TESTS OF SELECTED DEVELOPMENT PLATFORMS AND ELECTRONIC COMPONENTS FOR THE CONSTRUCTION OF A WIRELESS SYSTEM FOR MONITORING AND REMOTE CONTROL OF NOISE AND VIBRATION

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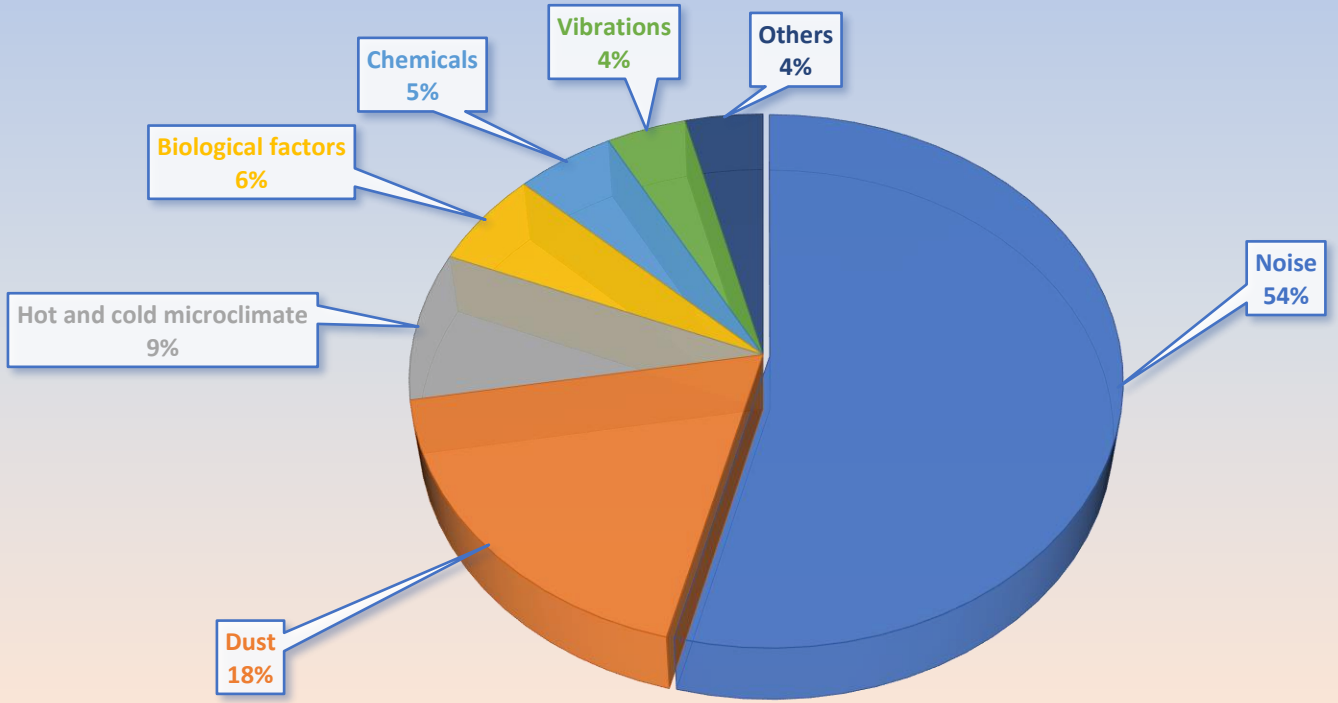
Outline of presentation

1. Introduction.
2. Concept of the system:
    - Assumptions.
    - Previously developed monitoring systems.
    - Structure Diagram of the Monitoring System.
3. Preliminary tests on selected system components:
    - Evaluation boards.
    - MEMS microphones.
    - Wearables.
    - Actuator modules
4. Conclusions.

Introduction – working conditions in Poland

Noise is the most common risk factor in Poland (54% of all cases of risks occurring at workplaces)
Working conditions in 2022, Statistics Poland.



INTRODUCTION –DETERMINING THE RISK FACTOR

Noise and vibration measurements are carried out in workplaces at biennial or annual intervals.

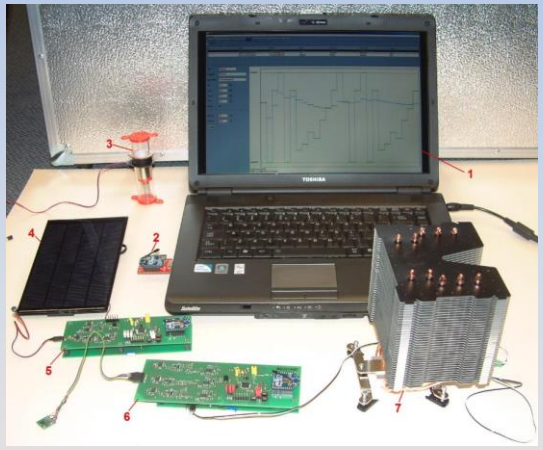
The intensity of risk factors may change, e.g. as a result of changes in the parameters of the work process.

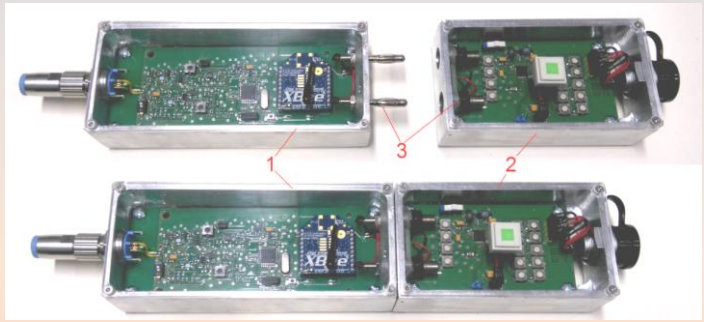
Rapid changes in risk factors, such as machine wear or failure, can be particularly hazardous to employee health.

The solution to these problems may be the implementation of continuous monitoring of vibroacoustic parameters in the work environment.

Previously Developed version of the Systems

A remote monitoring system for vibroacoustic parameters of the work environment powered by renewable energy sources.





A sensor network for monitoring the work environment and warning employees of hazards using wearable devices.

