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# A Real-Time Health Monitoring on Android Mobile

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***Abstract:***
***This paper describes a design for a smartphone accessory that aims to determine the human heart rate, especially for cardiac patients who need to monitor their heart rate, it being an important indicator for prognosis and diagnosis, and also share it with their physician anytime to seek medical advice when needed.The goal of this paper is to present our design of this compact sized and user friendly smartphone accessory that can be accounted in clinical care and practice.***

***Keywords:*** ***Android application, Arduino ADK board,Heart rate, ECG simulator.***

## INTRODUCTION

People don't use their smartphones for talking as much as they used to, but they are increasingly using them to detect and monitor their health. Indeed today's telemonitoring devices are smaller and more user-friendly, and can monitor heart rate, blood pressure, oxymetry and weight. Recent studies have shown that using telemonitoring devices,together with patient communications, have a significant impact on efficiency of care and quality of life, while decreasing re-hospitalization rates.Many medical centers nowadays install telemonitoring devices in patients' homes to keep track of their medical condition. Although this is a major breakthrough, it still limits the patient from leaving his/her home without being telemonitored to keep track of his/her medical condition. Smartphone technology breaks that limit as the smartphone when equipped with specific accessories and application can be more than just a phone but be also "Smart" to be a "telemonitoring device".

Smartphone technology is the fastest growing and most competitive field of the corporate mobile phone sector,with Apple's iPhone, Google's Android® and Microsoft's Windows Phone 7 striving to take over from Blackberry as the smartphone of choice for both business users and individuals. A substantial rise in smartphone applications would be those that are employed in the fields of health care and medicine.

Heart rate is an independent risk factor for patients with cardiovascular disease, in particular with arterial hypertension, myocardial infarction, coronary artery disease and heart failure. This relation is supported by a large number of animal studies as well as clinical trials. Continuous monitoring of patients' heart rate is crucial in keeping track of their cardiac condition. This can be achieved by making use of today's fastest growing technology which is smartphone technology.

## THE HARDWARE SYSTEM

### Arduino ADK Board:

The Arduino ADK board is a microcontroller board that has a USB host interface to connect with Android based phones. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs ,a 16 MHz crystal oscillator , a USB connection, a power jack, an ICSP header, and a reset button. The Arduino ADK board is programmed via the Arduino software 1.0 using Micro C programming language through the ICSP header that allows you to upload new code to it without the use of an external hardware programmer, the microcontroller can be programmed.

### Electrocardiogram (ECG) Signals:

Electrical waves cause the heart muscle to pump.These waves pass through the body and can be measured at

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electrodes (electrical contacts) attached to the skin.Electrodes on different sides of the heart measure the activity of different parts of the heart muscle. An ECG displays the voltage between pairs of these electrodes, called Leads, and the muscle activity that they measure, from different directions. For example, Bipolar Limb Lead I represents the voltage between the (positive) left arm (LA) electrode and right arm (RA) electrode. So Lead I= LA – RA. This display indicates the overall rhythm of the heart, and weaknesses in different parts of the heart muscle.The ECG signal can be divided into several parts,each with a specific time interval and a special significance and representation. ECG waveform components, as illustrated in Fig.2, are:

1. P wave: Depolarization of the right and left atria.
2. QRS complex: Right and left ventricular depolarization. The normal duration is 0.06 to 0.10 seconds.
3. T wave: Ventricular repolarization.
4. U wave: Late repolarization of papillary muscles.
5. PR interval: Time interval from onset of atrial depolarization (P wave) to onset of ventricular depolarization (QRS complex). The normal P-R interval is 0.12 to 0.20 seconds.
6. QT interval: Duration of ventricular depolarization and repolarization. In most cases, the Q-T interval lasts between 0.34 and 0.42 seconds.

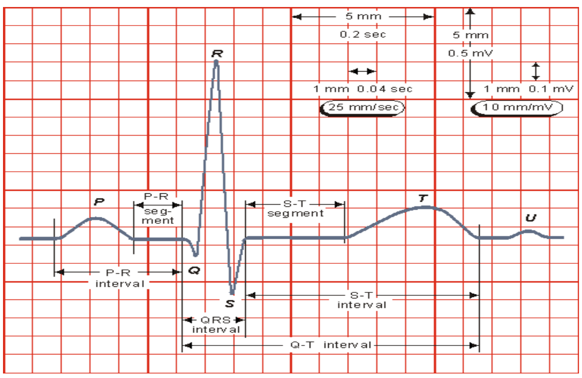


**Fig.1: ECG Waveform Components of Lead I**

The time required to finish a complete cardiac cycle is proportional to the heart rate per minute. The faster the heart rate, the faster the repolarization is, and therefore the shorter the Q-T interval. With slow heart rates, the Q-T interval is longer. The Q-T interval represents about 40% of the total time between the QRS complexes (the R-R interval).

