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ARDUINO BASED DEVICE FOR MEASURING PULSE

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Abstract: *The purpose of this paper is to describe how it can be built and used a device meant to measure the pulse and oxygen saturation, taking into account the properties of electronic and optoelectronic elements and also the operating mode of the operational circuit LM324. The device is based on the use of an Arduino Mega 2560 board, a pulse sensor, an LCD display and a sound emitter. This type of devices are very much used in the biomedical field to assess the physiological parameters of the human body. The use of the Arduino board allows the equipment to be easily made by any person with knowledges in the biomedical field but not only. This type of devices will be very useful to understand the biomedical apparatus but also to develop other equipment more precise and accurate than the ones that are very expensive.*
Keywords: *Arduino board, sound emitter, pulse.*

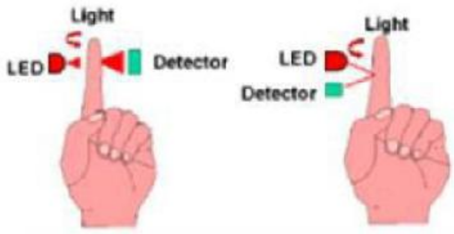
1. INTRODUCTION

Oxygen is a vital component in the functioning of the human body and in his absence, for a longer period of time, cells die. Oxygen transport constitutes an important indicator regarding the health of a patient
In order to be transported in the blood in appropriate limits, the respiratory and circulatory system must be operating in normal parameters. Ventilation is the first step, this allows the air to get into the lungs during inspiration and expelling during expiration. Gas exchange is carried out in the alveoli into the lungs, oxygen is transferred into the blood while carbon dioxide is removed. Oxygenated blood circulates in the body and then spread to all cells after this the blood absorbs carbon dioxide that is transported to the lungs to be evacuated during expiration. The process of respiration is controlled by the neuronal system. The ventilation and circulatory system are in close coordination.
The pulse oximeter consists of an optoelectronic sensor applied to the patient and a microcontroller-based system that processes and displays measurements. The sensor consists of two high-intensity LED with low voltage and a photodetector. Signal from the photodetector is low amplitude, and provides noise and therefore must be amplified and filtered. Then, the signal will be divided into red and infrared component by a demodulator. This signal will be filtered to remove ambient and electrical noise and digitized by an analog-digital converter then the absorbance ratio R of the two wavelengths will be synchronized with ECG waveform.
The current needed by the two LEDs is derived from a specialized control circuit.
A positive current controls the infrared LED while the red LED is controlled by a negative pulse. This current is controlled by a feedback loop as a response of the signal that reaches the photodetector. [1]
The physiological, electronical and informatics knowledge are combined in order to achieve the instrument that will be able to measure the pulse and oximetry of the blood. The results will be displayed on an LCD display or further on sent to a speaker for persons that need this type of help. Nowadays there is a need to build devices that integrate the latest technology. [2] This conducts to use biomedical knowledges, in order to achieve equipment that is cheaper, and customable.

2. PHOTO PLETHYSMOGRAPHY DETECTION

Photo plethysmography detection is based on the change in the opacity of tissue that changes with the pressure wave, by means of a photoelectric element, or in other words the determination of optical properties of the skin area.

Photo plethysmography transducer has a monochromatic light source and a photocell. Light beam passes through skin and is partially absorbed by haemoglobin in circulating blood mass at sub-cutaneous level. Blood being more opaque than the surrounding tissues attenuate the reflected light in a greater proportion. Reflected light intensity changes depending on the density of tissue. The measurement is localized to the microvascular skin beneath the electrode layer. [3]
The unabsorbed fraction will reach, by transmission or reflection, the photodetector, and the quantity of light received by the photocell produces a current which will be amplified and recorded graphic (photo plethysmogram). Changes in systolic-diastolic blood flow in the skin network determines equivalent variations of the current, and the shape of the graph will be similar to the arterial pulse. Normal pulse wave has a steep anacrotic slope, a spike and dicrotic wave which has a concave base.
With the help of photo plethysmography it can determine parameters for the diagnosis of peripheral vascular disease: pulse wave shape, amplitude and wave frequency components. Pulse waves are attenuated in the presence of arterial occlusive disease. Arterial obstruction causes depression wave gently sloping, rounded tip and a loss dicrotic wave (the concave becomes convex). [4]
Photo plethysmography transducer consists of a light source and a photoelectric element (photodiode). (Fig. 1) Light beam passes through the tissue and is absorbed partially by the haemoglobin in the circulating blood mass. [5]



a) *b)*

Figure 1: P*rinciple of photo plethysmography through absorption (a) and reflectance (b) [6]*

