International Journal of Scientific & Engineering Research, Volume 6, Issue 8, August-2015 1260
ISSN 2229-5518

Wireless Acquisition of Biosignals for Physiological Variability

Manasi M. Gharat, Laxmi S. Sargar, Aarti Bokade, U.R.Bagal

Abstract Functional disorder of the human systems can be estimated using the parameters obtained from physiological signals. An electronic system for real-time acquisition and wireless transmission of an electrocardiogram is designed. It can be used for monitoring of physiological parameters, short term variability at rest, during surgery and in stress. ECG is picked up using surface electrodes in lead II configuration and amplified using AD620 instrumentation amplifier from Analog Devices. An Ultra low powered MSP430FG4618 microcontroller from Texas Instruments is used for digitization and wireless transmission of ECG through Bluetooth module HC-05. The ECG is received by computer with inbuilt Bluetooth support. The signal is acquired and displayed in user friendly GUI using LabVIEW from National Instruments.

Index Terms Bluetooth, ECG, HC-05, LabVIEW, MSP430FG4618, AD620, Wireless

1. Introduction

The monitoring of vital physiological signals is proven to be the most efficient ways for continuous and remote monitoring of the health status of patients. Acquisition and analysis of physiological signals (ECG, EEG, and EMG etc.) can be used for the extraction of several disorders [7]. The use of Conventional acquisition systems for monitoring physiological signals limit the freedom of movement of the subjects whose biopotentials are being measured. Most of these systems are heavy enough to cause difficulty in making casual movements or urgent transportation of the patients from one location to another location, thus limiting the freedom of mobility of the subjects. The wires used to connect electrodes and the electronic circuit often constitutes a source of motion artifact, noise to the acquisition system.

Considering above problems in view, the implementation of wireless acquisition system helps to eliminate the restrictions caused by the wires in the conventional system for capturing the signal. The designed system pertains to the development of a wireless monitoring system for ECG, as there is evidence that number of people in the world suffering from cardiac disorders have increased and an ECG being non- invasive technique can be utilized to evaluate heart electrical activity and the physiological variability.However, the techniques and the designed concepts used in the this system can be used for the development of a multiparameters (EEG, EMG, oxygen saturation etc) wireless acquisition system.

The designed system acquires ECG data of the subject during an excersice, surgery and thereafter the data can be sent to the nearby station for expert's opinion. It also allows capturing ECG data for short duration (5 mins) and continuous real time acquisition for variability analysis.

2. SYSTEM DESIGN

In the designed system, we fabricated a wireless acquisition system. The aim of the wireless ECG acquisition system is to eliminate the need of cables to transmit acquired ECG signals to remote station and to store the received data in .xls and .csv for monitoring short term physiological variability. This system takes the input from the patient, amplifies it, converts it in digital form and sends to the remote station in wireless mode using class II Bluetooth module. The designed Wireless Acquisition System shown in Fig 1 incorporates the following features:

- Bipolar lead II configuration
- Front end ECG acquisition circuitary
- Rechargeable battery
- 16-bit MSP430FG4618 microcontroller
- Digital output
- Bluetooth Transmission using HC-05
- LabVIEW GUI development for real time ECG acquisition

I. INPUT:

Bipolar lead II configuration has been used as it offers minimum person to person variation. These electrodes detect biopotentials generated by the heart tissues such as the sinoatrial node while causing the heart to pump.

- *Manasi M. Gharat is currently pursuing masters degree program in Biomedical engineering in MGM College of Engineering and Technology, Mumbai University, India.*
- *Laxmi S. Sargar is currently pursuing masters degree program in Biomedical engineering in MGM College of Engineering and Technology, Mumbai University, India.*
- *Aarti Bokade is working as Assistant Professor, Biomedical Engineerin Department, MGM College of Engineering and Technology, Mumbai Uni-versity, India.*
- *U.R.Bagal is working as Assistant Professor, Biomedical Engineering Department, MGM College of Engineering and Technology, Mumbai University, India.*

