Development of Real-Time ECG Signal Monitoring System for Telemedicine Application

Mr.S.Bashyam
Department of ECE
SRM University
Kanchipuram, India
bashyam.s@ktr.srmuniv.ac.in

Dr.B.Ramachandran
Department of ECE
SRM University
Kanchipuram, India
ramachandran.b@ktr.srmuniv.ac.in

Abstract— **This work presents the development of low cost, portable real-time Electrocardiogram (ECG) signal monitoring system with abnormality detection capability. The 3-lead Electrocardiogram device takes the physical pulse input using electrodes stuck to the arms and right leg of the patient under observation. The ECG signal is processed by the microcontroller AT89S52 in the portable wireless unit to count the heart beat for a duration of one minute and the Heart Rate is displayed on LCD display. The amplitude and intervals of some critical components are obtained, processed and displayed in a graphical user interface. If an abnormality is detected in the ECG signal, an alert SMS is sent by the system to the doctor through GSM modem to enable him to take appropriate protective measures. The system is intended to use for telemedicine application. Further, the system can be improved to monitor multiple physiological signals and to allow patient mobility by transmitting signals wirelessly.**

Index Terms— ***Real time monitoring system, Electrocardiogram signal (ECG), Heart Rate (HR), Telemedicine.***

I. INTRODUCTION

The foremost causes of disability and precipitate death in the developing countries are non-communicable diseases such as diabetes, chronic respiratory disease, and cardiovascular disease. The delay between the first symptom of any cardiac disease and the call for medical assistance has a huge impact among different patients and can have lethal consequences. The exploitation of resources for premature detection and treatment of heart disease has a higher perspective of reducing casualty associated with cardiac disease than superior care after hospitalization. Telemedicine is the utilization of medical information sent from one place to another through communication networks to monitor the health status of the patients. It gives a new approach to delivering health care services when the doctor and patient are separated by long distance.

In the recent works many novel architectures [1], algorithms [2]-[3] and software systems [4] are proposed to implement the telemedicine system. The design challenges in human physiological signal monitoring system [5]-[8] is addressed through novel technologies. But, the received ECG signals from the system is not carrying adequate information about different ECG parameters like amplitude level of p wave, the time duration of QRS complex and T wave which helps in diagnosing cardiac arrhythmias, ventricular hypertrophy, myocardial infection and other abnormalities.

A novel non-contact electrode for mobile electrocardiogram, wearable cardiac healthcare System and patient-personalized systems [9]-[13] are implemented for telemedicine application. The cardiovascular disease is well diagnosed if the doctor/ caretaker of the patients receives all the extracted ECG parameters [14] in real time without any delay, here the implemented systems lags in the transmission of reliable ECG signals with some signal integrity issues. So the monitoring system with reliable signal transmission of vital parameters in real time is indeed for emerging telemedicine application.

In this paper, the real time ECG signal monitoring system is proposed to address the above issues. The heart rate is calculated and any abnormality in the heart rate is intimated to doctor through GSM module. Further, the duration of different ECG signals is extracted from ECG waveform and displayed in PC which can be accessed by the doctor through remote login procedure when he gets an SMS alert on his mobile phone.

This paper is organized as follows: Section II presents details of the hardware implementation along with software description. The results are discussed in section III. The paper is concluded with future enhancements in section IV.

II. HARDWARE IMPLEMENTATION

The Telemonitoring system aims for two application scenarios: monitoring at the hospital and at home. The wireless monitoring system developed for the present project enables the monitoring of a patient at home. The signals from