FACTORS INFLUENCING THE ARCHITECTURE OF THE SYSTEM

Scalability

Data management

Latency

Connectivity

Security

User interface

Accuracy and repeatability

Cost

Power consumptions

Environmental conditions

Integration with existing systems

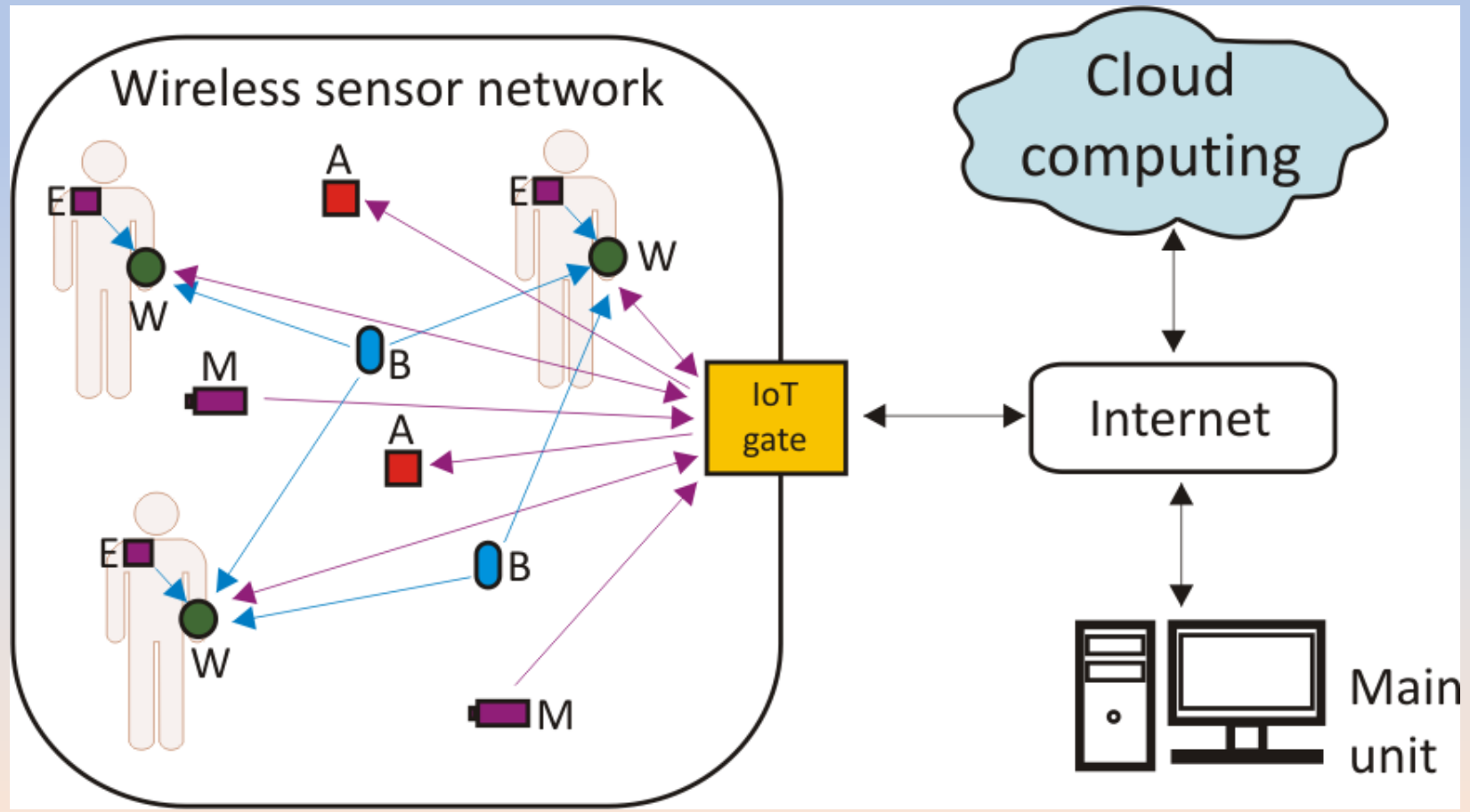
Concept of the system - assumptions

1. A system that allows for real-time monitoring of noise and vibrations in the work environment.
2. With the capability to provide workers with warnings about excessive exposure.
3. Based on relatively inexpensive components.
4. Enabling remote control of machines.
5. With the ability to detect wear or damage to machines and equipment based on changes in the characteristics of generated noise or vibrations.

System diagram

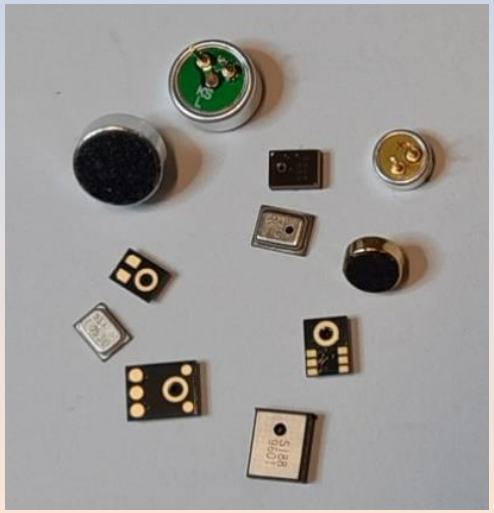
Basic Structure Diagram of the Monitoring System:

- **M**: Noise or vibration meters
- **N**: Wearable device in the form of a watch
- **E**: Personal noise meter
- **B**: Radio tags
- **A**: Actuator module
- **Purple Arrows**: Wireless Wi-Fi connections
- **Blue Arrows**: Wireless Bluetooth connections
- **Black Arrows**: Ethernet connections

