

# ECG RECORDER FOR TELEMEDICINE APPLICATION

Rashmi Revanna. A<sup>1</sup>, Sunil L. Tade<sup>2</sup>

Dept. of Electronics and Telecommunications  
Pimpri Chinchwad Collage Of Engineering  
Nigdi, Pune-44, India

<sup>1</sup>rashmi19290@gmail.com, <sup>2</sup>suniltade\_2006@rediffmail.com

**Abstract**—Continuous monitoring of heart is required to obtain a better understanding of the key medical variables by increasing the measuring frequency. Development of new wearable bio-medical sensors within a wireless infrastructure opens up possibilities for new tele-medicine applications leading to significant improvements in continuous monitoring and better quality of patient care. Here new concept for a wireless electrocardiogram (ECG) system intended for continuous monitoring of ECG activity is described. Patient will be wearing an ECG sensor, "Wearable electrode", which measures the ECG signal. The measured signal will be first amplified and filtered. This analog signal will be digitized using analog to digital converter. UART of processor will transmit these digitized signals to Bluetooth module from where data will be transmitted wirelessly. This data is read by the android application built in smart phone via Bluetooth and it will also record the data. This recorded data can be accessed globally via internet. The data can be sent to medical centres to get the early treatment opportunity. User can observe the ECG waveforms on Smart phone display screen to get the proper heart condition. The user can store the ECG waveform for further processing. For short term storage purpose ECG can be stored on SD of Smart phone also. Or it can also be sent to the computer or laptops for long term storage and can be transmitted to medical centres or physicians via internet.

**Keywords:** Android, ECG (Electrocardiogram), Smart-phone, SD(Storage Device), Bluetooth.

## I. INTRODUCTION

Medical advice is sought more often, since people become more health conscious, but do not want to spend more time at health centres or hospitals. The only possible solution is to set up the health and patient management systems that provide continuous monitoring. Electrocardiogram (ECG) is the only way to check the heart condition, and if ECG can be done frequently, then it is easier for the physician to identify a problem from the ECG's history of a person. The use of smart phones has increased dramatically and there are nearly a billion users on 3G and 4G networks worldwide. Nearly 70 percent of the Indian population uses smart phones to access the internet, and smart phone sales now surpass those of desktop and laptop computers. The speed of wireless communication technology on 3G and 4G networks and the widespread adoption provide infrastructure for the transmission of wireless biomedical data, including ECG data. These technologies provide an unprecedented opportunity for physicians to continually access data that can be used to detect issues before symptoms occur or to have definitive data when symptoms are present. As patient advocates, physicians and particularly cardiac electro physiologists should embrace the future and promise of wireless ECG recording, a technology solution that can truly scale across the global population.

An ECG is a way to measure and diagnose abnormal rhythms of the heart, and helps to diagnose properly particularly abnormal rhythms caused by damage to the conductive tissue

that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances. The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. At rest, each heart muscle cell has a negative charge, called the membrane potential, across its cell membrane. Detected tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle [1].

## II. EXISTING METHODOLOGIES

Few existing methodologies like, A Portable ECG Recorder [2] used the wearable conduction belt as a sensor and commercially available product KY202 as a signal processing unit for the ECG Recorder.

Design of a PC-Based Electrocardiogram (ECG) Recorder as -Internet Appliance [3] explains step by step development work to produce an ECG data acquisition system that is suitable for use at home and for transmitting ECG data globally using internet. An 8-bit microcontroller is used to control the hardware and to communicate with the computer. A Portable ECG Recorder for shipboard use [4] is a 12-channel electrocardiogram (ECG) recorder and it also weighs approximately 11 pounds. This technique is very old and was designed for use on submarines only and it can store up to 50 ECG tracings.

## III. PROPOSED METHODOLOGY

Electrocardiography (ECG or EKG from Greek: *kardia*, meaning heart) is a transthoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body. The patient is wearing an ECG sensor i.e. a removable suction cup electrode, which measures the ECG signal. The signal is measured first and then conditioning i.e. noise filtering and amplification is done. Signal is digitized using ADC and using UART of FPGA Signal from ADC will be sent to the smart-phone via Bluetooth. The ECG waveform is displayed on smart-phone screen to monitor the heart condition. The user can also store the ECG waveform for further investigation. SD card is used to store the waveform in the smart-phone for short term storage. It can also be transmitted to the computer for long term storage and be accessed globally via the Internet.

