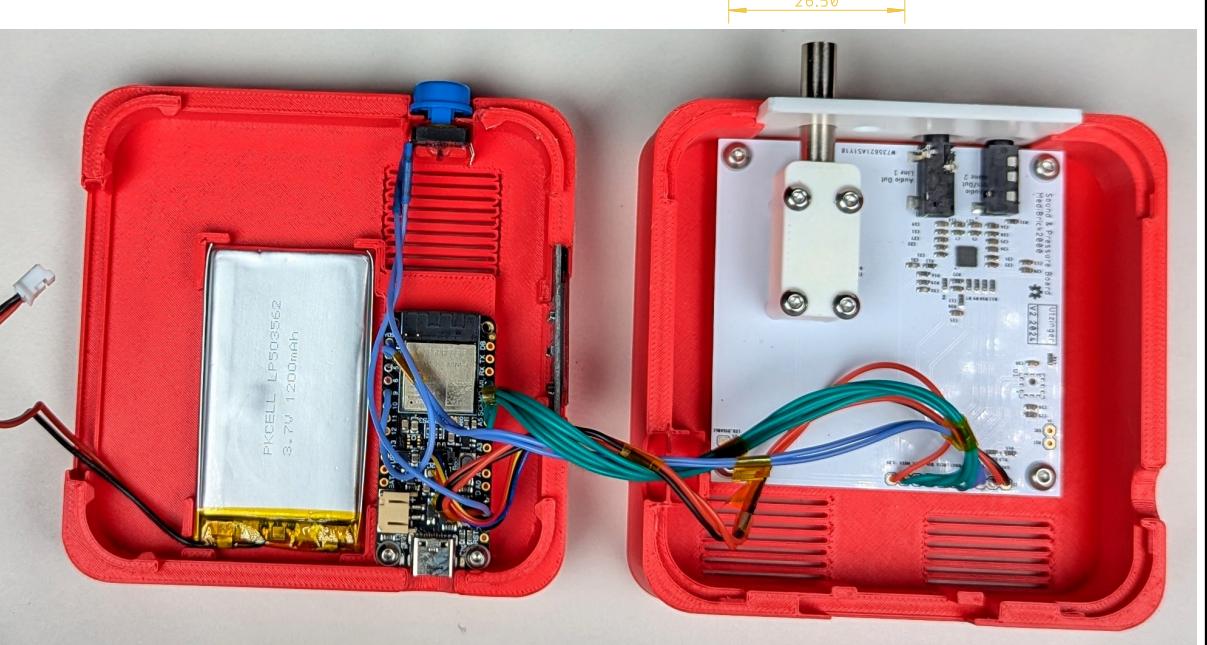
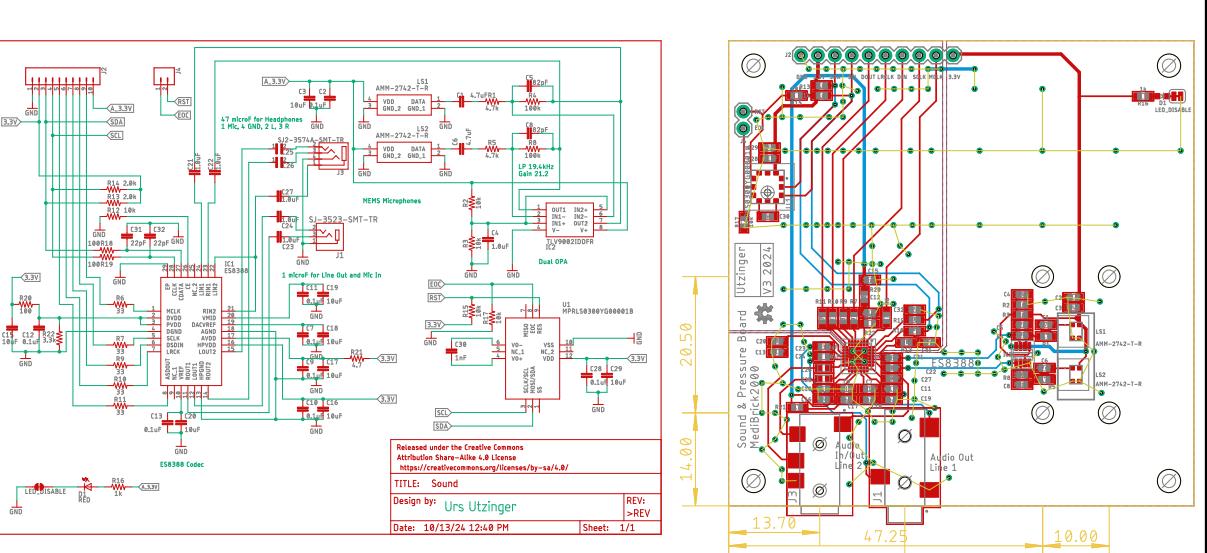
Material Costs approx. \$140