978-1-5090-4980-6/17/$31.00 @ 2017 IEEE

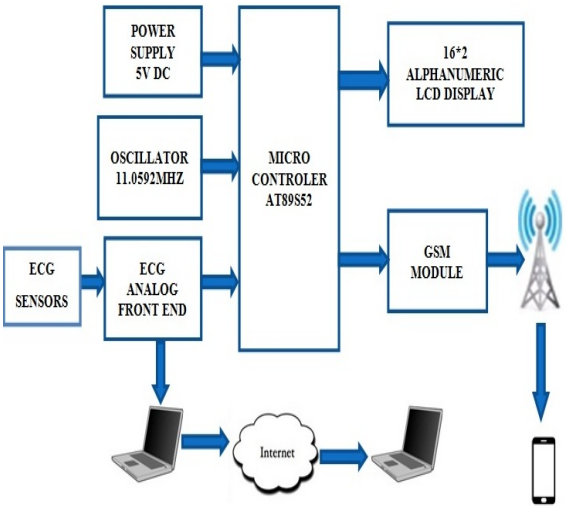

Fig.1. System Architecture

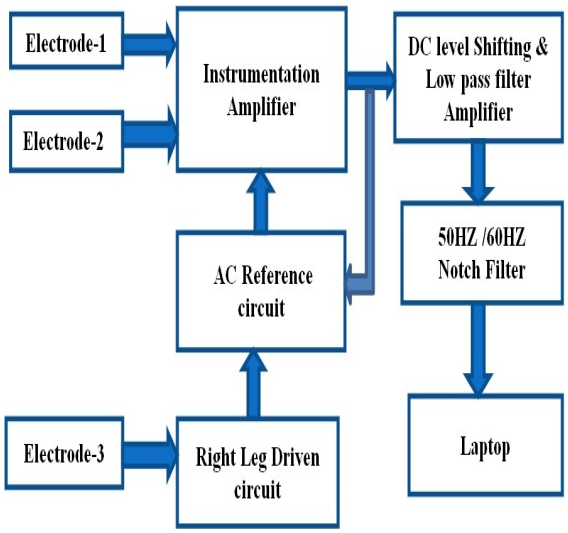

Fig.2. ECG Analog front end circuit

Sensors attached to the patient are directed to the ECG analog front end module. It is then processed for heart rate calculation. The architecture is shown in Fig.1.

The microcontroller used is AT89S52 operates at 11.0592 MHz at 5V D.C. The microcontroller obtains the input from the ECG sensors and manipulates the heart beat rate. The abnormality detected in heart rate is sent via SMS using GSM module and displayed on LCD also. The ECG waveform and related parameters are displayed on a PC through a graphical interface which can be remotely monitored by the doctor.

A.ECG ANALOG FRONT END

Electrical impulse (waveform of depolarization) is picked up by placing electrodes on the patient. The voltage change is sensed by measuring the current change across 2 electrodes. The positive deflection is caused by electrical impulse travels towards the positive electrode whereas the impulse travels away from the positive electrode which results in a negative deflection. The ECG analog front end block is shown in Fig.2.

The pretended ECG signal is generally around 1mV peak-to-peak and is affected by external high-frequency noise and common mode voltages. So instrumentation amplifier is used to amplify the signal. The measured electrical potential is an AC signal with a frequency range of 0.05Hz to 100Hz in which 50Hz/60Hz noise is suppressed by Notch filter.

The common mode voltages include the 50Hz power-line frequency interferences and DC electrode offset potential. This is the result of the electrode contact with skin, giving rise to a potential difference of up to ±300mV. Noise filtering is thus required and it is performed by digital signal processing tool in LabVIEW.

B.SOFTWARE DESCRIPTION

The ECG waveform is also sent to the microcontroller to detect the heart rate. Based on QRS complex received from ECG waveform the heart rate is calculated in beats per minute (BPM). The proteus software is used for simulating the AT89S52 microcontroller with LCD and evaluates heart rate abnormality detection, then send SMS via UART command through GSM module. The simulated output is shown below in Fig.3.