ISSN 2229-5518

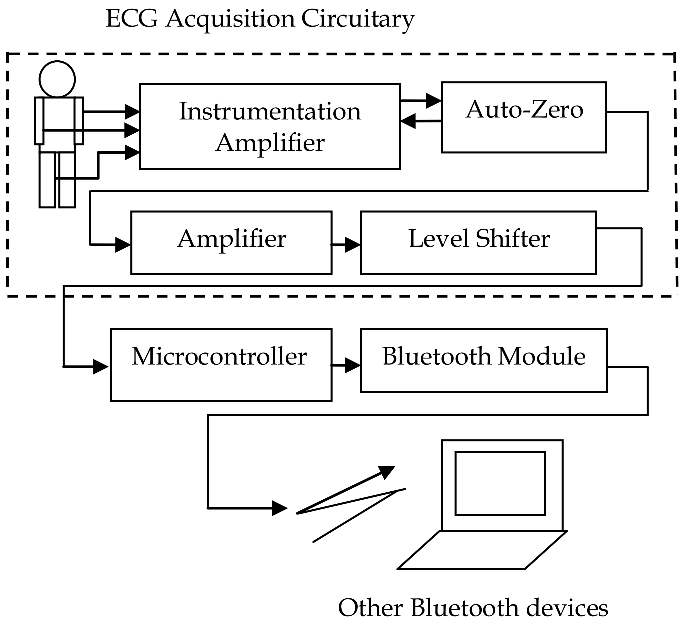

Fig.1 Block Diagram of Wireless Acquisition of Biosignals for physiological variability

II. Front End ECG Acquisition Circuitry:

- Instrumentation Amplifier: This is the most important part of the ECG acquisition circuitry. It enables to amplify the ECG signal to an appropriate level, reject the common mode signal and suppress the noise. Its achieved using instrumentation amplifier which is mainly used in ECG & medical instrumentation, battery powered portable equipments and data acquisition systems.AD620 from Analog Devices is featured with: CMRR in dB (gain) of 100 (10), high frequency response in KHz (gain) of 120 (100), low input bias current of 1.0 nA max, low cost, high accuracy that requires only one external resistor to set gains of 1 to 10,000.

  The Bio- potentials picked up using surface electrodes are fed to an instrumentation amplifier through series resistances. The differential gain of instrumentation amplifyer is kept 5.To achieve this, gain resistance is taken as 10kΩ based on the formula: Gain (G) =1+ (49.4K/Rg), where Rg=Gain resistance [4].

- Auto-zero circuit: Auto-zero circuit has been implemented using first section of LMC6044. LMC6044 is quad op-amp with ultra low power consumption and low input leakage currents. It is mainly designed for the cut-off frequency of 0.05 Hz and corrects offset errors from all the sources. Its output is fed back to the Reference of AD620 to maintain the signal at the zero level for base line restoration. It eliminates small DC offset present at the input that may also get amplified causing amplifier to go in saturation. To avoid this, the output of an instrumentation amplifier has been fed to an auto-zero circuit.

- For further increase in gain the second section of LMC6044 has been configured and gain is set to 400. The dc level of the signal has been adjusted using level shifter designed using third section of op-amp LMC6044.

III. Microcontroller

The digitization has been done using MSP430FG4618. It is an ultra-low power consuming 16 bit RISC microcontroller developed by Texas Instruments mainly used for biomedical application. It is featured with five power saving modes which makes it suitable for the battery operated instrumentation. [14] The other features include universal synchronous /asynchronous communication interface(USART), 116KB+256B Flash or ROM Memory, 8KB RAM, Low Supply-Voltage Range: 1.8 V to 3.6 V,Ultralow-Power Consumption: Active Mode: 400 µA at 1 MHz, 2.2 V Standby Mode: 1.3 µA Off Mode (RAM Retention): 0.22 µA [6]. It has been programmed to achieve mainly two tasks:

- To digitize the analog signal obtained after amplification from front end ECG acquisition circuitry.
- To transmit digitized data serially to Bluetooth module HC-05 for the further wireless transmission.

MSP430 digitizes the analog signal using builtin ADC with 12 bit ADC resolution. The sampling rate is set to 100Hz. The implemented program includes routines for ADC Initialization and control, Baudrate setting of UART and controlling the interface between MSP430F4618 and laptop. Code Composer Studio has been used as a programming tool to generate final ROM image.

