Open source platform to measure physiological signals in a classroom setting

Github Repo

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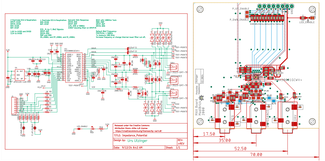
ECG & Impedance

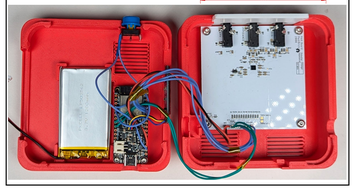
Material Costs approx. $110

The ECG & BIOZ MediBrick uses the Maxim **MAX30001G** analog front end.

It can measure:
- Biopotential
  - 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

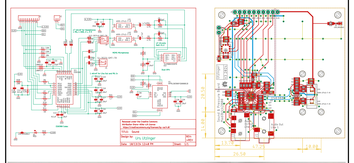
Material Costs approx. $140

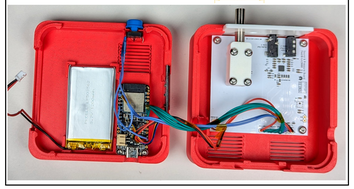
The Stethoscope MediBrick uses the **ES8388** audio codec and dual **AMM-2742** MEMS microphones recording heart sound and the background. Optional pressure is measured with a Honeywell **MPRLS0300YG** pressure sensor covering a 0 to 200 mm Hg range.

The module can record heart sounds, Korotkoff sounds or any other sounds collected by the stethoscope. External audio plugs allow sound playback and recording from other sound sources.

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.





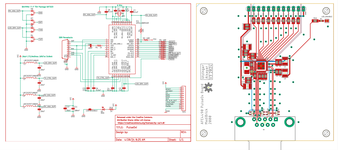
Pulse Oximeter

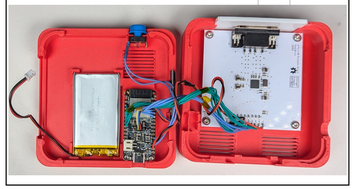
Material Costs approx. $90

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

The DB-9 interface is used for inexpensive adult reusable sensors as well as single use clinical sensors and small animal sensors.

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





Temperature

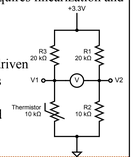
Material Costs approx. $100

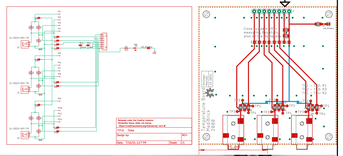
The Temperature MediBrick uses a passive **Wheatstone bridge** to record temperature with the microcontroller's internal analgo to digital converter.

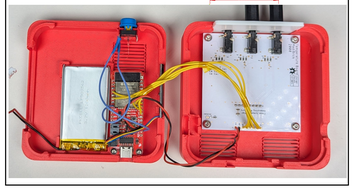
The module has been setup for 10k Ohm thermistors but can also record strain-gauge signals.

The internal analog to digital converter of a low cost microntrollers 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.







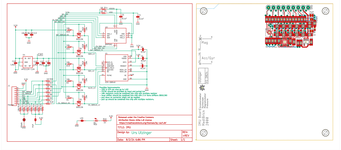
Activity

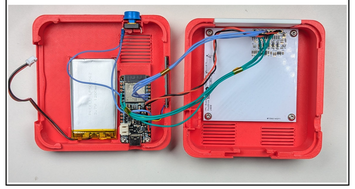
Material Costs approx. $70

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
- to determine accurate device orientation even if the device is moving





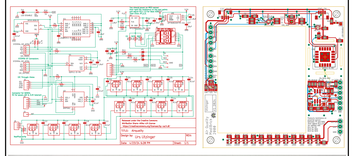
Air Quality

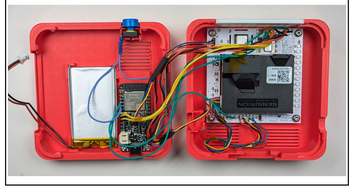
Material Costs approx. $180

TheAir Quality MediBrick is designed to measure:
- Particulate Matter with **SEN50**
- CO_2 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 solutions might lower the costs.

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





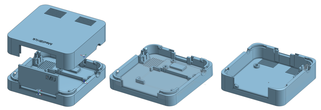
Software & Hardware

For Data Visualization :
https://github.com/uutzinger/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*

Modifying any of the designs requires:
- *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.