

# Designing and realization an ECG based the Arduino Mega 2560 development board

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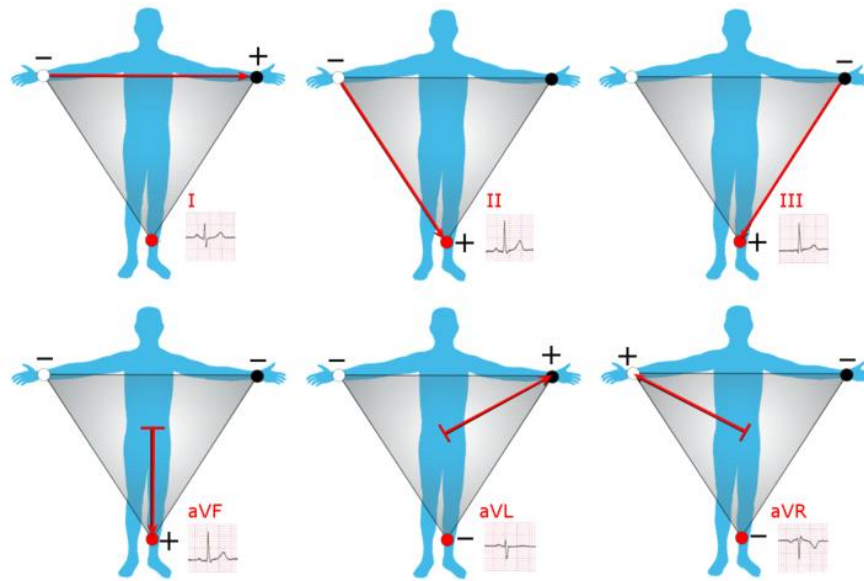
**Abstract.** The paper presents several aspects concerning the design and construction of an ECG using an Arduino Mega 2560 development board and a click ECG module. In the first part of the paper are presented some notions regarding electrocardiography. Electrocardiography is used to diagnose cardiovascular disease and monitor heart health. This type of test is easy to use because electrodes are placed in certain regions on the chest, arms, and legs that are connected by wires to an ECG device. The second part of the paper presents the main components of the device: the Arduino platform, the ECG cables, the ECG click module, the Arduino Mega Click Shield, the WI-FI module and the ECG simulator. The recording system can be on thermosensitive paper, ink, cathode ray tube TFT, and LCD. The last part of the paper is dedicated to testing the device and explaining the way how to do a test.

## 1. Introduction to Electrocardiography

The device is required to receive the vital signs of the patient's heart rate (pulse and pressure) so that he or she can perform an electrocardiogram and a measurement of blood pressure and pulse to send them to the specialist doctor. In this way, even if the patient goes to the medical office less often, the doctor may notice improvement or worsening of the health condition during a recommended treatment to determine whether it is working or needs to be changed.

A standard ECG uses 10 cables to receive and interpret 12 representations of heart activity. These representations can be divided as follows: standard deviations (there are 3 standard deviations that are composed between the legs and hands resulting in the Einthoven triangle (figure 1)), unipolar deviations of limbs and thoracic deviation (precordial). Starting from this standard type with 10 cables, there may be other electrocardiographic variants such as:

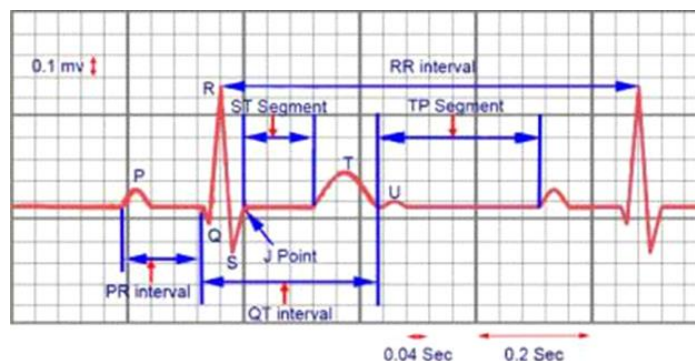
- A 5-channel and 5-electrode device (4 limbs and one chest) used for continuous monitoring (during surgery or an ambulance);
- A 3-channel system and 4 electrodes placed on the limbs to monitor heart rate;
- Portable ECG monitoring systems;
- Wireless ECG systems. [1]



**Figure 1** Graphical representation of Einthoven's triangle [2]

### *1.1. Analysis of the ECG route and identification of important parameters*

The results of the ECG are represented on a special paper in the form of waves, which form a PQRSTU complex (figure 2). As exemplified above, the result of the EKG is represented as a wave complex (figure 2).