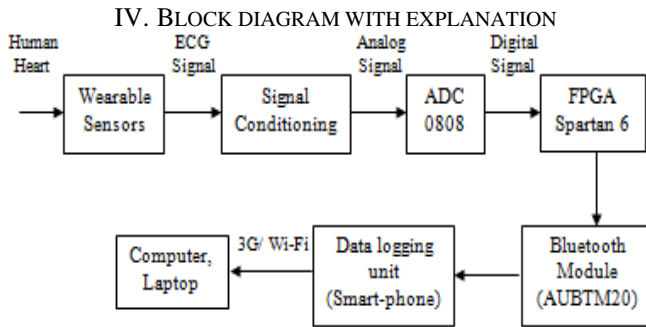


Fig 1: Block Diagram of ECG Recorder

A. Wearable Sensors

Sensors used here are known as Removable Suction Cup Sensors. Electrodes are attached by small suction cup or adhesive patches. A sensor in the pads detects the electrical activity of your heart. The test is usually performed while you lie still.



Fig 2: Removable Suction Cup Sensors

Main aim to choose this sensor is its Great Price/Performance Ratio and Accurate Measurement and Fast Responses and it is easy to Clean and Repair.

B. Signal Conditioning

Signal conditioning manipulates an analog signal in such a way that it meets the requirements of the next stage for further processing. It is most commonly used in analog-to-digital converters.

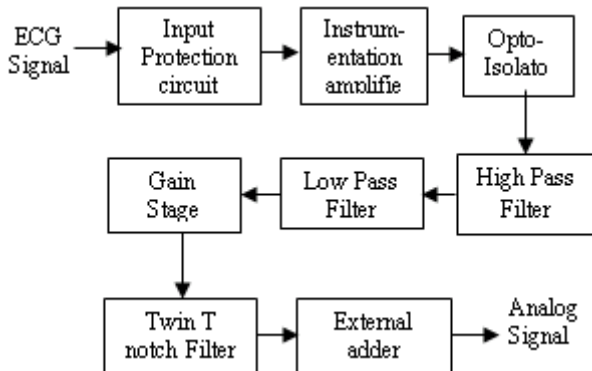


Fig 3: Block Diagram of signal Conditioning

The inputs can come from a myriad of sources: sensors, buttons, switches, relays, and communication devices etc. which carries excessive currents with them, So to avoid this excessive current simultaneously passing the useful current, input protection circuit is used.

Instrumentation Amplifier (IC AD620AN) is a Precision amplifier. Gain ranges from 1 to 1000 with only one external resistor. The features like low cost, high accuracy reliable, low power, low input bias current and low noise of the AD620 make it suitable for medical applications such as ECG and non invasive blood pressure monitors [5]

Opto-Isolator (MCT2E) is used as a component which transfers electrical signals between two isolated circuits by

using light. Opto-isolators or optical isolator or photo-coupler helps to prevent high voltages from affecting the system receiving the signal. [6]

High Pass Filter is an electronic filter that passes high frequency signal but attenuates (reduces the amplitude of) signal with frequencies lower than the cut off frequency. High Pass Filter allows through (passes) frequencies above its cutoff frequency i.e. 0.5 Hz and attenuates frequencies below its cutoff frequency [7]

Low Pass Filter is a filter that passes low frequency signals and attenuates (reduces amplitudes of) signal with frequencies higher than the cut off frequency. Attenuation for each frequency varies depending on specific design of filter. Here cut off is 35 Hz. [7]

Gain staging is the process of managing the relative levels in a series of gain stages. Gain stage prevents introduction of noise and distortion. Standard Gain here is 1000 according to AHA (American Heart rate Association) Standard. So to adjust the gain  $1000/7 = 143$  ( $7*143 = 1000$ )

Twin T Notch Filter is a combination of high Pass Filter and low Pass Filter is called as Twin T Notch Filter. Main source of noise is power line noise. Notch filter is used for eliminating the power line (50 Hz-60 Hz).

ADC accepts 0 to 5V, So to make signal compatible with ADC external adder is used which will provide 2.5 volts. ( $2.5 \text{ mV} * 1000 \text{ gain} = 2.5 \text{ V}$  and  $\pm 2.5 \text{ V} + 2.5 \text{ V} = 0\text{V}$  and  $5\text{V}$ ).