## Heart rate Estimation:

Heart Rates of 50 to 300 beats/minute can be estimated from the number of large squares in an R-R interval. Because there are 300 large blocks in one minute, the number of blocks between R-R intervals can be divided into 300 to approximate the rate. Heart Rates smaller than 50 beats/minute can be estimated with the aid of markings at 3-second intervals along the graph paper. To calculate the rate, the cycles on a 6- second interval are multiplied by 10.

## DESIGN OF PROPOSED HARDWARE SYSTEM

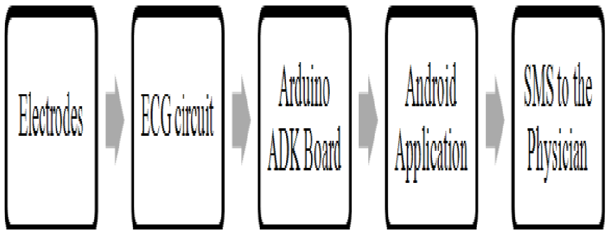


**Fig.2.The General Block Diagram of the Smart Phone Accessory Heart Rate Monitor**

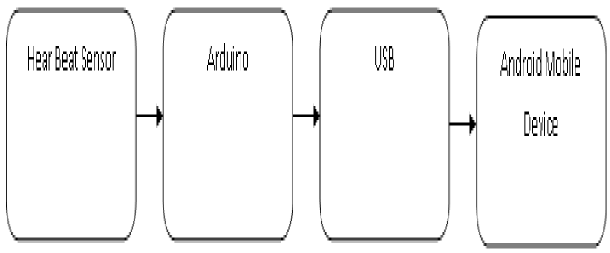


**Fig.3.Block diagram**

## BOARD HARDWARE RESOURCES FEATURES

### The proposed ECG Circuit:

In the proposed ECG circuit, the main goal was to minimize the size of the circuit and minimize the number of electrodes needed without compromising the accuracy of the measurement. The circuit is powered with a DC power supply (18V batteries). As a preamplifier, and to obtain Lead I= LARA, a high precision instrumentation amplifier AD624 was used.

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The bandwidth was limited to (8.8- 40 Hz) using a high pass filter of first order and the low pass filter of second order. The bandwidth and the orders of the filters are decided upon after experiment and trials to finally come up with the clearest ECG signal taken from only two surface electrodes placed on the thumbs.

The proposed ECG circuit is divided into five main parts each of a different role and significance as illustrated . First, the surface electrodes used are disposable adhesive pre-jellified electrodes attached to the left and right thumbs to acquire the LA and RA of Lead I to be analyzed later to obtain the heart rate of the patient. Second, we used the AD624 which is a high precision, low noise, instrumentation amplifier designed primarily for use with low level transducers, including load cells, strain gauges and pressure transducers. An outstanding combination of low noise, high gain accuracy, low gain temperature coefficient and high linearity make the AD624 ideal for use in high resolution data acquisition systems. The proposed ECG circuit aims to optimize the circuit and reduce it to minimal size without decreasing the accuracy of the ECG signal and thus calculating the correct heart rate. The Quad LM348N is used instead of 3 IC's. It consists of four independent, high-gain, internally compensated, low power operational amplifiers.

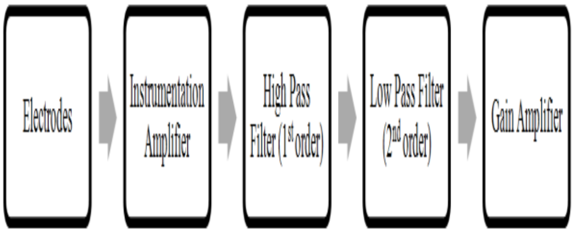


**Fig.4.Block Diagram of the Proposed ECG Circuit**

### Arduino ADK Board :

The Arduino ADK board is a microcontroller board that has a USB host interface to connect with Android based phones. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs ,a 16 MHz crystal oscillator , a USB connection, a power jack, an ICSP header, and a reset button. The Arduino ADK board is programmed via the Arduino software 1.0 using Micro C programming language through the ICSP header that allows you to upload new code to it without the use of an external hardware programmer, the microcontroller can be programmed.