The Stethoscope MediBrick uses the ES8388 audio codec, AMM-2742 dual MEMS microphones recording heart sound and the background. Optional pressure is measured with a Honeywell MPRLS0300YG pressure sensor covering a 0 to 200 mm Hg range.

It can record heart sounds as well as Korotkoff sounds.

With the inflatable pressure cuff, the pressure sensor and the stethoscope, systolic and diastolic pressure can be recorded.

The codec uses the Arduino Audio Tools and Arduino Audio Driver library.



Pulse Oximeter

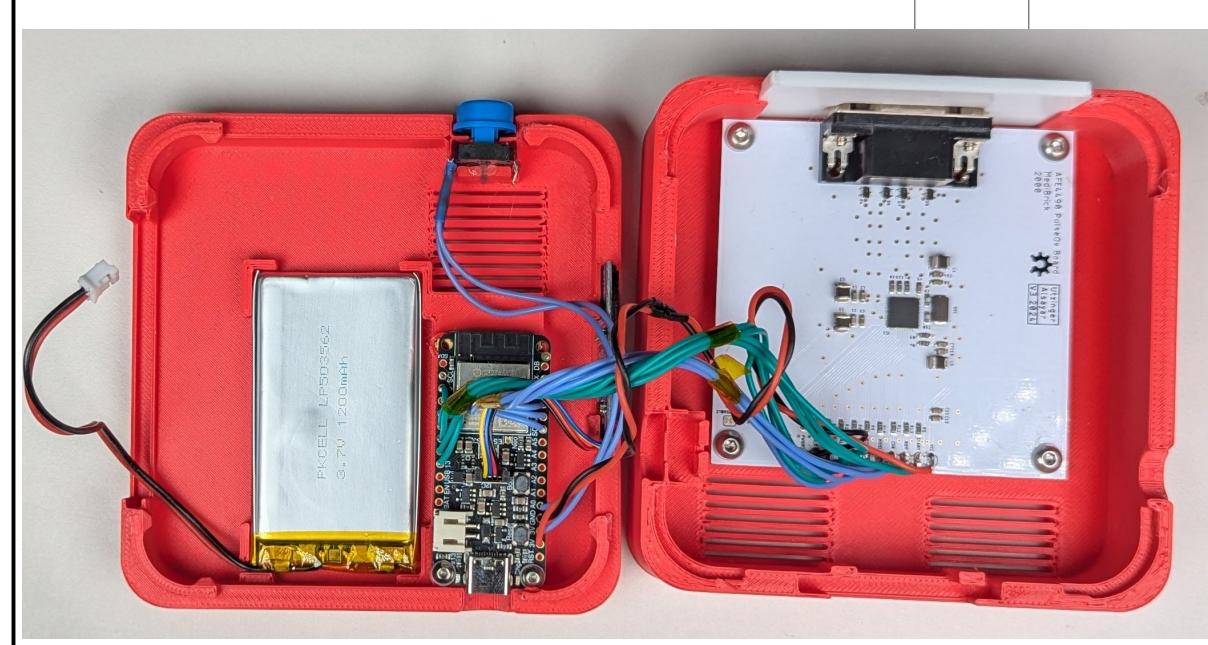
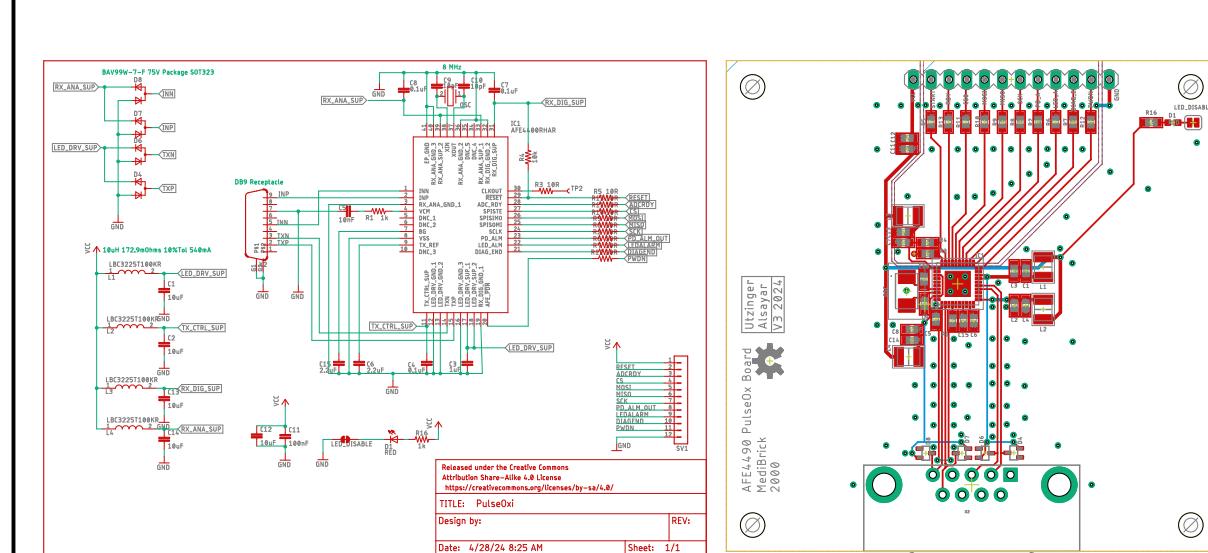