C. Analog to Digital Convertor

An analog-to-digital converter (abbreviated ADC, A/D or A to D) is a device that converts a continuous physical quantity (usually voltage) to a digital number that represents the quantity's amplitude.

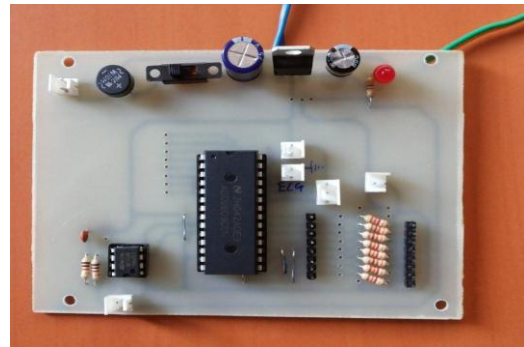


Fig 4: ADC Board

ADC works on 5V but the processor used here i.e. FPGA Spartan-6 works on 3.3V. So to make it compatible with FPGA Spartan 6 board we have used simple 8 resistors which will convert 5V into 3.3 V.

The ADC0808/0809 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. Data coming from ADC will be given to Bluetooth module using UART of FPGA Processor.

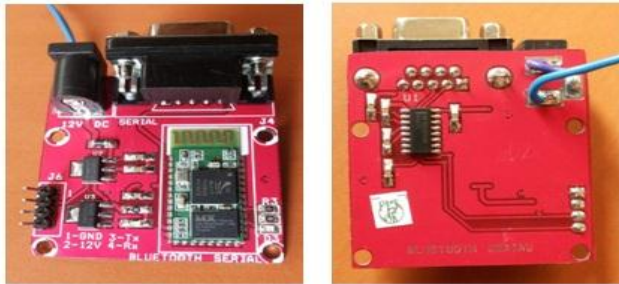
D. FPGA

For Proposed technique, Spartan 6 FPGA Processor family is used. Field-programmable gate array (FPGA) is re-configurable in nature and consist of pipe-lining which increases the designs execution speed. Use of the FPGA provides the flexibility in the design which can be modified.

The recent FPGAs have added multipliers to perform DSP tasks more effectively. User can observe well defined interface between the tasks, each task here runs continuously as FPGA helps to eliminate unexpected interactions between the tasks.

**E. Bluetooth Module (AUBTM20)**

AUBTM-20 is a Bluetooth v1.2 module with SPP profiles. The module is intended to be integrated into another HOST system which requires Bluetooth functions.



**Fig 5: Bluetooth Module (AUBTM20)**

UART is initially configured to work at 9600 bps baud rate, 8-bit, no parity and 1 stop bit. The host could reconfigure the UART by issuing command. The HOST system could send commands to AUBTM-20 through a UART. AUBTM-20 will parse the commands and execute proper functions.

**F. Data Logging Unit (Smart-Phone)**

ECG signal coming from ADC is then sent to the data logging unit i.e. to smart phone via Bluetooth module. Android APP is built in Smartphone which will read the message wirelessly when Bluetooth of Smartphone is turned ON and when device is paired with Bluetooth module. ECG data will get recorded in that smart-phone. The recorded ECG can access globally via internet.

**V. EXPERIMENTATION RESULTS**

**A. ECG signal conditioning on DSO**

Input to the system will be given from the removable suction cup electrodes i.e. sensors which will take ECG of heart and will pass it to signal conditioning circuit. ECG coming from heart is very noisy as shown in fig.5 (a). So this circuit will help the signals to remove the noise and it will amplify and rectify the ECG signal. At the end we can observe the amplified noise free ECG signal as shown in fig.5 (b)



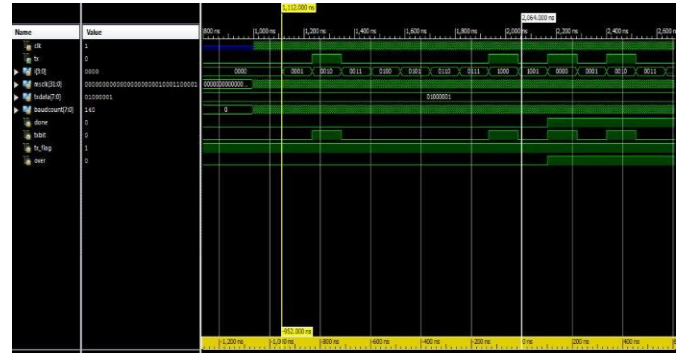
**(a) Before Conditioning (b) After Conditioning**