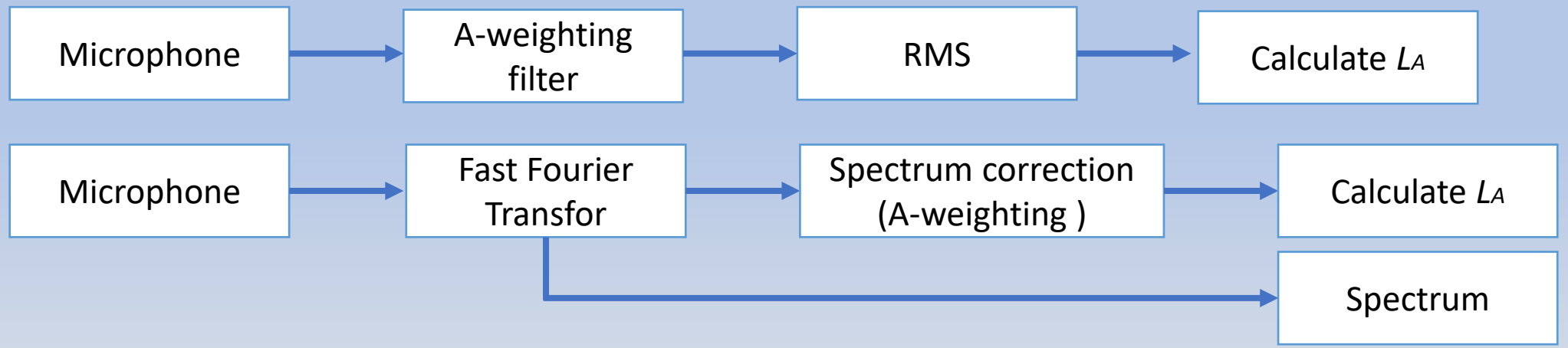


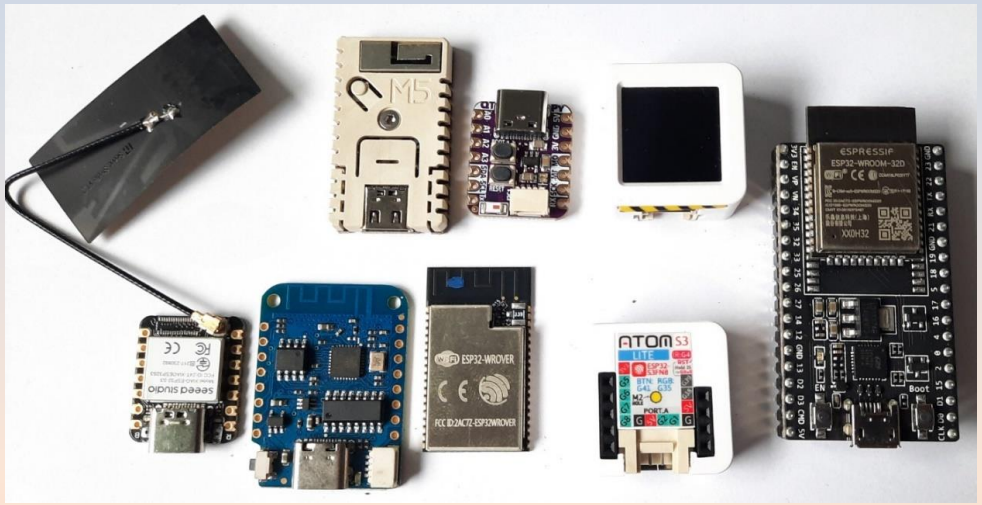
REQUIREMENTS –NOISE METER

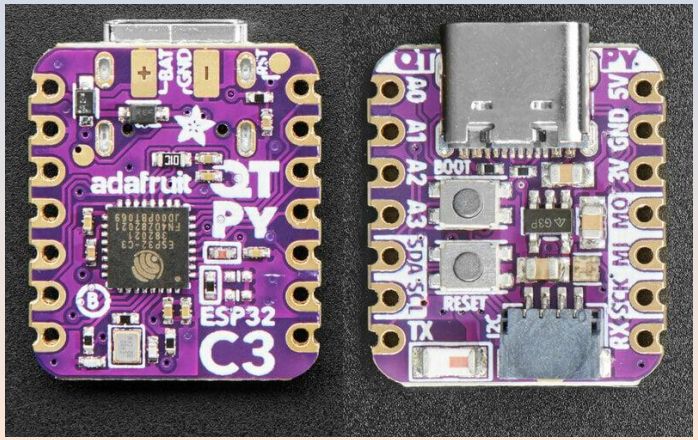
1. *A noise measurement system should determine the values of parameters characterizing noise in the workplace*
   - *noise exposure level related to 8-hour daily working time, $L_{EX,8h}$ (85 dB), or corresponding daily noise exposure, $E_{A,Td}$ (3,64·103 Pa^2·s)*
   - *maximum A-weighted sound level, L_{Amax} (115 dB),*
   - *C-weighted peak level, L_{Cpeak} (135 dB).*
2. *The noise meter system should enable determination of the noise spectrum*