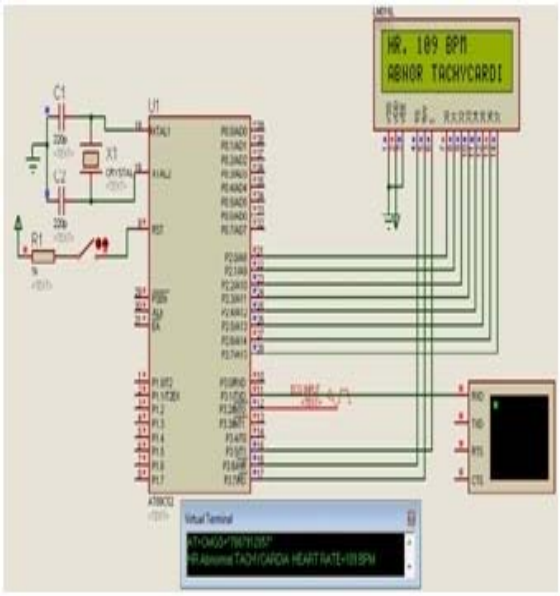

Fig.3. Heart Rate monitor simulation

LabVIEW is a unique software in which biomedical toolkit Package is used to convert the processed electrical impulse signal into a visual representation. The applications are built for baseline wandering removal, noise cancellation, QRS complex detection, heart rate extraction and etc. Usually, the ECG signal acquisition hardware can remove the baseline wandering and other wideband noises, however, the software scheme is more realistic and it is used for ECG signal processing.

III RESULTS AND DISCUSSION

The Signal produced by the Lub dub simulator is similar to the Real-time ECG signal. The system is tested using the Lub dub ECG simulator. The measurement result is shown in Fig.4.

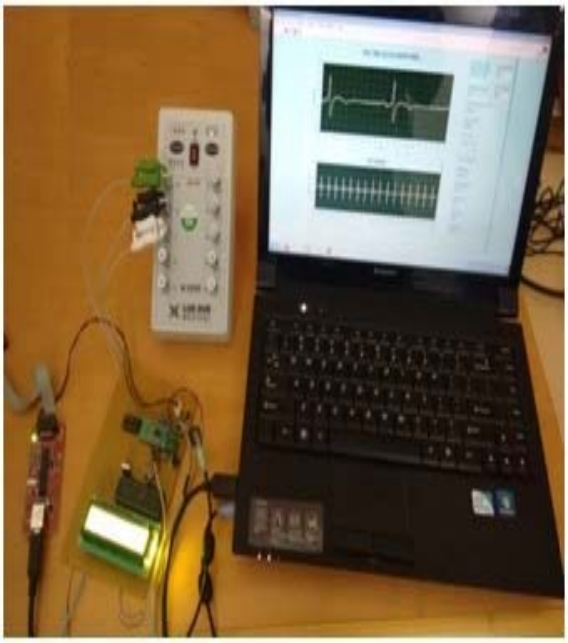

Fig.4. Measured results

The simulated ECG signal is given to prototype hardware then tested result is obtained as shown in Table I. The Heart rate between 60 to 100 BPM of the patient is considered to be normal. If the heart rate is less than 60 BPM, it is abnormal which is called as bradycardia and if it is above 100 BPM is also indicates abnormality which is called as tachycardia and doctor get alerted by SMS in both cases.

The lab VIEW GUI is designed for real-time monitoring ECG signal and to extract the ECG waveform parameters. The web publishing tool is selected from the LabVIEW package and Software web link is launched. It enables the doctor to visualize the condition of a patient remotely and appropriate treatment measures are communicated to the caretaker/junior doctor of the patient at home. The real-time telemonitoring GUI is shown in Fig.5.

Table I. Heart Rate Indication Results

Simulated ECG signal Heart rate	**Analysis result in LCD display**	**SMS Alert message**
60 BPM	HR.060 BPM NORMAL	No
30 BPM	HR.030 BPM ABNORMAL BRADYCARDIA	HR. Abnormal Bradycardia Heart rate=30 BPM
120 BPM	HR.120 BPM ABNORMAL TACHYCARDIA	HR. Abnormal Tachycardia Heart rate=120 BPM

The pulse rate, amplitude level, and duration of ECG waveform parameters are extracted and displayed in the Lab View GUI. In Table II the proposed system is compared with some of the existing ECG monitoring systems available. LabVIEW based ECG waveform extraction is a new feature in the proposed low-cost ECG monitoring system. Also, abnormality detection using GSM and remote monitoring of real-time ECG signal through online helps patients in diagnosing cardiovascular disease in time.

