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ECG simulator

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ABSTRACT

An electrocardiogram is information of heart signals and activities of an individual measured by electrocardiography using an electrocardiograph machine. Machines tend to have malfunctions, failures, errors, damages, and misuse on usage. Medical equipment cannot be neglected to exist with such factors as it is concerned and connected to the lives of patients. There are several medical errors repetitively ruining several lives every year globally. Therefore, in this case, an ECG Simulator is used to perform calibration and testing over the instruments such as patient monitors and other electrical heart activity recording equipment periodically. To make this viable to every region, we need an economically convincing model. Models: We developed a simulator with basic electronic components for normal sinus rhythm signals generating over 60 and 120 beats per minute. We also developed another simulator that can be loaded with processed ECG arrhythmia signals essential to effectively test any instrument. Result: Both the models produced a promising output as per their configuration respectively.

Keywords: *Electrocardiogram (ECG), Electrocardiograph Machine, Simulator*

1. BACKGROUND

Electrocardiogram (ECG) signals consist of important source of information for the cardiologists. For diagnostics and treatment of cardio vascular diseases, proper diagnostic and well calibrated equipment is required. The initial test for diagnosing any heart disease is carried out by ECG. Cardiovascular diseases (CVDs) are one of the major causes of death worldwide. For calibration of such equipment, test equipment is used. ECG simulator is the major equipment used for calibration and testing of ECG machines and Patient Monitors. An ECG simulator is a device used to generate electrical signals similar to human heart electrical signals, which calibrates different ECG machines and patient monitors. It simulates an ECG for cardiac rhythms and is used to check different heart problems. It is usually in the form of a software program and is also available online. Currently available ECG Simulators are very costly and microcontroller based, which consists of some specific number of signals that cannot be changed. Due to the involvement of too much electronic circuitry in pre-existing designs of ECG Simulator, it makes them very difficult and time consuming to troubleshoot. Different designs of ECG simulators have been developed. Some are capable of generating nine ECG signals and a calibrated square wave of 1Hz, 1mV at lead II.

2. MODELS

A. Ideology

The idea behind this project was to design and develop of a cost effective and customized Arduino based 3-lead ECG Simulator. It is customized in such a way that user can change the waveform and type of signal, according to the requirement. It will be beneficial for students for their research purpose as well as local manufacturing industry for production of device. Analog ECG signals were burned into arduino uno board. User interface was designed in such a way that user can easily select the required ECG signal and observe it on a patient monitor well as on serial plotter (by using arduino IDE). This whole designing and working is carried out by using arduino software. The output signals are the combination of limb leads (Right Arm, Left Arm and Left Leg). These waveforms consist of basic sinus rhythm and 5 types of arrhythmias – atrial premature beats, atrial fibrillation, atrial flutter, ventricular flutter and fusion arrhythmia. The type of signal chosen from the user interface can be observed on Organic Light Emitting Diode (OLED) and its waveform can be seen on a patient monitor as well as serial plotter (arduino IDE).

In the design we have configured, samples of ECG waves were organized in the form of look up tables(LUT) in arduino uno with the microcontroller AtMega328. The program reads the waveform samples step by step in the form of LUT and writes them into the 8 bit D/A converter (MCP4725). The analog output from the D/A converter is processed with a signal processing circuit. The different waveforms or arrhythmias can be chosen with modes using push buttons. Arduino is an open source platform of electronics which is composed of a microcontroller, programming language and an IDE (Integrated Development Environment). It is compatible with Windows, Mac OS X and Linux. Its software can be used with any arduino board. The Arduino Uno board that is used in this project has a built-in microcontroller with easily accessible ports. It is cheap and readily available. C is the programming

language that is used to build code and upload on the board. Over all, this arrangement may provide a cheap and customizable solution to test and calibrate ECG devices where the users could choose many normal and pathological ECG signals.

B. Working

The proposed ECG simulator has a 3-lead configuration which provides its output with the RA, LA and LL (Right Arm, Left Arm and Left Leg) combination based on the Einthoven's triangle. The ECG signals are loaded into MATLAB and the variable file is converted to an excel sheet. The corresponding excel sheet is saved as an csv file in the SD card, which is connected to the Arduino Uno board with a SD card module. The processed csv file is loaded into the Arduino Uno board with the interfacing software of Arduino IDE using C++ code language. The file is read by the given program in digital form.

The D/A (MCP4725) is used to convert the digital signal to its analog form. It 5 is a low-power, high accuracy, single channel, 12-bit buffered voltage output Digital to Analog Convertor (DAC) with non-volatile memory (EEPROM). Its on-board precision output amplifier allows it to achieve rail-to-rail analog output swing. An ideal DAC device where design simplicity and small footprint is desired, and for applications requiring the DAC device settings to be saved during power-off time. The analog output signal from the MCP4725 is processed with a signal conditioning circuit that consists of 3 resistor – 10k, 1ohm, 10k which splits the 3 leads RA, LA, LL respectively. The output can be viewed in a patient monitor, ECG machine and the serial plotter in Arduino IDE.

User interface is designed for the ease of any user who can interact with the simulator device easily. This interaction is carried out using Organic Light Emitting Diode (OLED). Two push buttons are used to shift between the modes or different waveforms. The input is sent by using the push buttons for selection of specific signal. The output can in the OLED display. The ECG signal is loaded in MATLAB and the corresponding graph of the signal is converted to a bitmap file. The bitmap data is loaded into the Arduino program, which displays the kind of arrhythmia and its waveform, bpm. This set up can be used for display and educational purposes.

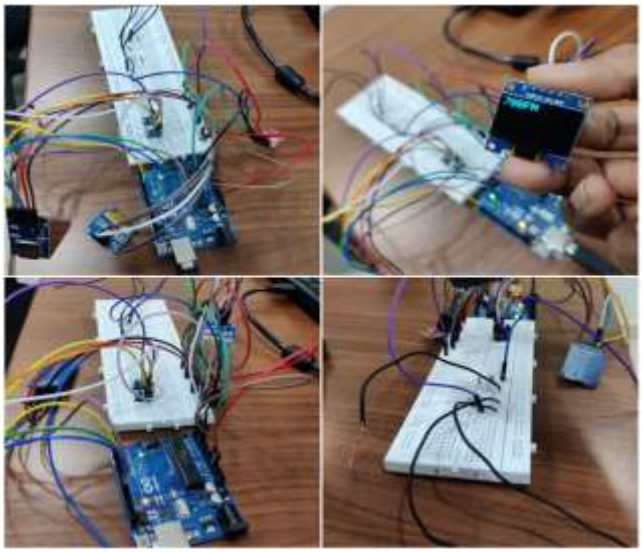

Fig. 1: Final Circuit

3. RESULT

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5. REFERENCES

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