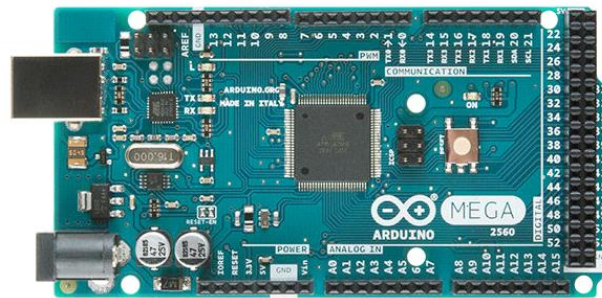
**Figure 2** Example of electrocardiogram [3]

## **2. System components**

An electrocardiograph must collect the signals from the activity of the heart to amplify them with a device and print them on a special paper. Signals can be interpreted as potential differences in heart activity and varying in time and space. The electrical activity of the heart is an analog signal that needs to be converted into a digital signal to be interpreted by the device that also contains an electronic amplification system.

### *2.1 Arduino Mega Development Board*

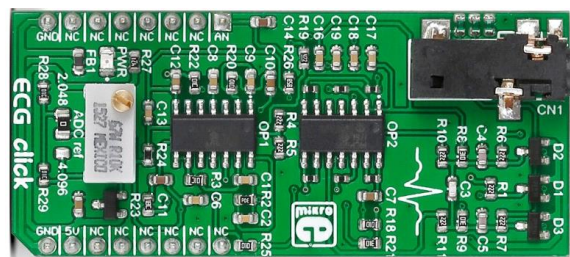
The Arduino Mega (figure 3) is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.



**Figure 3.** Arduino Mega development board [4]

### 2.2 Kit ECG click

The kit contains the ECG click bundle acquisition card, the 3 signal pickup electrodes and the disposable electrodes that stick to the patient's skin in 3 specific locations according to a scheme below. The acquisition card works with an input current of 5 V, and the interface is analog. It contains an operational amplifier MCP609 and is developed by MikroE. To achieve connectivity with the development board, use a special shield made for the type of plate used (figure 5).

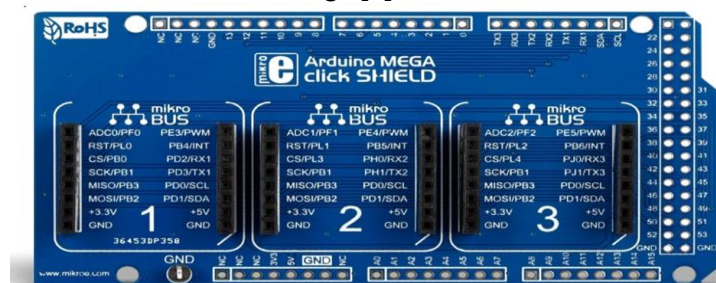


**Figure 4.** Acquisition board ECG; [5, 6]

This is an ECG (or EKG) machine on a click board. It measures the electrical activity of a beating heart through electrodes taped to the skin. The board requires little setup, and the final measurement results can be displayed as an Electrocardiogram using a free Windows app. With the ECG click bundle (click + cable + electrodes) you will be able to prototype your health-tracking, and fitness devices, quantified-self wearables or you can make an LED blink in sync with your heart [7].

### 2.3 Arduino Mega Click shield

Arduino Mega Click shield is an extension for Arduino Mega and any other boards that share its pinout. It's a simple shield with three mikroBUSTM host sockets that allow you to connect more than 150 different types of click boards to the Arduino Mega.[8]