IV. Transmission:

The design uses Bluetooth protocol for wireless transmission due to its fast, secure voice and data transmission ability with the range of connectivity upto 10 meters, with no need of line of sight required for infrared communication. To establish wireless communication, HC-05 bluetooth module has been used. The baud rate for transmitting databits from microcontroller to Bluetooth module and to receive data at remote terminal has been kept to be 115200.

Some of the key hardware features of HC-05 include

- Typical 80dBm sensitivity.
- Up to +4dBm RF transmits power.
- Low Power 1.8V Operation, 3.3 to 5 V I/O.
- UART interface with programmable baud rate.
- With integrated antenna.

Whereas software features include

- Permit pairing device to connect as default.

- Auto pairing PINCODE:"1234" as default.
- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.
- The Bluetooth radio uses a low powered transceiver that supports digital wireless communications at the 2.4GHz ISM band allowing data rates of 721kbps [10]. It operates in the range of 2400– 2483.5 MHz (including guard bands which is Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. A radio technology called frequency-hopping spread spectrum [3] is used.

The Bluetooth radio unit

- Functions even in noisy radio environments, ensuring audible voice transmissions in severe conditions.
- Protects data by using error-correction methods.
- Provides a high transmission rate.
- Encrypts and authenticates for privacy [1].

The interconection between Microocntroller MSP430 and HC-05 is shown in Fig 2.

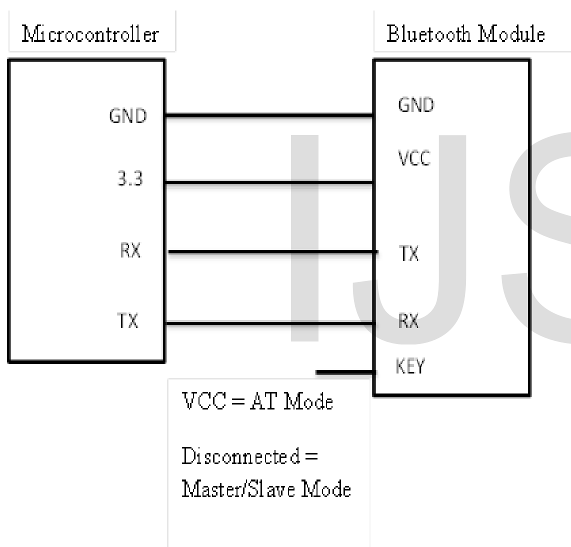

Fig 2 Microcontroller and Bluetooth interfacing

To display the received signal at the remote station GUI (Graphical User Interface) has been developed in LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench), a tool from National instruments. The received data is saved in .csv and .xls format for monitoring physiological variablity and further analysis.

V. **Graphical User Interface Development**: The steps followed in the GUI development can be summarized from the flowchart shown in Fig 3. The block diagram window and developehe front panel developed for wireless data acquisition are shown in Fig 4 and 5 respectively.