Material Costs approx. \$90

The Pulse Oximeter MediBrick uses the Texas Instruments AFE4490 dual LED and photodiode driver. Regular sensors with DB-9 connector can be attached.

Inexpensive adult reusable sensors as well as single use clinical sensors and small animal sensors can be attached.

A comprehensive Arduino library was created and made available through the Arduino IDE library manager.



Temperature



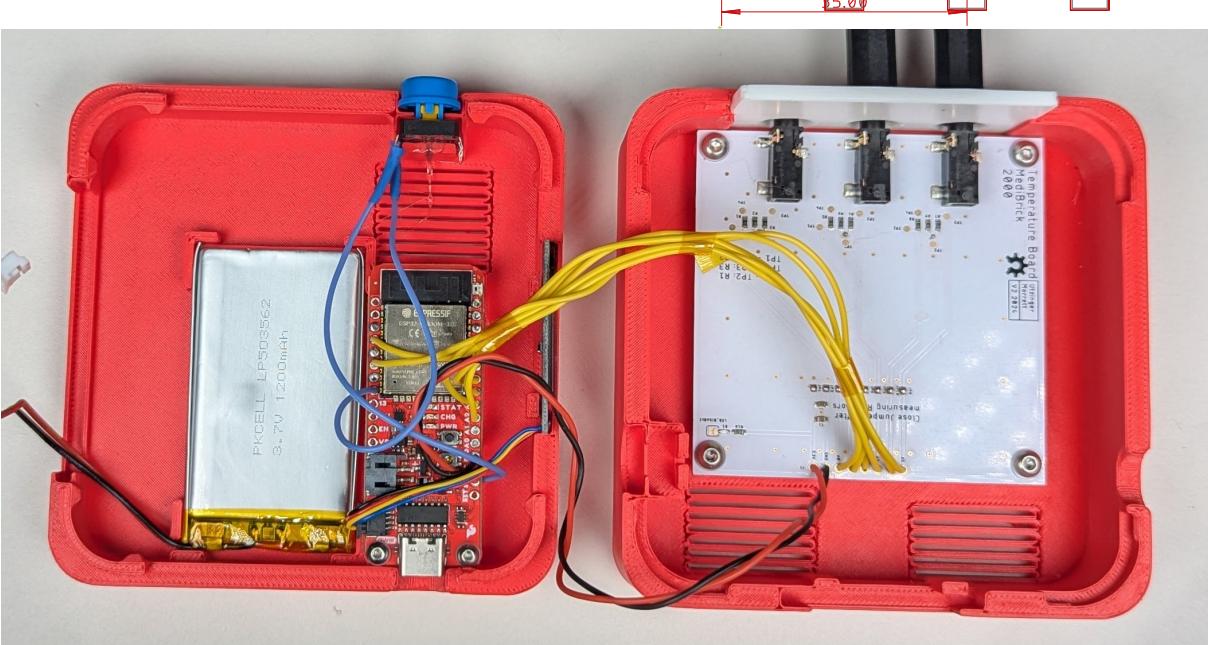
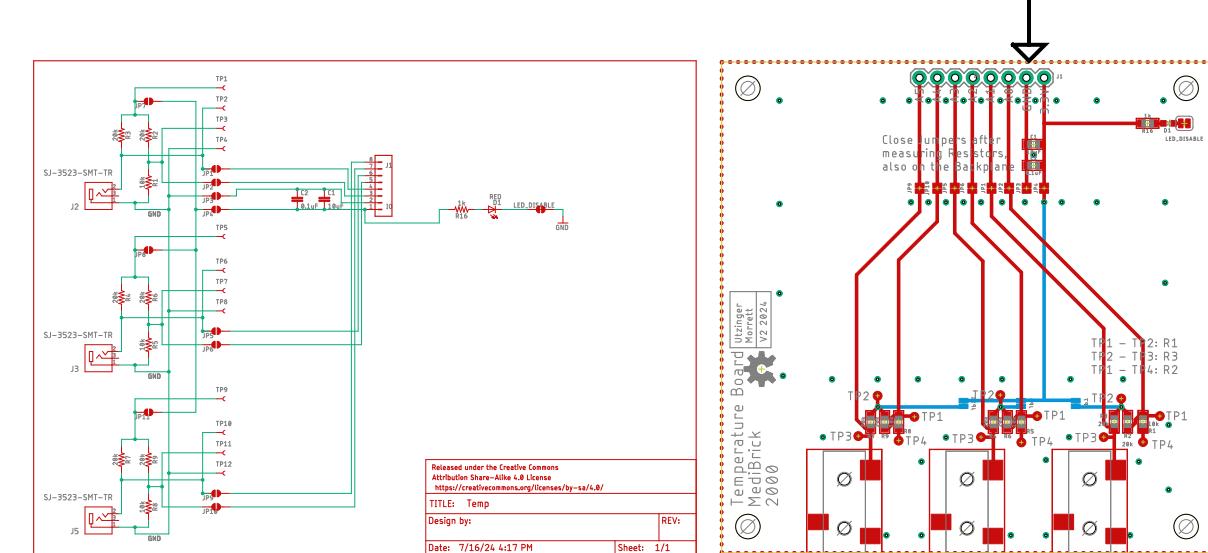
Material Costs approx. \$100

The Temperature MediBrick uses a passive Wheatstone bridge to record temperature with the microcontroller's internal analog to digital converter.

The module has been setup for 10k Ohm thermistors can also record strain-gauge signals.

Low cost microcontrollers' internal analog to digital converter is not accurate and requires linearization and noise filtering.

The Arduino Audio Tools Library was enhanced to measure interrupt driven analog signals from up to 6 channels at audio sampling rates. After averaging, temperature accuracy and noise is better than 0.1° C.