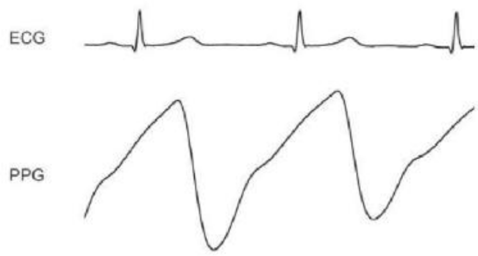


Figure 2: ECG waveform and corresponding *photo plethysmogram [7]*

Photo plethysmography wave (PPG) is a physiological waveform (Fig. 2) attributable to synchronous changes in the blood volume within a cardiac cycle, and generally has a fundamental frequency approximately equal to 1 Hz, in accordance with the heart rate, there are similarities between the waves made by the electrocardiograph and photo plethysmography recorded.

3. NEW SOLUTION TO PHOTO PLETHYSMOGRAPHY- ARDUINO BOARD WITH CORRESPONDING SENSORS

The device is intended to implement the electronics and assisted optoelectronics in creating a system for measuring pulse that provides acoustic instructions, is portable and easy to use.
The system is developed from the study of existing devices, trying to add a new element, that of acoustic signals.
In order to achieve the manufacturing of this device it was used an Arduino Mega 2560 board, pulse sensor (Fig 3), LCD display and a sound shield. (Fig. 4)

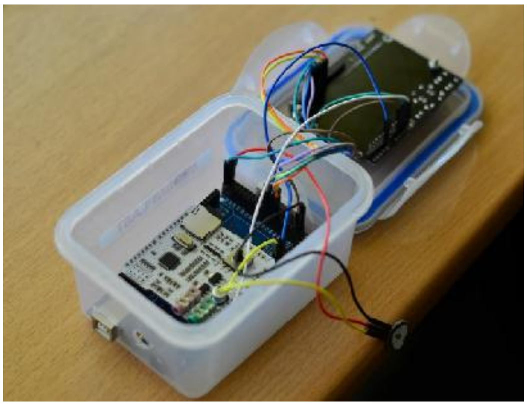


Figure 3: *The experimental device with pulse sensor.*

Pulse sensor takes the pulse of the user and send it to the Arduino board, which displays it on the display and also sends acoustic information.

Figure 4: *The experimental device with pulse sensor and sound shield.*

To operate the device it was developed a software program that lets the user control the circuit. Control program was developed in the Arduino software 1.6.9.
Program control system was designed in the programming language C ++ and is used to transmit user commands to the microcontroller.
Part of the source program includes libraries like:

```
#include <LiquidCrystal.h>
#include <SD.h>
#include <SPI.h>
#include <arduino.h>
#include <MusicPlayer.h>
```

It also includes a part that analyses the pulse rate:

```
volatile int BPM; // used to hold the pulse rate
volatile int Signal; // holds the incoming raw data
volatile int IBI = 600; // holds the time between beats, the Inter-Beat Interval
volatile boolean Pulse = false; // true when pulse wave is high, false when it’s low
volatile boolean QS = false; // becomes true when Arduoino finds a beat.
```

The program is quite complex and it can’t be included in its functional form.

4. CONCLUSION

This paper was designed to perform a practical and convenient device for measuring the pulse. The importance of these types of devices can’t be neglected since regarding medical devices is essential to be within the optimum operating limits in order not to endanger the patient’s life.
Unlike other heart rate monitoring devices, this device offers sound instructions about its functions being easier to use.
The device has the advantage of low cost elements, their interchangeability and is easy to use requiring no specialized knowledge.

5. ACKNOWLEDGEMENT

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REFERENCES

[1].Paranjape, S. (1991) *Electronic Instrument Control.* Wisconsin : Webster;

[2].Lamonaca, F., Polimeni, G., Barbe, K., Grimaldi, D. (2015) *Health parameters monitoring by smartphone for quality of life improvement*, Measurement, Science Direct, pp. 82-94;

[3].http://cadredidactice.ub.ro/crinelraveica/files/2011/10/ingnerie-biomedicala-3.pdf. Accessed on: 21 June 2016;

[4].http://www.romedic.ro/fotopletismografia-0C410. Accessed on: 21 June 2016;

[5].https://fitziu.wordpress.com/2012/09/03/fotopletismografia/. Accessed on : 21 June 2016;

[6].http://www.angioscan.ru/en/radiascan/devices/radiascan-501/16-science/publish. Accessed on: 21 June 2016;

[7].Kawther, A. (2011) *Fuzzy Logic Haemoglobin Sensors.* El-Minoufia : Institutul Tehnologic Karlsruhe;