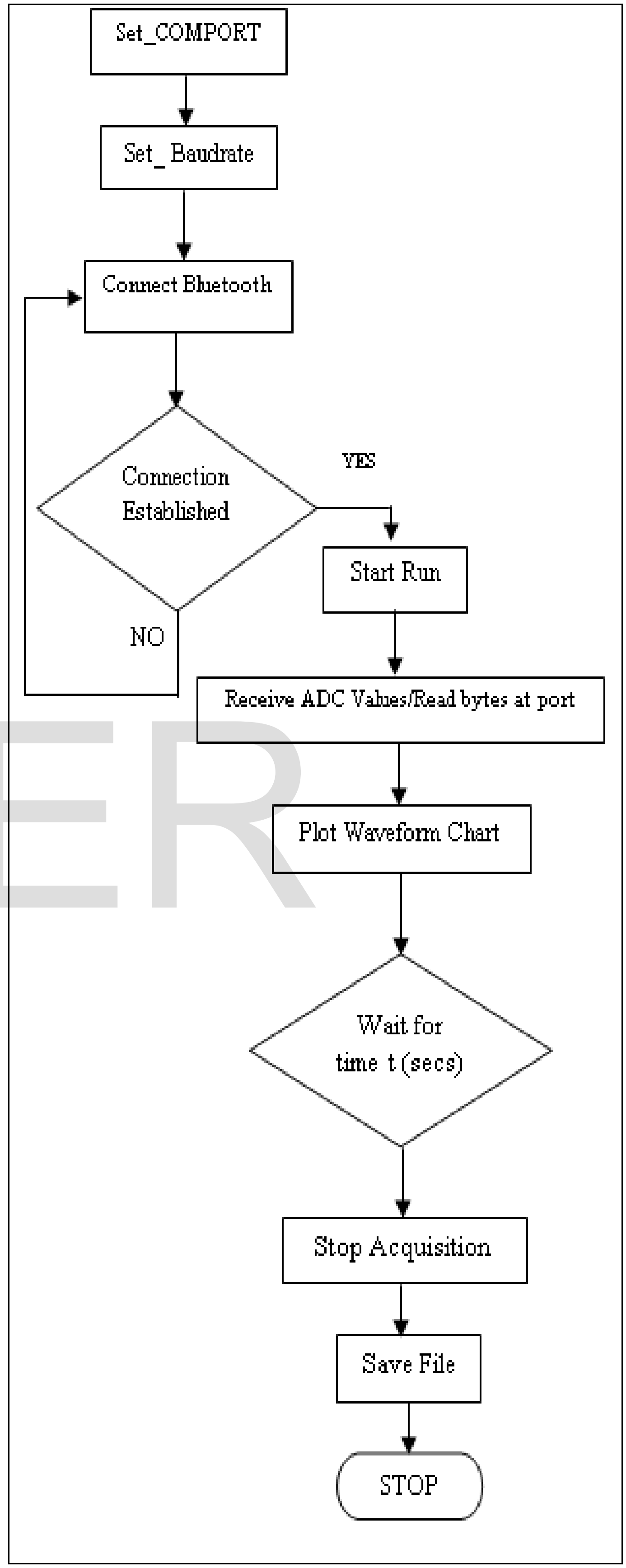

Fig 3 Flowchart for LabVIEW Program

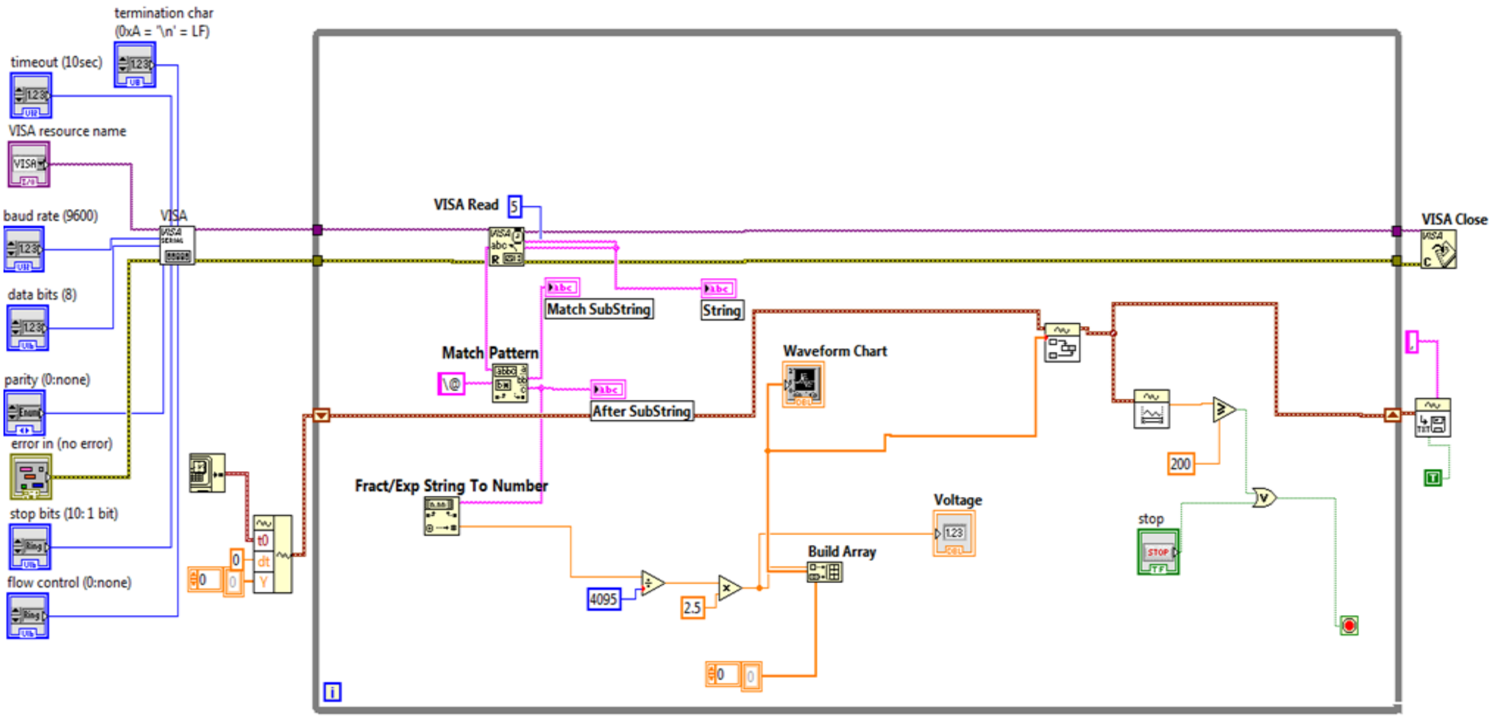

Fig 4 LabVIEW Block Diagram

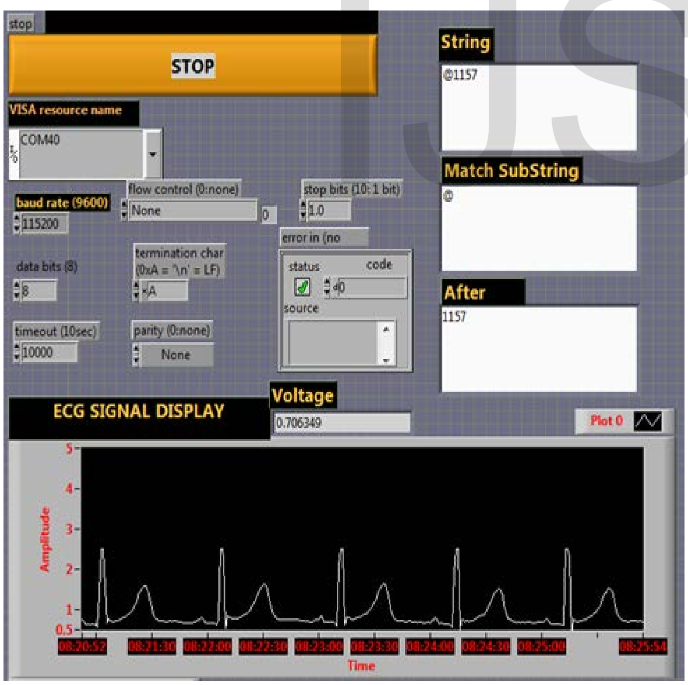

Fig 5 GUI developed for ECG signal display (Front Panel)

3. Results

The system was tested by sending sine wave of various amplitudes and frequencies generated from function generator to the remote terminal through wireless means. The obtained results are shown in Fig 6, 7 and 8. Also the ECG signal Received at remote terminal is shown in Fig 9.