Activity



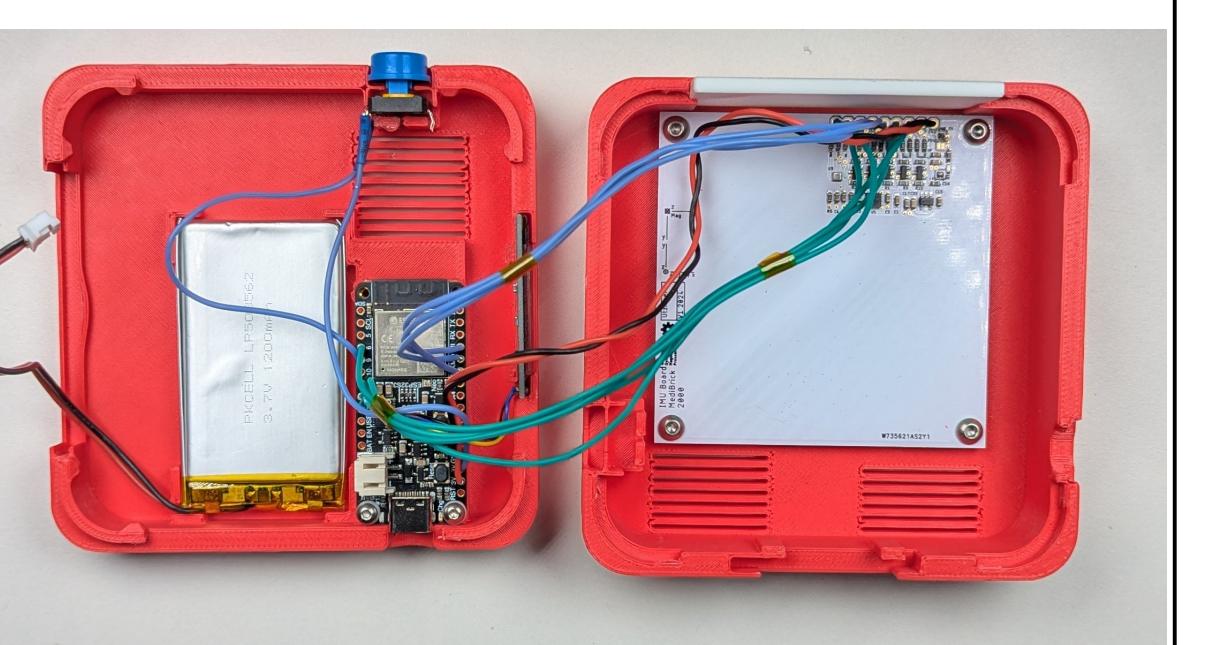
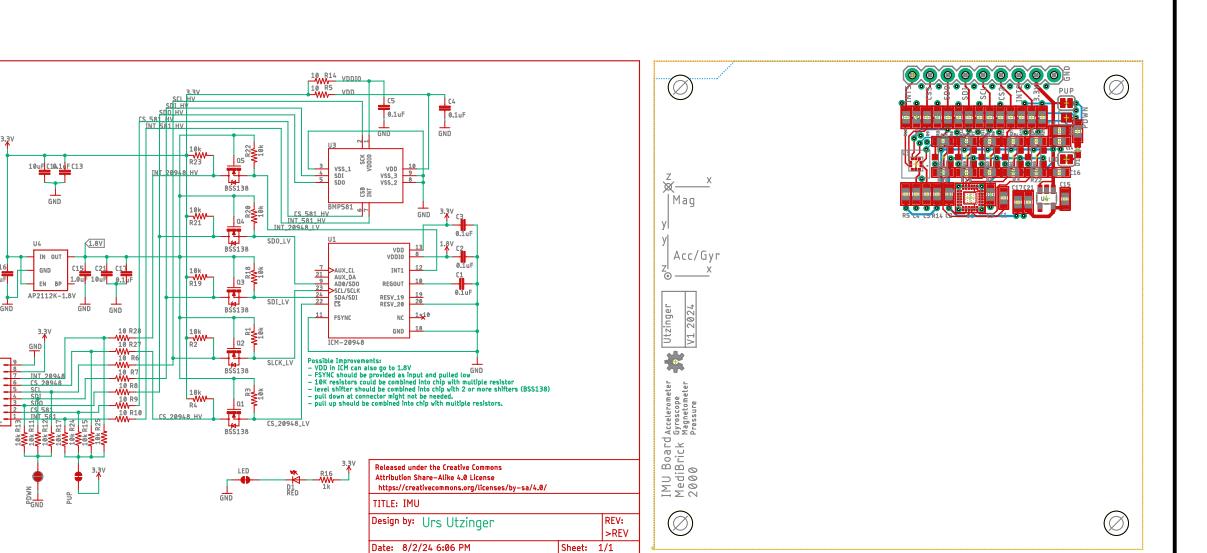
Material Costs approx. \$70

The Inertial Measurement Unit MediBrick uses the Invensense/TDK ICM20948 as well as the precision barometric pressure sensor BMP581 from Bosch.