### Flow Chart of the Arduino ADK:

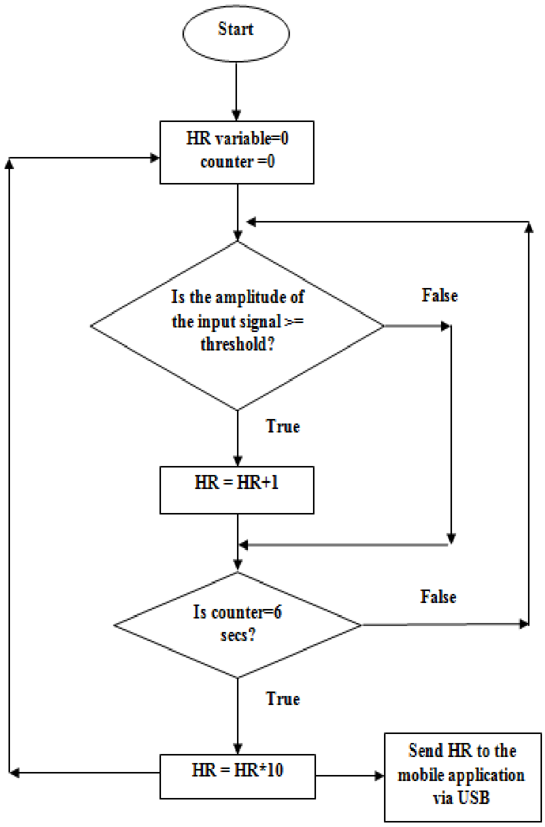


**Fig.4: Flow Chart of the Arduino ADK Programming**

### The Android Smartphone Application:

Android is a Linux-based operating system for mobile devices such as smart phones and tablet computers. It is developed by the Open Handset Alliance led by Google. The Android software has been chosen in the proposed mobile heart rate monitor over other software stacks for mobiles due to its open sources and the Android SDK which provides the tools and APIs necessary to begin developing applications from scratch on the Android platform using the Java programming language.

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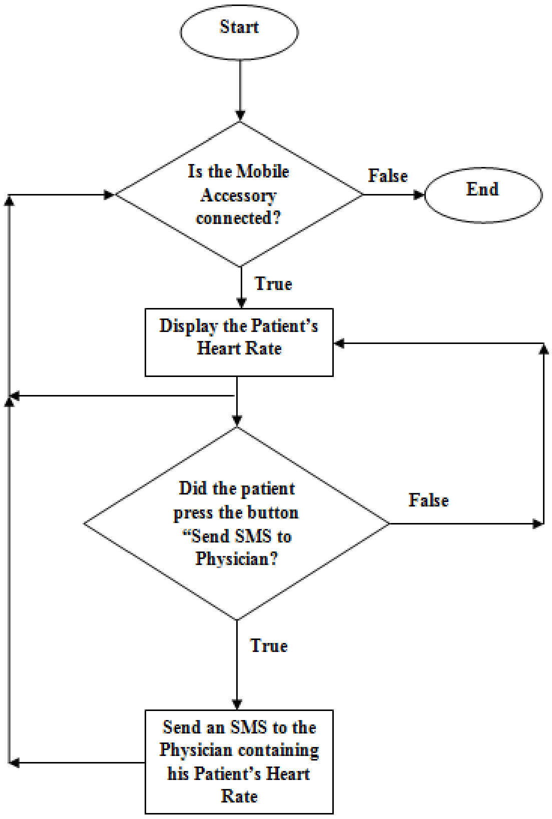


**Fig.5: Flow Chart of the Android Application Developed**

## RESULTS

In this section, the results of the proposed design are presented. To validate the precision of the ECG circuit designed, the output signal is displayed on an oscilloscope.Furthermore, to validate the accuracy of the Heart Rate calculated, an ECG simulator is used with selective heart beats/ minute. After verifying the above, a measurement from the patient's thumbs is taken to obtain 66 beats/ minute.

The ECG waveform components, P wave, QRS complex, T wave, U wave, PR interval, QT interval, are with no trouble discerned from the patient's ECG displayed in Fig.6. This is favorable to obtain an accurate calculation of the Heart Rate which depends on recognizing the QRS complex from the other waves.The ECG simulator is 1st set to 60 beats/ minute in Fig.7A. The calculated Heart Rate displayed on the phone application is equal to 60 beats/minute. Similar results occur for when the ECG simulator is set to a different Heart Rate as shown in Fig.7B.