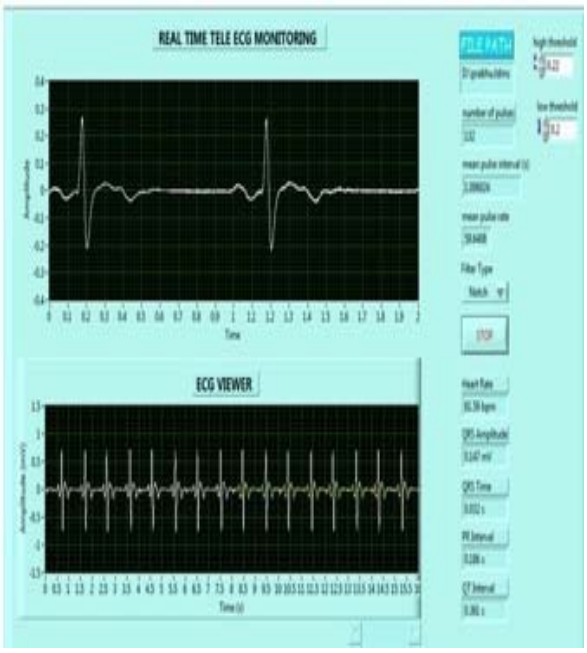

Fig.5. Lab VIEW GUI

978-1-5090-4980-6/17/$31.00 @ 2017 IEEE

Table II. Comparison of ECG monitoring system

Ref no.	Signals acquired	Communication technology	ECG waveform extraction	Remarks
[1]	Heart rate, ECG &Temperature	Internet	Not available	RTOS based architecture enables telecast of Video streaming of the patient.
[7]	ECG, Heart rate	GSM	Not available	FPGA based Arrhythmia detector is proposed.
[8]	ECG, SpO2, Temperature, and BP	GPRS, Internet	Not available	Wireless telemedicine system which integrates sensor, processing & communication unit is proposed.
[10]	ECG, Heart rate	GSM, GPS	Not available	New non-contact electrode circuit is proposed. Heart rate abnormality is intimated.
[11]	ECG, Heart rate	GSM	Available	Wearable Cardiac Healthcare System is proposed. The raw ECG waveform is not monitored remotely.
[13]	ECG, Heart rate, SPO2, PCG & Temperature	Internet, Mobile phone	Available	Vital signs of Patients monitored remotely through the internet. The internet access always needed to intimate the abnormal detection of vital signs of the patient.
Presented work	ECG, Heart rate	GSM, Internet	Available	Proposed system enables the doctor to remotely monitor ECG waveform. Abnormal detection of heart rate is intimated through GSM module.

IV CONCLUSION

The Real time monitoring system presented in this paper produces reliable ECG waveforms and alerts the doctor for the abnormality in heart rate. In addition, ECG waveform extraction is made for premature detection of the cardiovascular-related diseases to take precautionary measure. In the future, the system can be enhanced by providing wireless connectivity between electrodes with flexible antenna and monitoring portable system that allows arbitrary movement of the patient. Further, development of portable and low-cost multiple health parameters wireless monitoring system will be the future scope of our work.

REFERENCES

[1] M. Jagadiswara Rao and M. Kameswara Rao, "An RTOS based Architecture for Patient Monitoring System with Sensor Networks", *Indian Journal of Science and Technology,* vol. 9(17), May 2016.