**Fig 5: ECG signal before signal conditioning on DSO**

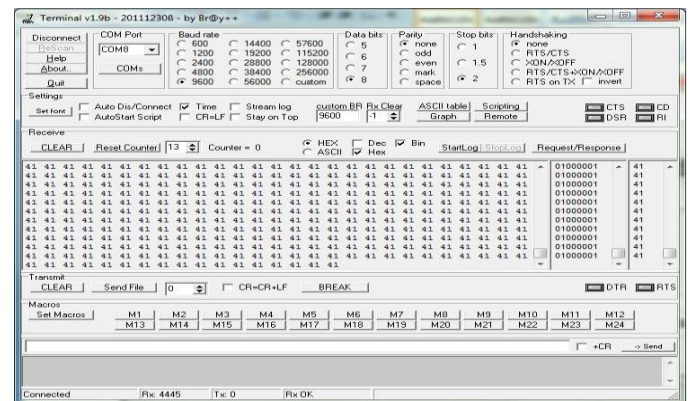
**B. Character simulation/Transmission using UART**

UART connection is used to transmit digital data from ADC to the Bluetooth module. Here for demo purpose I have transmitted 41h data in XILINX ISE Design 14.2 and

observed its simulation. Same data is also observed on HyperTerminal.



**Fig 6: 41h Character simulation in Xilinx ISE Design**



**Fig 7: 41h Character transmission on hyperterminal**

**VI. CONCLUSION**

This Proposed methodology describes the design and development of an electrocardiogram (ECG) recorder that enables the recording of ECG at home and development of android software to receive the ECG data in Smartphone. First ECG signal was conditioned then digitized and finally transmitted digitized signal using UART to the Bluetooth module and to developed an app which will communicate with the Smartphone. Using this system patient can record his/her ECG and can send to hospital using internet. It is beneficial as it gives early treatment opportunity and also effectiveness of medicines can be observed. For the heart disease patients, they can use this device to track the effect of the medicine by storing the ECG before and after taking the medicine. This device can also be used in real-time which will be useful for remote medical care.

**REFERENCE**

- [1] Asifqbal Thakor<sup>1</sup>, Prof. Rahul Kher<sup>2</sup> and Prof. Dipak Patel<sup>3</sup>, "Wearable ECG Recording and Monitoring System based on MSP430 Microcontroller" International Journal of Computer Science and Telecommunications [Volume 3, Issue 10, October 2012
- [2] Sung-Yuan Ko, Kang-Min Wang, Wei-Cheng Lian, Chun-Heng Kao, "A Portable ECG Recorder" Dept. of Computer Science and Information Engineering, I-Shou University Etron Technology, grant no. NSC 100-2218-E-214 -002 Inc., pp 3063-3067
- [3] Bernard L. Ryack, PhD , "A Portable ECG Recorder for Shipboard Use" Behavioral Sciences Department, Naval Submarine Medical Research Laboratory, Naval Submarine Base New London, Groton CT 06349-5900, Vol 154, pp 184-185
- [4] Mahmud Hasan, "Design of a PC-Based Electrocardiogram (ECG) Recorder as - Internet Appliance" Computer Science Program, Faculty of Science, University Brunei Darussalam, Brunei, pp 607-633,2011

- [5] Genghuang Yang, Xin Cai, Feifei Wang, Shigang Cui and li Zhao, "Research of a portable ECG Monitoring Device" Tianjin key laboratory of information sensing and intelligent control, Tianjin University of Technology and Education Hexi,3000222, Tianjin, P.R China, pp 213-215

Datasheets referred

1. AD620AN Instrumentation Amplifier Datasheet
2. MCT2E Opto-isolator Datasheet
3. OP07 Op-amp Datasheet
4. AUBTM 20 Bluetooth



Rashmi. R. A received her B.E. degree from P.C.C.O.E, University of Pune in 2012 and currently pursuing M.E in VLSI and Embedded Systems from P.C.C.O.E, Pune University.



Prof. Sunil Tade is an assistant professor of electronics and telecommunication engineering at Pimpri Chinchwad College of Engineering, University of Pune, India. He received his B.E degree from Amravati University and M.E. degree from University of Pune. His research interests include signal and image processing.