Testing the accessory on the patient as shown in Fig.8, adhesive pre-jellified electrodes are attached to the patient's thumbs to extract the ECG signal to be filtered by the ECG circuit, analyzed by the Arduino board to calculate the Patient's Heart Rate to be displayed on the phone application, and be sent if chosen to the patient's physician.


**Fig.6: The output ECG signal of the proposed ECG circuit obtained from a patient's thumbs**


**Fig.7 A: The Heart Rate set by the ECG simulator displayed on the phone application**

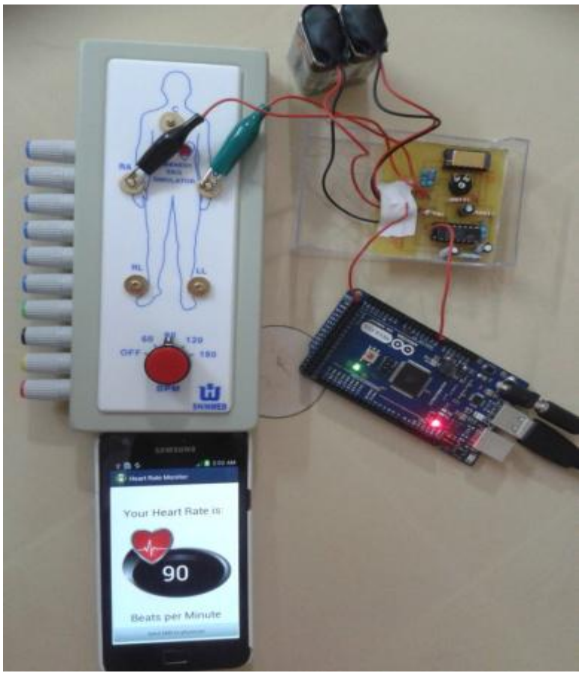


**Fig.7 B: The Heart Rate set by the ECG simulator displayed on the phone application**

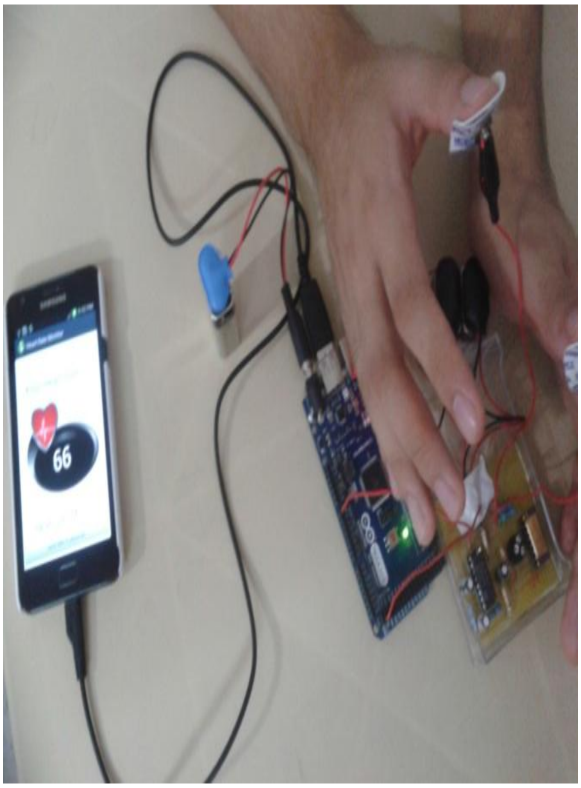


**Fig.8: Heart Rate of a patient displayed on the phone application**

## CONCLUSION

In this paper, we described a design for a mobile accessory that once connected via USB to the patient's Android based device displays his heart rate, calculated from his ECG extracted from two electrodes connected to his thumbs, and provides him with the option of sharing the result of his heart rate with his physician via SMS by a press of a single button. This proposed design is helpful for patients suffering from cardiac diseases as heart rate is an independent risk factor for patients with cardiovascular disease, in particular with arterial hypertension, myocardial infarction, coronary artery disease and heart failure. Studies demonstrated detrimental effects of increased heart rate on the function and structure of the cardiovascular system. Heart rate can be easily detected and therefore allows a conclusion on prognosis and efficiency of therapy.

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