[2] Christina Orphanidou, Timothy Bonnici, Peter Charlton, David Clifton, David Vallance, and Lionel Tarassenko, "Signal-Quality Indices for the Electrocardiogram and Photoplethy-smogram: Derivation and Applications to Wireless Monitoring", *IEEE Journal of Biomedical and Health Informatics*, Vol. 19, pp. 832-838, May 2015.

[3] Jonathan Herzig, Amitai Bickel, Arie Eitan, and Nathan Intrator, "Monitoring Cardiac Stress Using Features Extracted From *S*1 Heart Sounds", *IEEE Transactions On Biomedical Engineering*, vol. 62(4), pp. 1169-1178, April 2015.

[4] Sebastian Thelen, Michael Czaplik, Philipp Meisen, Daniel Schilberg, and Sabina Jeschke, "Using off-the-Shelf Medical Devices for Biomedical Signal Monitoring in a Telemedicine System for Emergency Medical Services", *IEEE Journal Of Biomedical And Health Informatic,* vol. 19, pp. 117-123, January 2015.

[5] Riccardo Cavallari, Flavia Martelli, Ramona Rosini, Chiara Buratti, and Roberto Verdone, "A Survey on Wireless Body Area Networks: Technologies and Design Challenges" *IEEE Communications Surveys & Tutorials,* vol. 16(3), pp. 1635-1657, third quarter 2014.

[6] Meng Zhang, Anand Raghunathan, Fellow IEEE, and Niraj K. Jha, "Trustworthiness of Medical Devices and Body Area Networks", *Proceedings of the IEEE*, vol.102, pp. 1174-1188, August 2014.

[7] G. Kavya and V. Thulasibai, "VLSI Implementation of Telemonitoring System for High Risk Cardiac Patients" *Indian Journal of Science and Technology,* vol.7(5), pp. 571-576, May 2014.

[8] M. Abo-Zahhad, SabahM. Ahmed, and O. Elnahas, "A Wireless Emergency Telemedicine System for Patients Monitoring and Diagnosis", *International Journal of Telemedicine and Applications*. 2014;http://dx.doi.org/10.1155/2014/380787, 2014.

[9] Boudewijn Venema, Johannes Schiefer, Vladimir Blazek, Nikolai Blanik, "Evaluating Innovative In-Ear Pulse Oximetry for Unobtrusive Cardiovascular and Pulmonary Monitoring During Sleep", *IEEE Journal of Translational Engineering in Health and Medicine,* 2013, vol. 8, Digital Object Identifier 10.1109/JTEHM. 2013.2277870, August 2013.

[10] Bor-Shyh Lin, Willy Chou, Hsing-Yu Wang, Yan-Jun Huang, Jeng-Shyang Pan, "Development of Novel Non-contact Electrodes for Mobile Electrocardiogram Monitoring System" *IEEE Journal of Translational Engineering in Health and Medicine.* Vol.4. Digital Object Identifier 10.1109/JTEHM.2013.2253598, June 2013.

[11] Diptyajit Das, Arnab Pal, Souvik Tewary, Shreyosi Chakraborty, Sauvik Das Gupta, "A Smart and Wearable Cardiac Healthcare System with Monitoring of Sudden Fall for Elderly and Post-Operative Patients" *IOSR Journal of Computer Engineering.* 2014,April, 16(2), pp. 126-133.

[12] LeiClifton, David A.Clifton, Marco A. F. Pimentel, Peter J.Watkinson, and Lionel Tarassenko, "Gaussian Processes for Personalized e-Health Monitoring With Wearable Sensors", *IEEE Transactions On Biomedical Engineering*, Vol.60, pp. 193-197, January 2013.

[13]Mr. Bhavin Mehta, Ms.Divya Rengarajan, Mr. Ankit Prasad, "Real Time Patient Tele-monitoring System Using LabVIEW", *International Journal of Scientific & Engineering Research.*, vol.3(4), April 2012.

[14] Carlos Casillas, "Heart Rate Monitor and Electrocardiograph Fundamentals" Freescale Semiconductor. Application Note, Document Number: AN4059, 3/2013.