CAPABILITIES – NOISE MEASUREMENT SYSTEMS

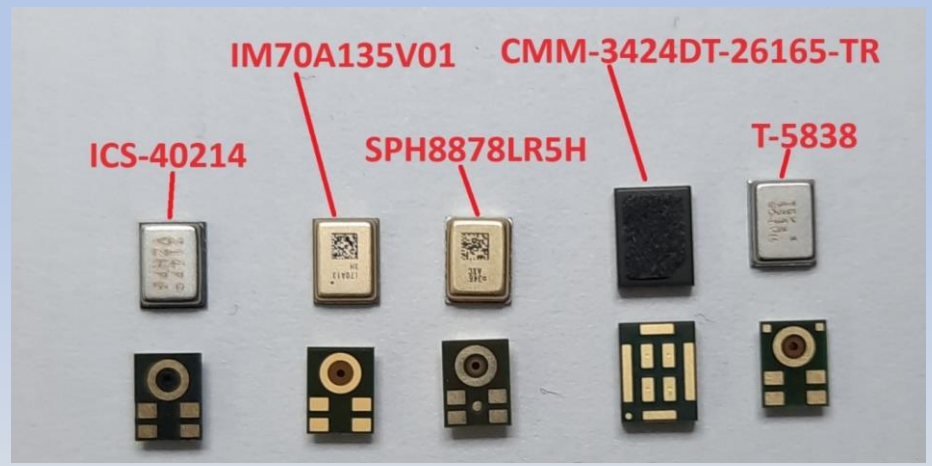


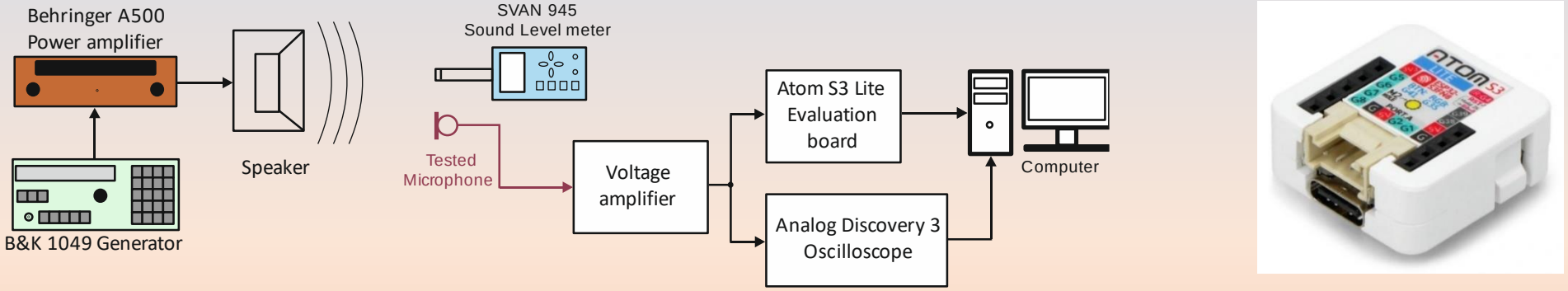




MEMS MICROPHONES

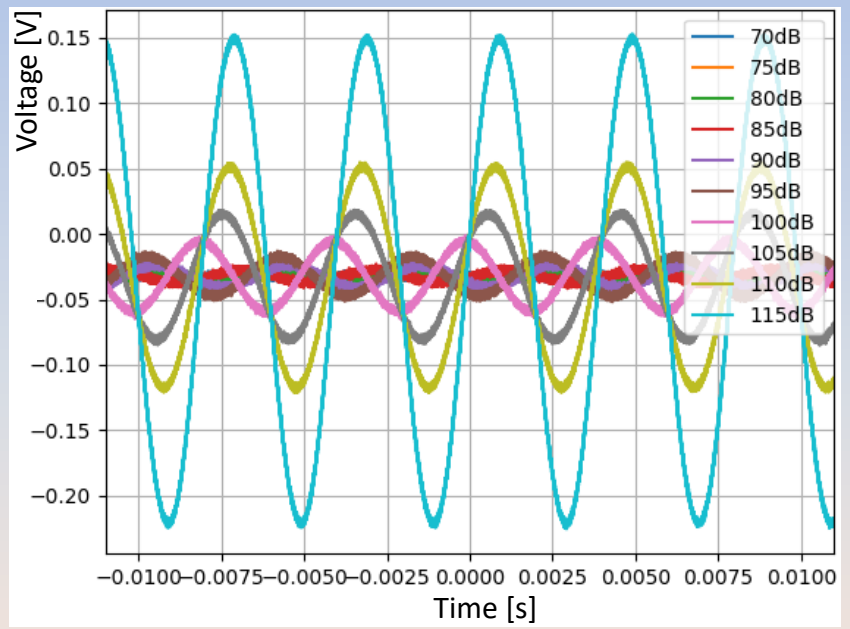
Microphone	Manufacturer	Type	AOP [dB]	SNR [dB]	Sensitivity [dBV]
ICS-40214	TDK	Analog, Single-Ended Output	128	66	-38
IM70A135V01	Infineon	Analog, Differential Output	135	70	-38
SPH8878LR5H	Knowles	Analog, Differential Output	134	67	-38
CMM-3424DT-26165-TR	CUI Devices	Digital, PDM	120	65	26
T-5838	TDK	Digital, PDM	133	68	-41



