



Co-funded by  
the European Union



## Report on the implementation of the exercise: Lab #1: Design of an Electrocardiogram (ECG) circuit (Student Group no. 1)

CONN'COR, Project No. 2024-1-FR01-KA220-HED-000250882

WP3: Development of new and modernization of existing selected courses  
as examples of teachers' collaboration

Activity 3.2: Development of the course Home Compatible Labworks

Lab work duration: 6h00

Implementation date: June 2025

Name of the students:

- Cosa Teodora-Amalia (IS-5378), Bialystok University of Technology,
- Istodor Maria-Alexandra (IS-5379), Bialystok University of Technology.

Supervisor of this project:

- Assoc. Prof. Jarosław Makal, PhD Eng.

### 1. Project Objective

The objective of this project was to design and build an electronic circuit for amplifying the electrocardiographic (ECG) signal using commonly available components, and to perform signal acquisition using surface electrodes.

### 2. Project Implementation

The work was conducted with a 2-person team using: a breadboard, resistors, the  $\pm 9$  V power supply, opamps OP482 and LF356, Tiga-Med Electrodes, module Analog Discovery 3 Card.

- The schematic was based on a classic differential amplifier configuration. The gain was designed by experimentally selecting resistor values, tailored for a typical ECG signal amplitude (0.5 to 5 mV).
- The first project session focused on familiarization with the tasks, circuit diagrams, and identifying required components (approx. 2 hours). The second session (2 hours) was dedicated to assembling the circuit and learning how to interface it with WaveForms software. The third session (2 hours) involved troubleshooting, refining connections, and verifying the signal quality to ensure the circuit functioned correctly and could produce clean ECG waveforms.

### 3. Problems Encountered

- **Incorrect ECG signal shape** (see Fig. 1) made it difficult to identify characteristic waves (P, QRS, T).
- The resistors did not provide perfectly equal values in the differential amplifier branches, leading to degraded common-mode rejection and poorer noise suppression.



- The necessity was identified for additional filtering and shielding of the wires to further reduce interference (Fig. 2).

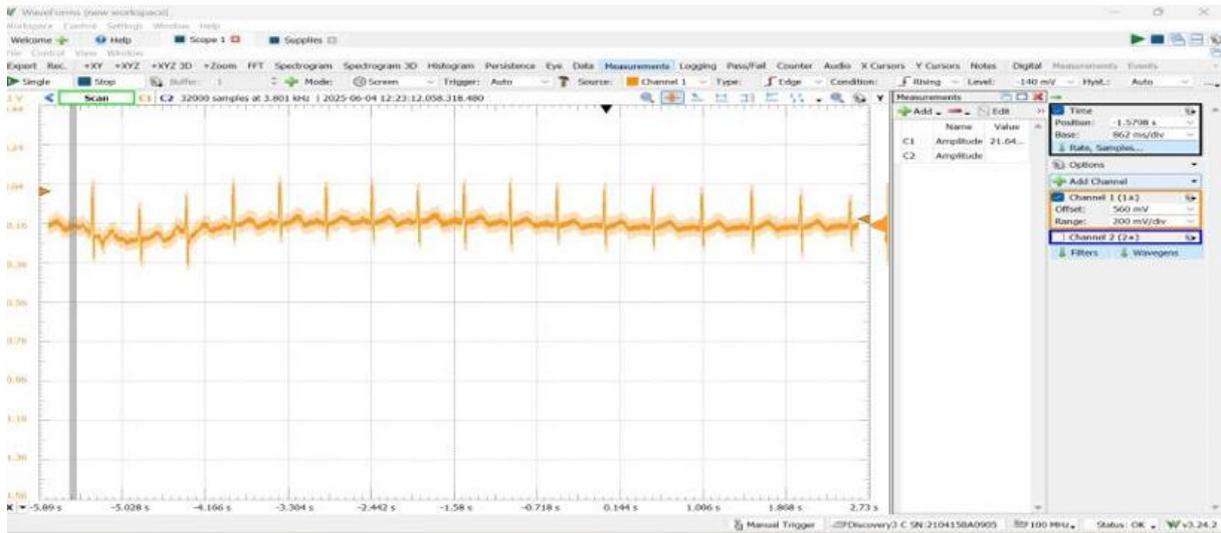


Fig.1. Incorrect ECG signal shape (before filtering).