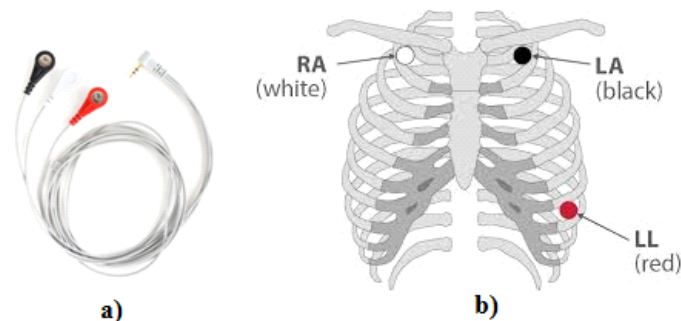


**Figure 5.** Arduino Mega Click shield [8]

### 2.4 ECG cables

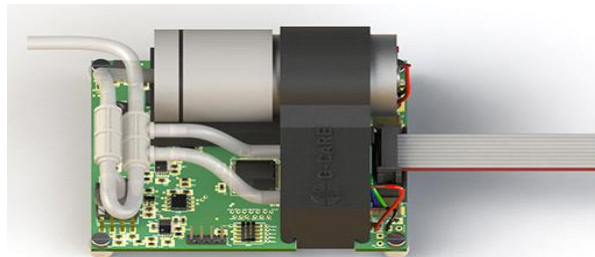
Making connections with a 3-electrode cable makes it possible to use this electrocardiograph by people who do not have medical training. It is positioned, respecting the colors engraved on the cables

and connecting to the receiving device and displaying them as a graphic on a special paper or the screen. The cables and how to connect them can be seen in figure 6 a and b.



**Figure 6.** a) ECG cables [9]; b) Position of the electrodes [10]

### 2.5 Non-invasive blood pressure module



**Figure 7.** Non-invasive blood pressure module developed by Dulon Innovative Electronics [11]

The voltage module is used to measure blood pressure in the blood (figure 7). It is powered at 12V because it contains a motor and pump that introduce air into the blood pressure sleeve. The tension is divided into systolic, diastolic, and will also measure the pulse of the patient.

### 3. Programming your device

Example code for programming the ECG click card provided by the MIKROELEKTRONIKA plate manufacturer is shown below.

The code shown at their website initializes the ADC for measuring the ECG, and UART for talking to the PC. When the button is pressed, the timer interrupt will be initialized. An interrupt is generated every 3.9 ms, upon which the MCU gathers ADC and time data, and sends it to the PC over UART until the timer reaches 15 seconds. [12]

### 4. Device Testing

For testing this device, use an ECG simulator produced by SANATRONIC in Bucharest. This generates ECG signals similar to a real patient. With it, adjustments can be made before he can test patients. SimEKAR is an electrocardiogram simulator, with 12 derivations and arrhythmias, for periodic and post-repair checking of the technical and functional characteristics of electrocardiographs. This ECG simulator is endowed with the Medical Engineering Laboratory (Product Design, Mechatronics, and Environment Department).

### 5. How the ECG works

The operation of the electrocardiograph in this project is presented below. To begin with, there are several buttons that can be pressed to perform various functions. Pressing a button triggers an interruption in the program and performs the instructions for it. After the device is switched on, the

necessary connections are made to record the signals from the simulator or the patient. These consist of connecting the 3 electrodes for the ECG according to the scheme in Figure 6.b and placing the sleeve on the patient arm. If only a test is desired, the other connection is dropped. Press the button specific to the desired function and wait.

To achieve the tension, it is expected that the sleeve swells to a pressure superior to the pressure it feels as systolic pressure. Then it will slowly deflate until you notice the last beat that represents diastolic pressure. These pressures will be displayed on the screen, and the sleeve will completely deflate and be pulled out of the patient's arm.

For the ECG the sensor captures signals with each interrupt coming from the program at 3.9 ms, enough time to re-record the electrocardiogram signal. The program then converts the signals from the sensor into a graphic that will be displayed on a specific grid and the printing paper (figure 2). Various parameters can be calculated based on the wavelength of the electrocardiogram. A representation of these places is exemplified in Figure 2.

## 6. Conclusions

This system is easy to use in family doctor's offices at home, but also in hospitals or clinics. The device can be improved by adding more sensors to measure several important parameters for health status measurement (eg: an expired air sensor - the introduction of a spirometer, a sensor for measuring muscle activity - useful when patients are at bed more time and need for monitoring and muscle activity to help them recover more efficiently, a pulse oximeter sensor, etc.). The device can be easily maintained and used, requiring minimal knowledge in this area.

## Acknowledgments

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