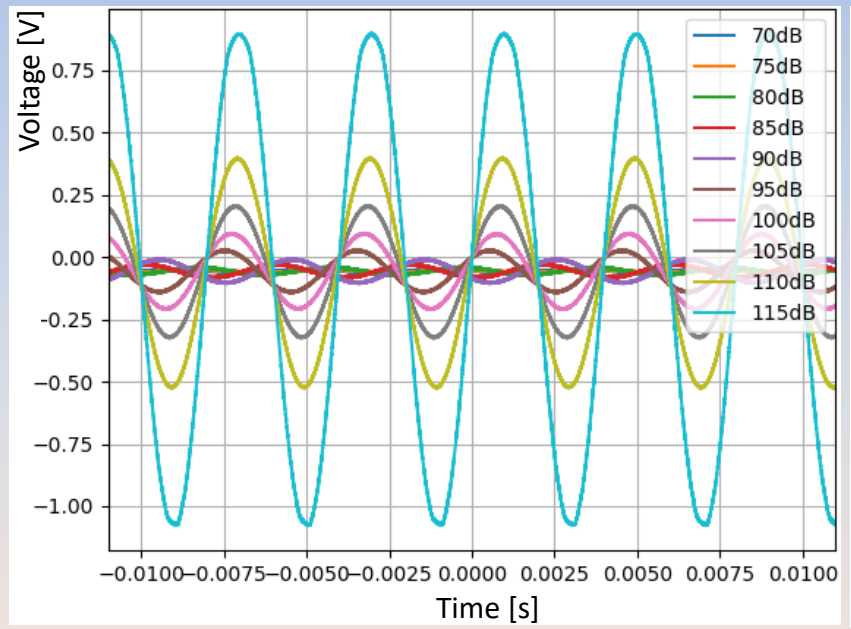


MEMS MICROPHONES – MEASUREMENT RESULTS

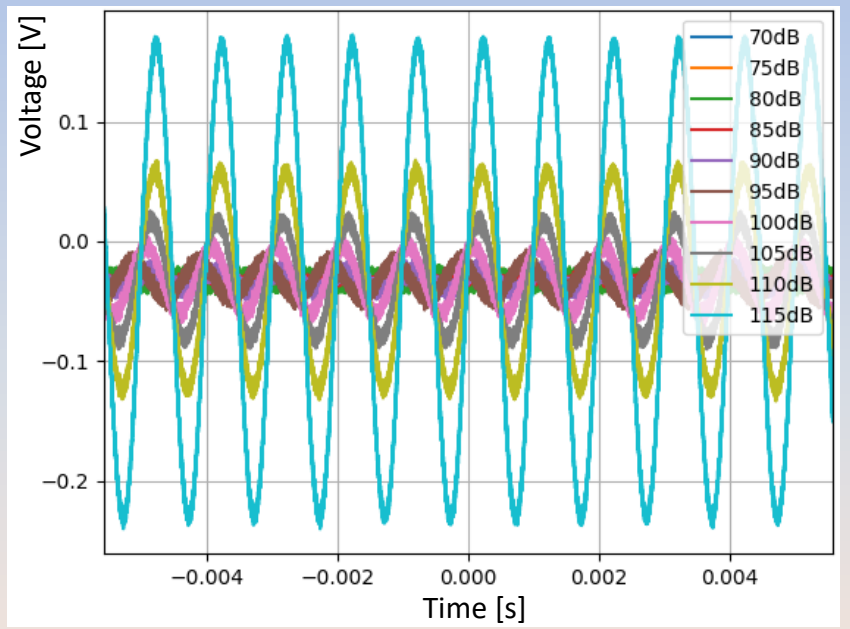
TDK_T5838 microphone, frequency: 250 Hz



CMM-3424DT microphone, frequency: 250 Hz

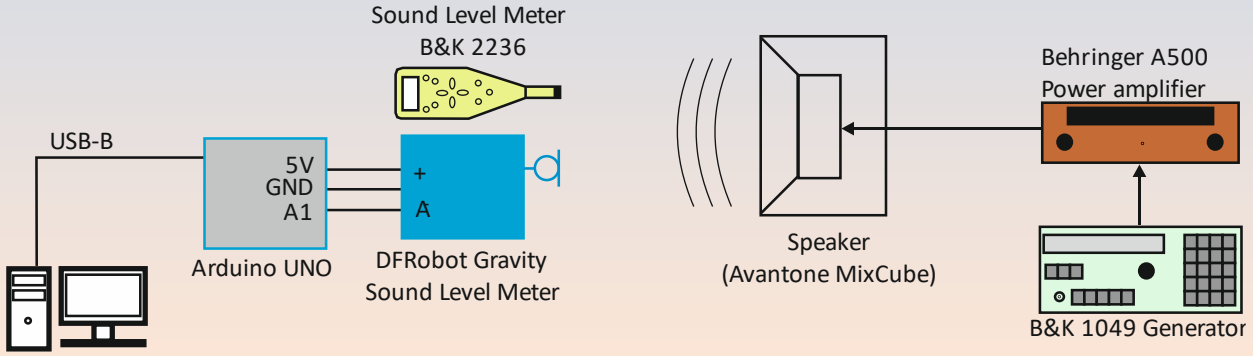


TDK_T5838 microphone, frequency: 1 kHz



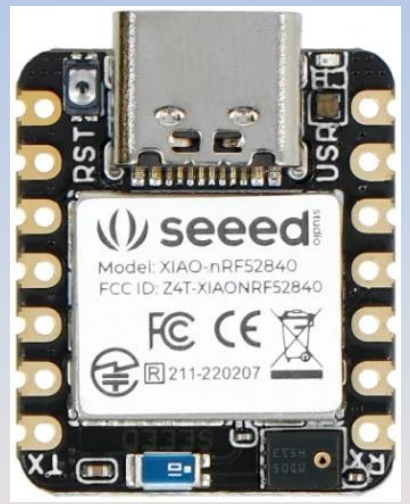
SELECTED MEASUREMENT RESULTS OF EVALUATION BOARDS

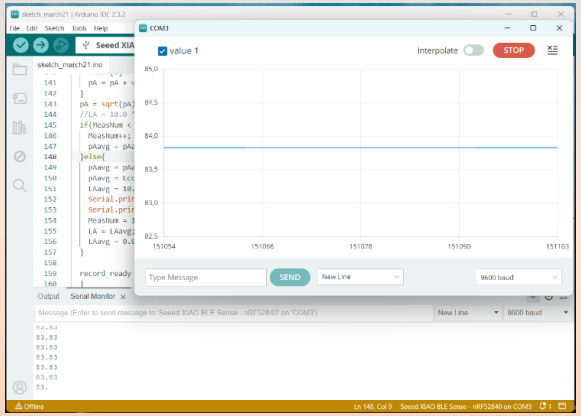
- *Analog sound level meter – DFRobot Gravity*

