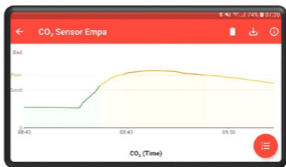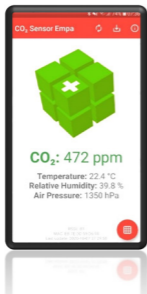# The EmpAIR Ventilation Advisor

A CO_2 Monitor for
Indoor Air Quality Control

1. The EmpAIR device

- Monitors air quality
  - CO_2 concentration
  - Temperature
  - Humidity
  - Air pressure
- Wireless transmission
- Visualization on your Android/iOS mobile device

2. Why air quality matters

Air-borne pathogens such as the new Corona virus that caused the current pandemic are transmitted, among other things, via aerosols, i.e. tiny particles or liquid droplets in ambient air. An infected person exhales virus-containing aerosols that can spread in an unventilated room. It is thus crucial to ventilate classrooms and the like on a regular basis to minimize the risk of spreading the disease. Since we all exhale CO_2 the CO_2 concentration within a room is a good proxy for the occupancy of that room: the more people, the faster the CO_2 concentration rises above background levels – and thus make a ventilation advisable. The EmpAIR device measures, among other environmental parameters (see 3.1), CO_2 concentration and sends out alerts (for instance, to your smartphone – see 3.2) as soon as a certain threshold level is reached. It is thus a reliable tool that will tell you when you need to ventilate the room.

3. How to use the device

EmpAIR is a sensor for CO_2, temperature, relative humidity and air pressure. It transmits its measurements via Bluetooth to your smartphone or other receivers. Currently, Apps for Android and iOS devices are available in the respective stores. The CO_2 concentration is an excellent indicator for the ventilation rate of a room. Therefore, EmpaAIR allows you to optimize ventilation.

3.1 Features
- CO_2 concentration
- Air temperature
- Relative humidity
- Air pressure
- Room illumination (relative)
- Broadcasting data via low-energy Bluetooth (BLE)
- Visualizations apps for android and iPhone
- No device pairing required
- Two years battery life time
- Open access
- QR-code on case provides a link where all information can be found

3.2 Apps for mobile phones and tablets

3.2.1 Installation
- Go either to the Google Play (Android), the App Store (iOS) or the project homepage (to download app.apk for Huawei mobile phones)
- Search for EmpAIR
- Install and start app
  - Permission for location services must be given (Android). This is required to access any BLE services. No location is stored by the App.
- If the app cannot find a sensor: Enable location services in general on your device (Android)
  - Settings > Security and Location > Privacy > Location > On

3.2.2 Usage

🏠	Home page: Cube color depends on CO_2 concentration and indicates the need for ventilation
⊞	Graph page: Observe the CO_2 concentration over time
☰	Sensor list: Select a specific sensor[1]
ⓘ	Info page for settings and information
📥	Start logging to file[2]
📥	Stop logging[2]
↻	Rescan available sensors and connect to the nearest one [3]
🗑	Clear the graph

[1] Higher RSSI means a stronger Bluetooth signal
[2] Not for iOS; options and file path see info page
[3] Open the sensor list page to see all available sensors
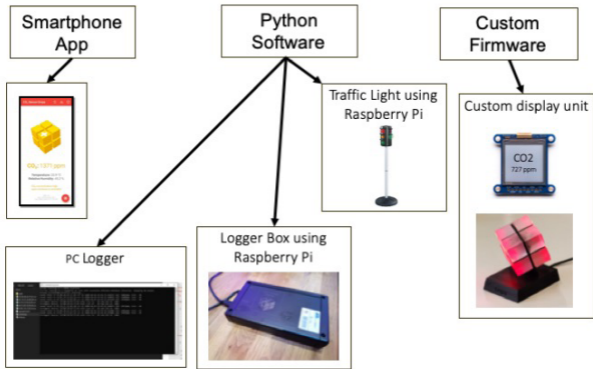
3.3 BLE broadcast

The data of the various sensors are broadcasted as an advertising BLE package about every second. The package contains 20 bytes of data. The following table describes the data format. The MAC, address, which is engraved on the housing, can be used to differentiate between several EmpAIR devices. This allows to record data from multiple sensors simultaneously.

Byte	Content	Conversion
0...1	Manufacturer ID	Fixed to 0xFFFF
2...3	Empa ID "**Empa CO2**"	Fixed to 0xEC02
4	Cycle/Status	Bit 0...3 cycle counter
		Bit4 Error Senseair Sunrise
		Bit5 Error Bosch BME680
		Bit6 Error generic
5...6	CO2 Value	x1ppm (uint16)
7...8	Temperature	x100 °C (int16)
9...10	Humidity	x100 %RH (uint16)
11...13	Pressure	x100 Pa (uint24)
14...15	Ambient Light	ADC digits (uint16)
16...17	Battery level	x1mV (uint16)
18	Version	Bit 0...3 Firmware Version
		Bit 4...7 Hardware Version

Byte order: LSB, MSB

3.4 Recording data with other devices

Every BLE-capable device can be used to receive the data. A code example in python can be found here: *https://www.empa.ch/web/s405/EmpAIR*

This example uses the BLEAK library *(https://pypi.org/project/bleak/)* and runs on a PC (x86) or Raspberry Pi (ARM) with Python installed and available Bluetooth hardware. An overview of potential receiving devices is given below:

Smartphone App

Python Software

Custom Firmware

Traffic Light using Raspberry Pi

Custom display unit

PC Logger

Logger Box using Raspberry Pi

3.5 Specification

The EmpAIR device uses the following sensors:

- **Sensair Sunrise** CO_2 Sensor:
  https://senseair.com/products/power-counts/sunrise-hvac/
- **Bosch BME680** Environmental Sensor:
  https://www.bosch-sensortec.com/products/environmental-sensors/gas-sensors-bme680/
- **OSRAM BPW 34 S** Photodiode:
  https://www.osram.com/ecat/DIL%20SMT%20BPW%2034%20S/com/en/class_pim_web_catalog_103489/prd_pim_device_2219543/

3.6 Changing batteries

The batteries (3x AA Alkaline) need to be changed after approximately two years. Remove the back plate by pushing back the two notches with a screwdriver (or similar). Bend open the main housing a bit to remove the PCB. Pay attention on the orientation of the housing and the PCB to insert it back the same way.

3.7 Final note

The EmpAIR device is a contribution by Empa to combat the Covid-19 pandemic by providing information about indoor air quality. We developed the demonstrator in a very short time using various technologies available at Empa. If you have any comments or suggestion, or developed your own solution and want to share it with us, please contact *jonas.gartmann@empa.ch*

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Materials Science and Technology