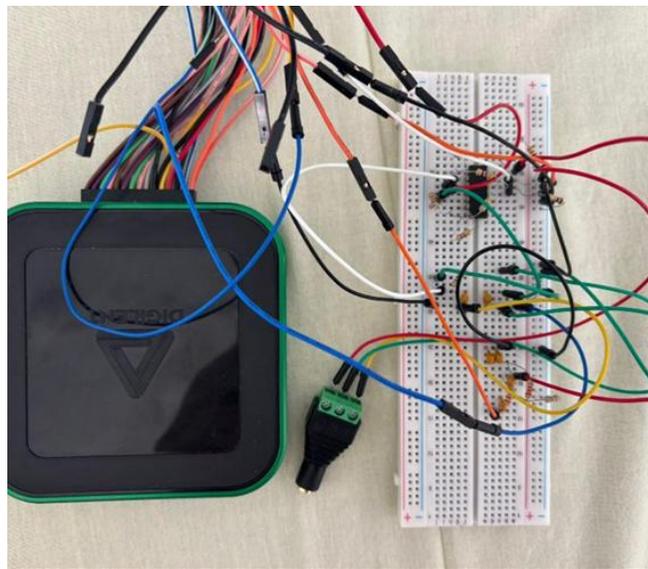


Fig. 2. The circuit built on a breadboard and connected with Analog Discovery 3

#### 4. Conclusions and Recommendations

- The project offered practical experience in analog processing of biomedical signals. Despite the difficulties encountered, a variable signal corresponding to heart activity was successfully recorded, though it requires further refinement to improve signal quality.

For future improvements, it is recommended to:

- select a dedicated low-noise operational amplifier,
- use precision resistors (e.g., 0.1% tolerance),
- introduce additional filtering and cable shielding.



## 5. Challenges During the Project:

- One of the most challenging parts of the project was selecting the appropriate resistor values to achieve a proper gain for the instrumentation amplifier. Through testing and adjustments, we better understood how each resistor influences the gain and refined the values until the ECG signal was clean and within the correct range (Fig. 3).

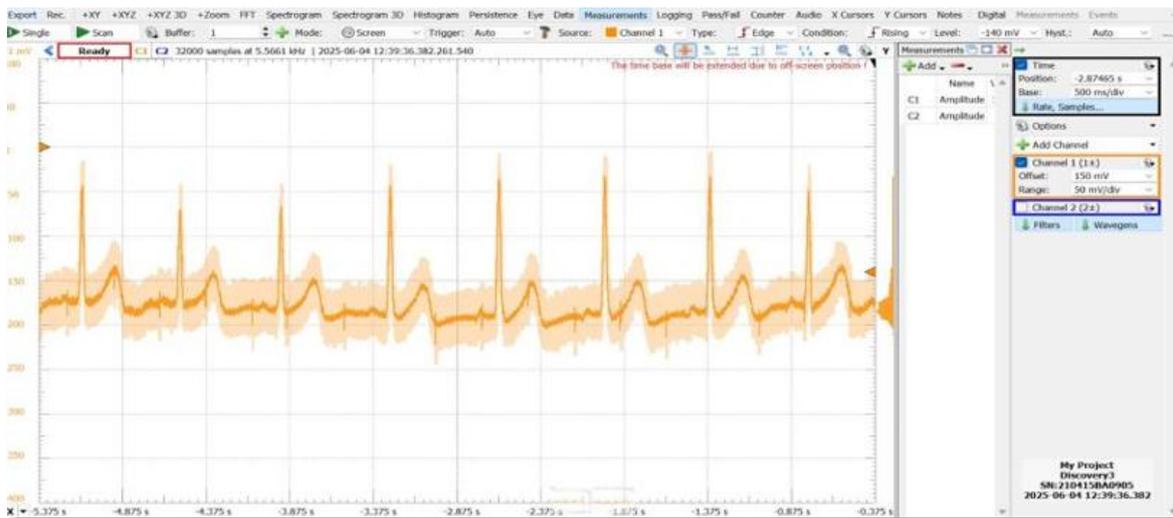


Fig. 3. Example ECG signal output on an oscilloscope (module Analog Discovery 3)

- Another challenge was related to the signal not displaying properly in the WaveForms software. We later discovered that some wires were not correctly connected (Fig. 4), which made troubleshooting difficult. This forced us to rebuild the circuit several times until we identified and corrected all connection issues.



Co-funded by  
the European Union



Fig.4. The electrodes placement (the ground at the leg)