The IMU and pressure sensors measure at more than 1000 samples per second. The IMU allows for internal sensor fusion to compute the attitude as well as gravity free acceleration.

This module allows to record:

- step count
- movement detection
- fall detection
- accurate device orientation even if the device is moving



Air Quality



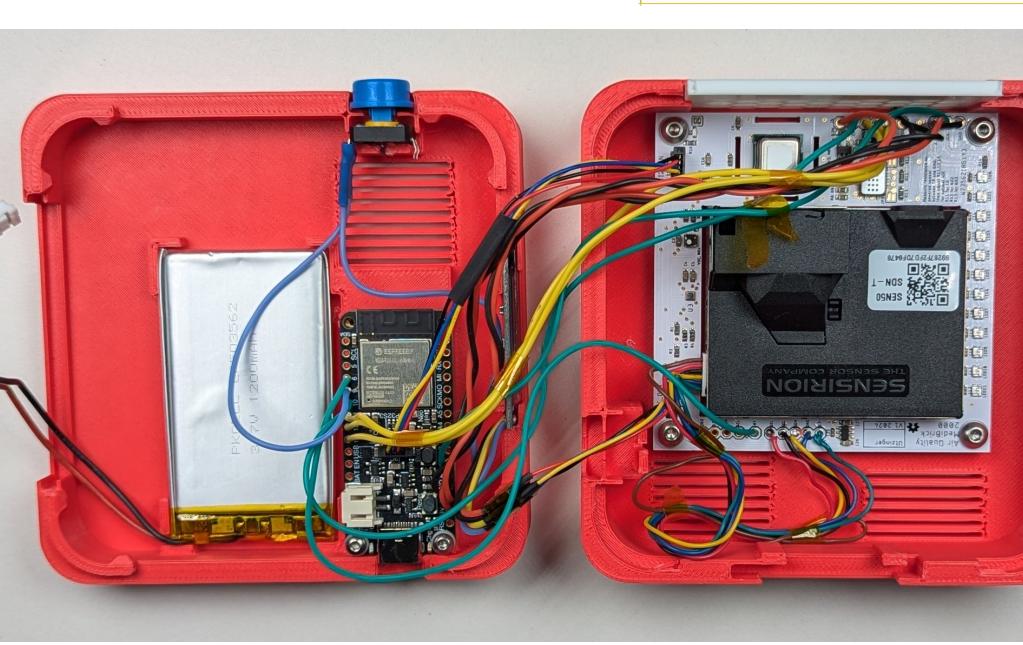
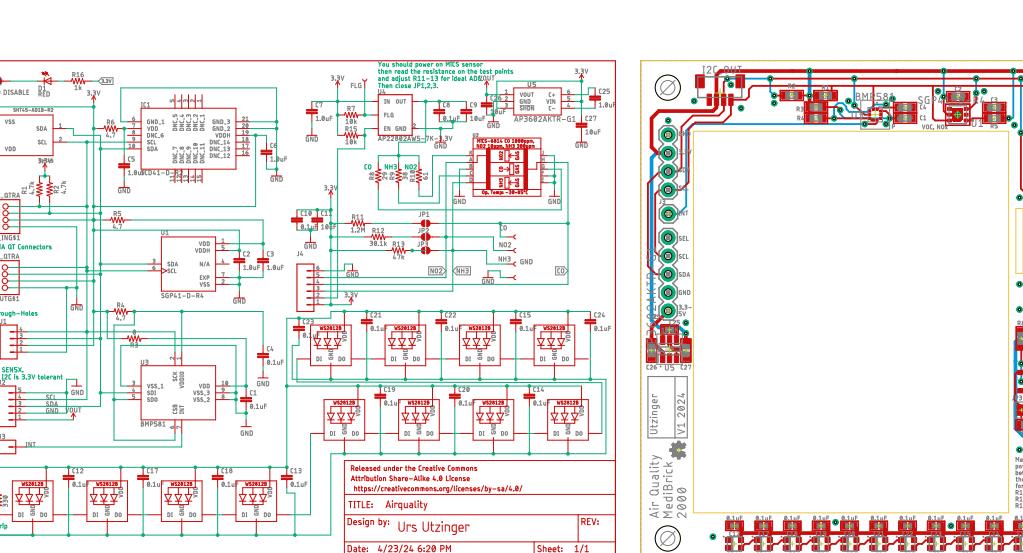
Material Costs approx. \$180

