OpenEarable

Open-Source AI-Earphones for Advanced Biosensing

OpenEarable is an innovative open-source AI platform that transforms wireless earphones into intelligent wearables. It integrates more sensors into earphones than ever before, enhancing communication in noisy environments, protecting the wearer's health, and improving overall safety. Additionally, OpenEarable can be controlled hands- or eyes-free.

Open-Source Principles

OpenEarable consists of open-source hardware (MIT license), firmware, and software. Researchers, developers, and industry can adapt and expand the AI platform to suit their needs.

The wireless earphones are equipped with various sensors for revolutionary functionalities. (Photo: KIT/TECO)

Sensors and Functionalities

Various sensors and the corresponding hardware capture physiological and environmental phenomena with high precision. These sensors enable a wide range of applications, from industry to healthcare.

- **Bosch BMX160 nine-axis IMU:** For motion tracking, including fall detection and activity monitoring.
- **Bosch BMA580 three-axis bone conduction microphone:** Captures clear audio signals in noisy environments, such as factory halls, and enables HiFi conferences with integrated high-linear speakers.

- **MAX86161 pulse oximeter** and **Melexis MLX90632 optical temperature sensor:** Monitor health parameters and detect overload conditions such as heatstroke or cognitive strain.
- **Bosch BMP388 ear canal pressure sensor:** Enables human-computer interaction through facial expressions and gestures, hands- and eyes-free.
- **Knowles SPH ultrasound-capable microphones:** Support advanced authentication methods.
- **Nordic nRF5340 with dual M33 ARM + Analog Devices ADAU1860 Audio DSP:** For AI processing and Bluetooth communication.
- **Varta CP1454 high-performance battery**

Independent of its sensors, OpenEarable also functions as a standard audio earphones, allowing users to make calls and listen to music or podcasts.

Software Ecosystem

- **ZephyrOS:** OpenEarable runs on an embedded real-time operating system.
- **Mobile and Desktop App:** OpenEarable offers a smartphone app for iOS and Android, a web-based dashboard, and dedicated desktop apps for macOS, Windows, and Linux.
- **Flutter Library:** A cross-platform library makes OpenEarable easy to extend and customize.
- **edge-ml.org:** A web-based, low- and no-code ML service that enables the development of machine learning models in minutes, which run directly on OpenEarable.

OpenEarable can be easily programmed to evaluate new application use cases. (Photo: KIT/TECO)
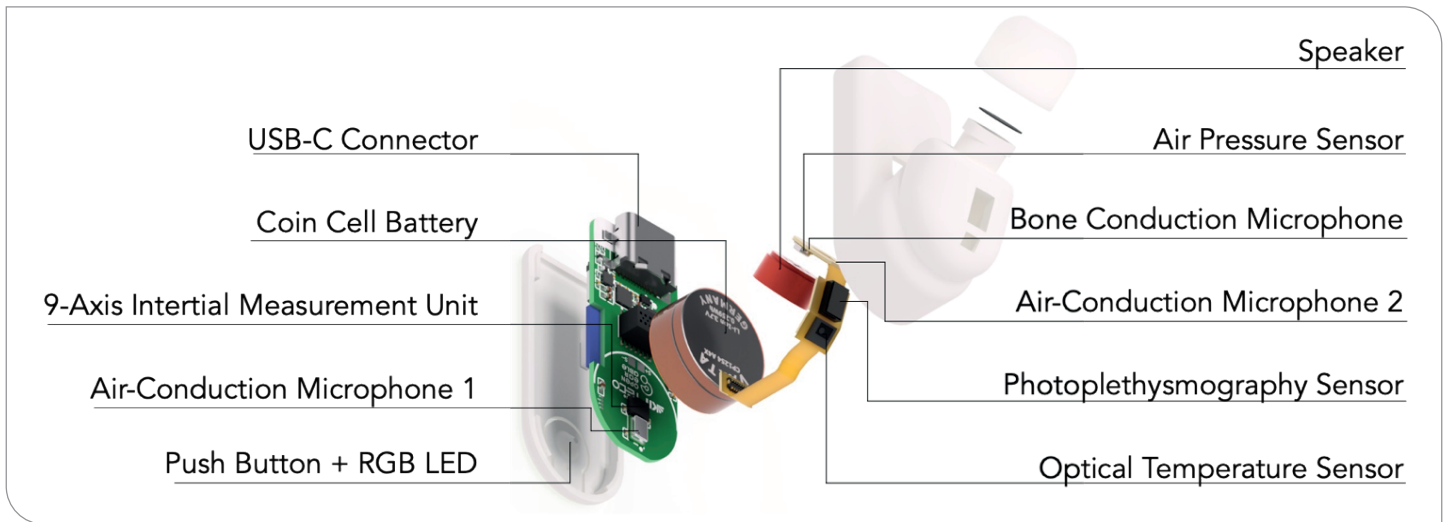
OpenEarable with various sensors for audio capture, heart rate monitoring, skin temperature measurement, and body movement tracking. (Graphic: KIT/TECO)

Labels (left side):
- USB-C Connector
- Coin Cell Battery
- 9-Axis Intertial Measurement Unit
- Air-Conduction Microphone 1
- Push Button + RGB LED

Labels (right side):
- Speaker
- Air Pressure Sensor
- Bone Conduction Microphone
- Air-Conduction Microphone 2
- Photoplethysmography Sensor
- Optical Temperature Sensor

Technical Specification

- Dual-Core ARM 2 × Cortex-M33 processor and Analog Devices ADAU1860 Audio DSP
- Zephyr RTOS for efficient real-time processing
- Bluetooth Low Energy (BLE) 5.2 standard
- LE Audio streaming

- MicroSD storage for offline data recording
- USB-C for charging and as interface
- Up to 8 hours battery life (audio + sensors)
- Expandable via 10-pin FPC & 14-pin header
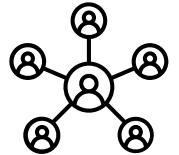
Industrial Applications

Enhanced workplace safety through bioparameter monitoring

Hands-free and eyes-free operation

Clear communication in noisy environments

Training and collaboration support

Karlsruhe Institute of Technology (KIT)
Institute of Telematics (TM)
TECO – Pervasive Computing Systems

Dr. Tobias Röddiger
Vincenz-Prießnitz-Str. 1
76131 Karlsruhe
Email: tobias.roeddiger@kit.edu
Web: https://open-earable.teco.edu/preview/index.html

OPEN eaR aBLe

TECO