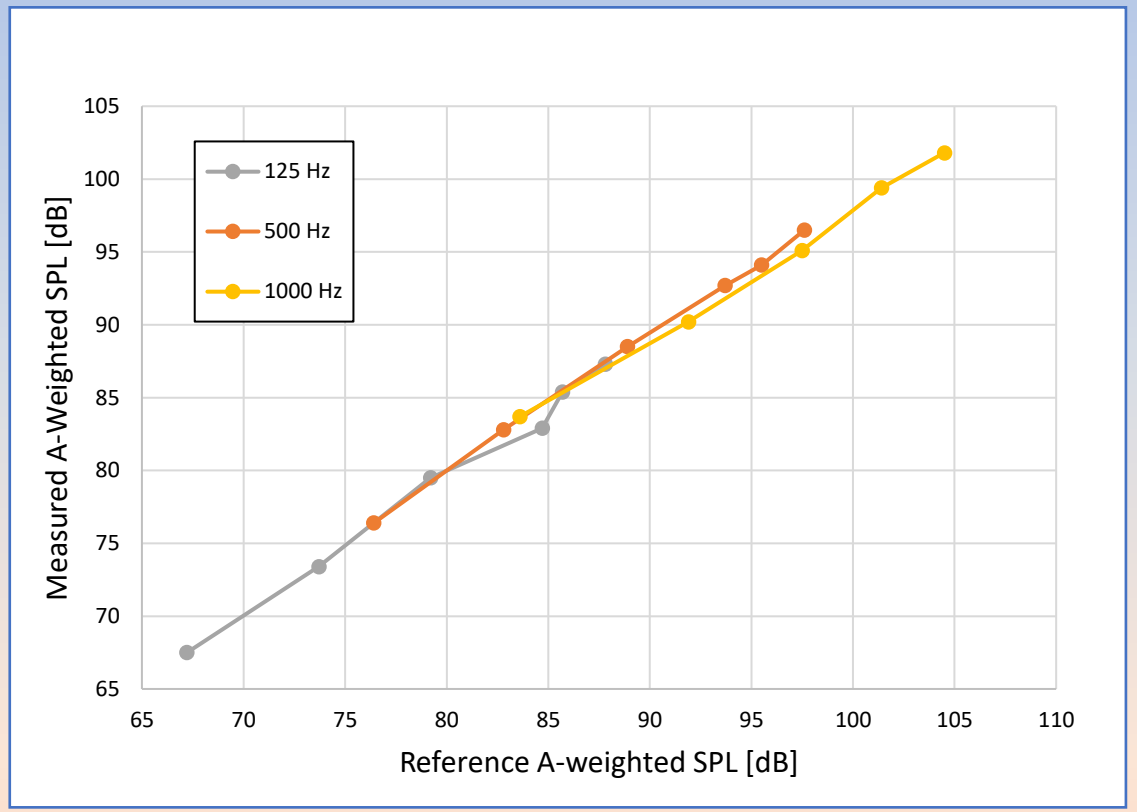


SELECTED MEASUREMENT RESULTS OF EVALUATION BOARDS

- *Evaluation boards Seeed Xiao BLE nRF52840 Sense*





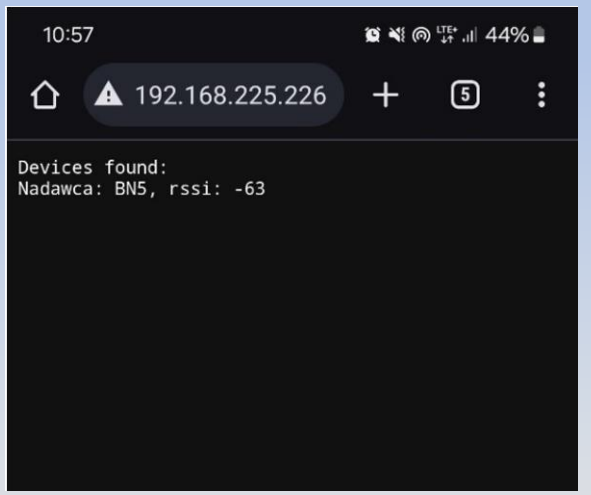


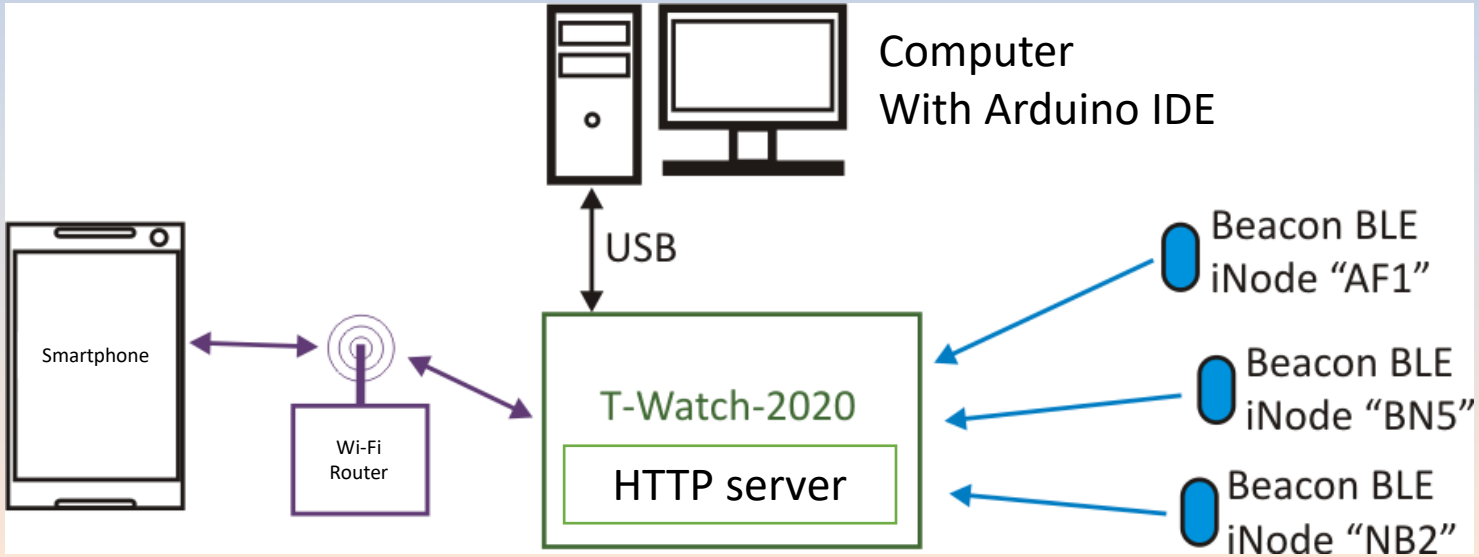
Requirements – wearables

- Form of a wristwatch,
- built-in vibration generator,
- built-in screen for conveying hazard information,
- capability for Wi-Fi communication (communication with central unit),
- capability for Bluetooth communication (communication with individual noise meter and radio tags)
- ability to run custom software providing device-specific functionalities.