The Air Quality MediBrick is designed to measure:

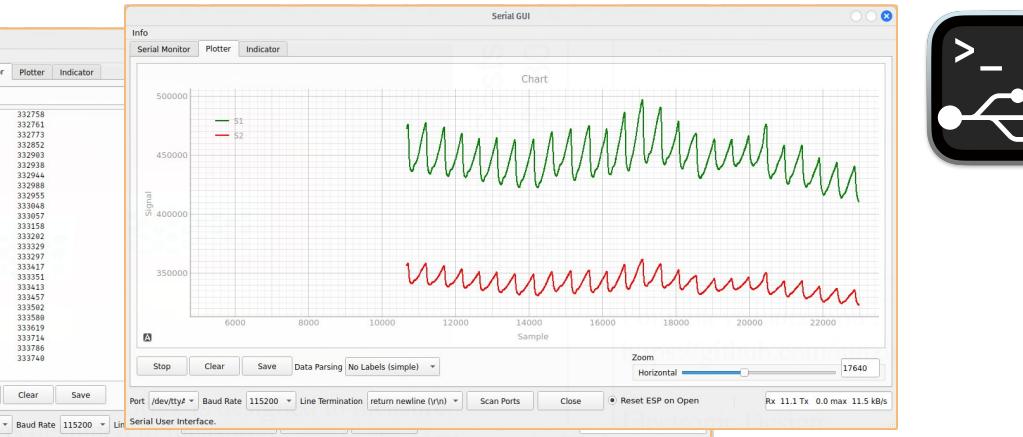
- Particulate Matter with SEN50
- CO₂ with SCD40
- relative Humidity and Temperature with SHT45
- barometric Pressure with BMP581
- eVOC, eNOx with SGP41
- Carbon Monoxide, Amonia, Nitrogen Oxide MiCS-6814

The module was designed for accuracy. Less expensive sensor solution might lower the costs.

A framework to operate the MiCS 6814 on 3.3V was developed.



Software & Hardware

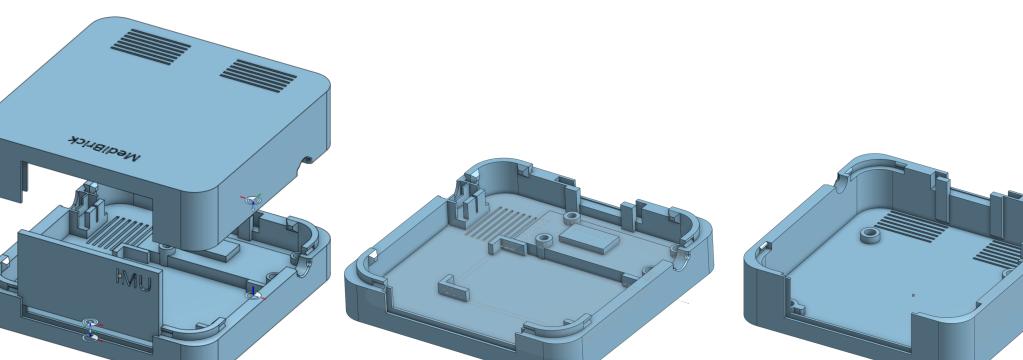


For data visualization :
[https://github.com/utzinger/SerialUI \(python\)](https://github.com/utzinger/SerialUI (python))

Electronic Design:
All modules are based on ESP32 microcontroller.
All boards and circuits were designed with Eagle CAD.
PCBs were manufactured and assembled by PCBWay.

Mechanical Design:
All mechanical components were designed using OnShape.
Components were designed to be 3D printed.

Assembly instructions are available for each module.



Minimum requirements to recreate the projects:
- Arduino IDE programming experience
- Through-hole soldering experience
- 3D printing experience
- Access to Makerspace

To modify any of the designs
- OnShape CAD account
- Eagle CAD or KiCad

All modules include teaching materials.

Disclaimers:
Costs are estimates and vary. They depend on the current component pricing and ordering quantity.
The authors will not manufacture, assemble or sell the MediBricks to you. For questions, engage with the forum on Github. For collaborations contact the lead author via email or here at BMES 2024 in Baltimore.