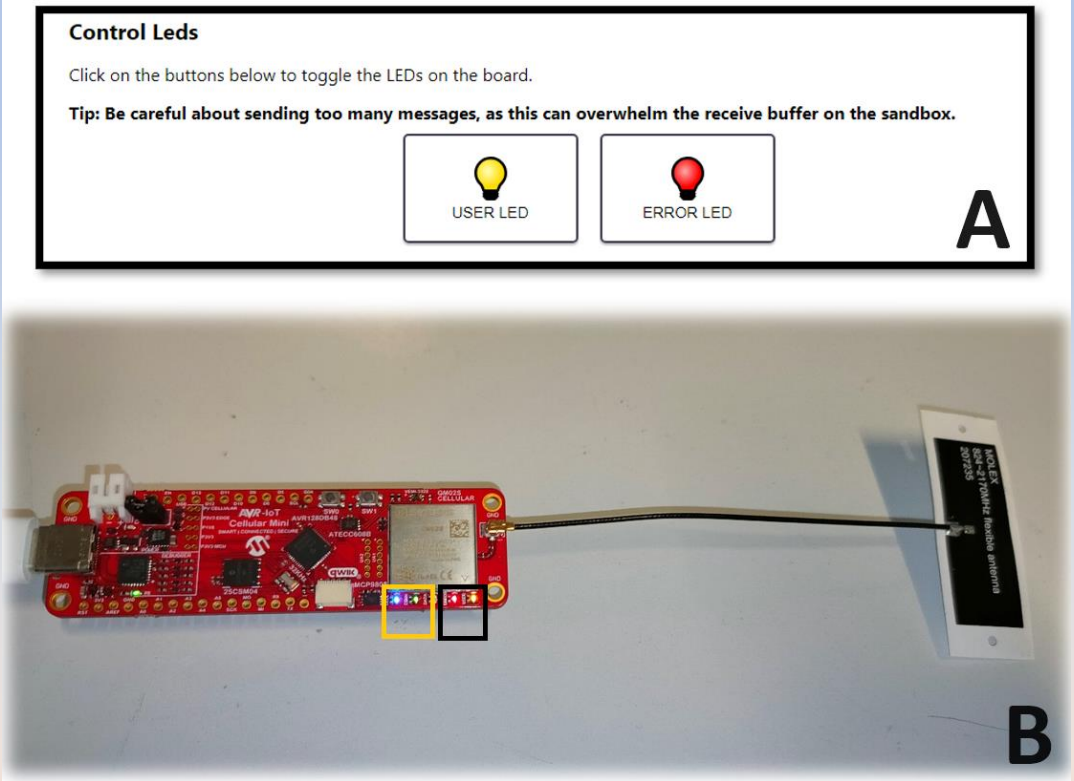
LilyGo T-Watch-2020 V1

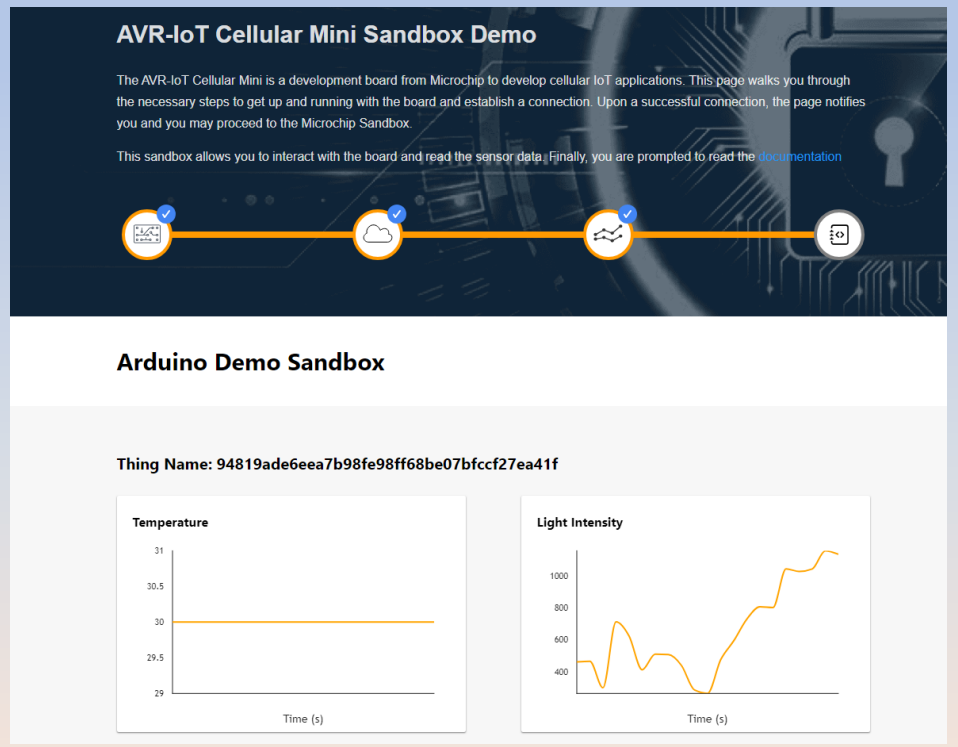
LILYGO T-WATCH-2020 – PRELIMINARY TESTS



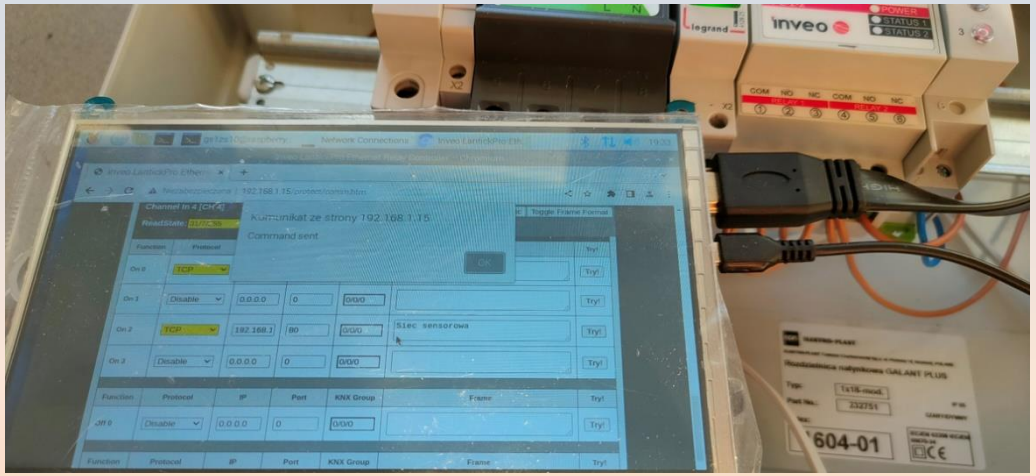


ACTUATOR MODULE - NB-IOT AVR-IOT CELLULAR MINI

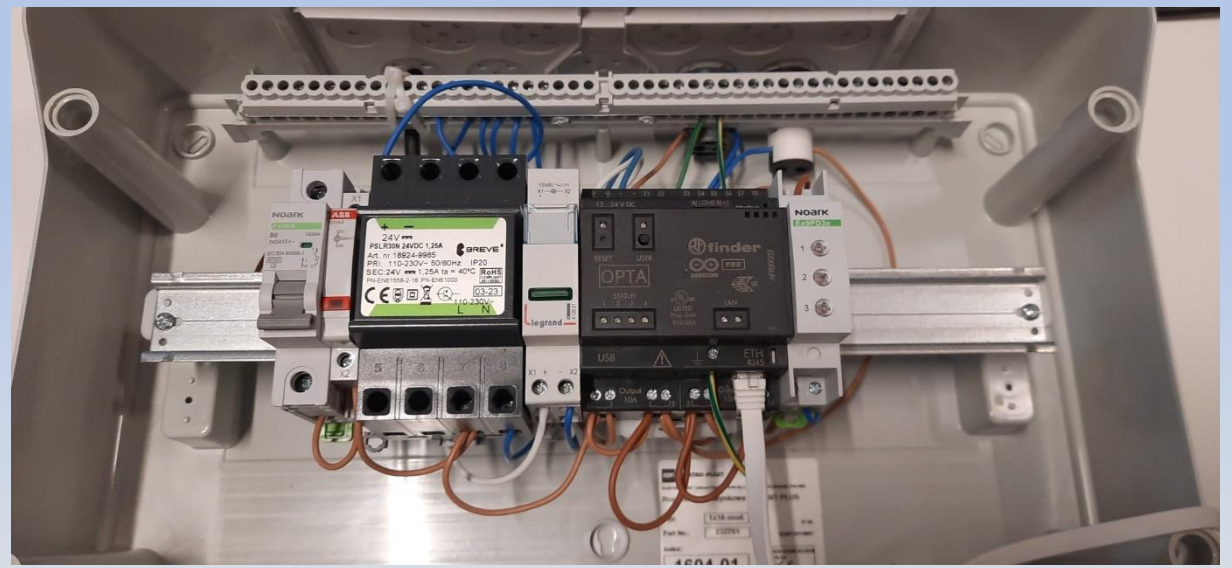


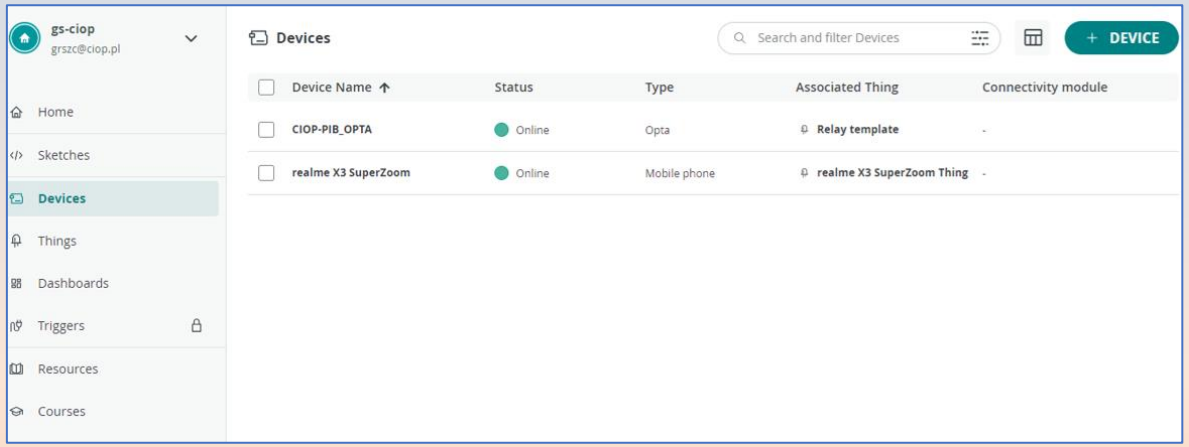


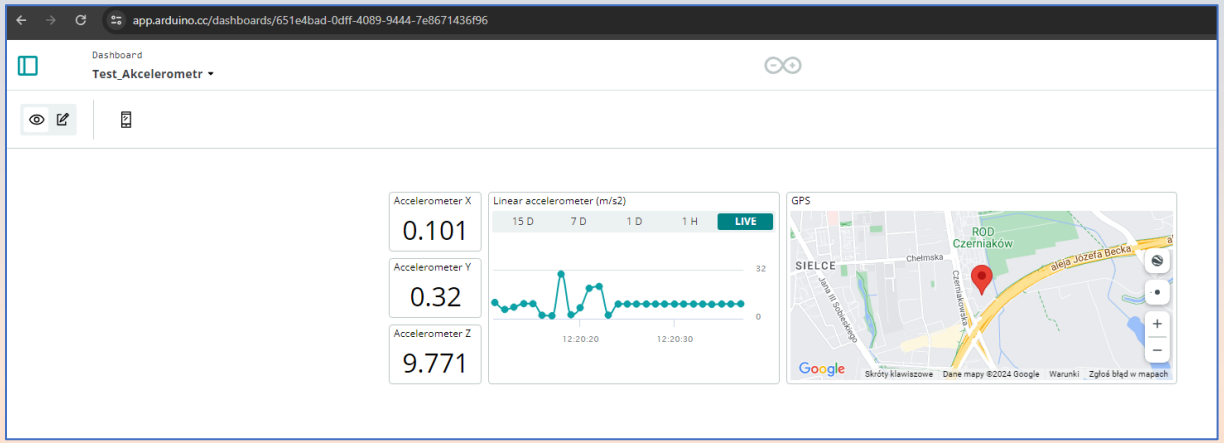
ACTUATOR MODULE - LANTICK PE-2-2 CONTROLLER



ACTUATOR MODULE –ARDUINO OPTA CONTROLLER







CONCLUSIONS

- The monitoring system will consist of: noise meters and vibration meters, wearables, individual noise meters, Bluetooth LE beacons, actuator module, and the system's central unit.
- It is possible to develop system components based on commercially available evaluation boards and development platforms. This approach simplifies the process of designing and implementing circuits and helps reduce the cost of their implementation.
- To simplify the design of the circuits and reduce costs, preference will be given to using a digital microphone and a fully digital signal processing path.
- Preliminary tests have shown the feasibility of using industrial automation controllers as actuators in the monitoring system.

Thank you for your attention!

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