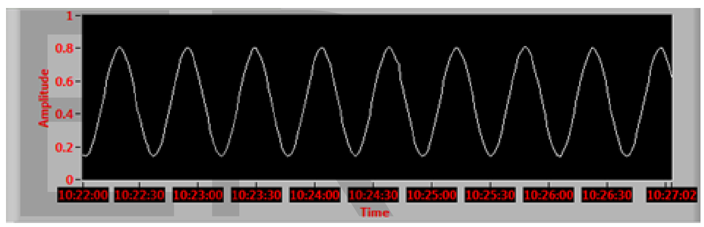

Fig 6 shows the graph plotted in labVIEW for sine wave with offset 200mV and frequency 2Hz

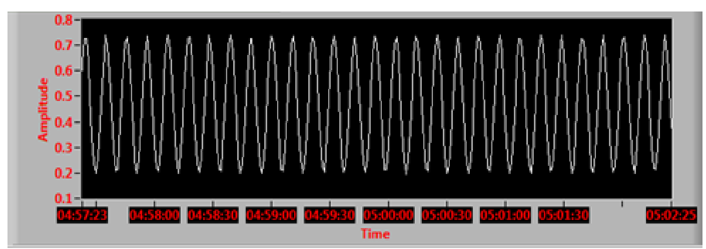

Fig 7 shows the graph plotted in labVIEW for sine wave with offset 200mV and frequency 9Hz

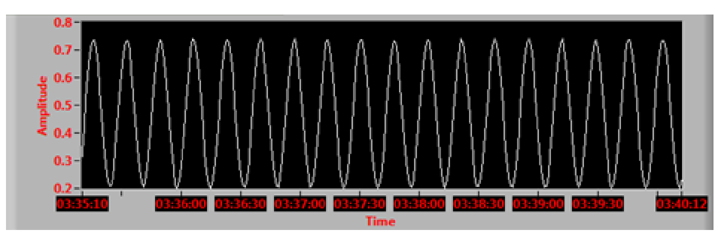

Fig 8 shows the graph plotted in labVIEW for sine wave with offset 200mV and frequency 5.5Hz

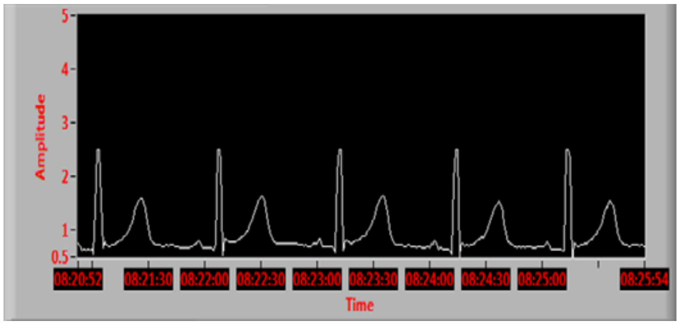

Fig 9 Wireless display of ECG in LabVIEW

TABLE 1
READINGS OF SAMPLES TRANSMITTED WIRELESSLY

Sr.No.	Recording Time	Subjects	No. of samples expected	No. of Samples transmitted
1.	5min data	Subject 1	30000	29733
2.	5min data	Subject 2	30000	29189
3.	5min data	Subject 3	30000	29001
4.	5min data	Subject 4	30000	29522
5.	5min data	Subject 5	30000	29990

4. CONCLUSION

The Wireless ECG acquisition System effectively acquires and wirelessly transmits diagnostic quality ECG signals to a monitoring unit (PC) even at ranges over 10 m. The acquired signals can be evaluated for the measurement of short term as well as long term variability with the upgradation in the used hardware resources.

DISCUSSION

The designed system allows monitoring Short term variability of a physiological signal. However by upgrading the system design it can also be utilized to monitor long term variability.The efficiency and quality of wireless transmission can be enhanced further by using latest featured Low Energy Bluetooth module.

Acknowledgment

The authors are thankful to Dr K G Narayankhedkar, Director General, MGM group of Engineering Colleges, Dr S K Narayankhedkar, Principal MGM College of Engineering and Technology, Navi Mumbai, Dr G D Jindal, Head Biomedical Engineering Department MGMCET for their encouragement right through this development.

REFERENCES

[1] D. R. Loker, P.E. Collin, G. Frampton, T J. McElhaney, J. R. Mook, A. M. Sansone "Remote data acquisition using bluetooth" in Proc. 29th Int. Spring Seminar, 2006, pp: 361 - 366

[2] J. W. Zheng, Z. B. Zhang, T. H. Wu, Y. Zhang, "A wearable mobihealth care system supporting real time diagnosis and alarm" Int. Fed. for Med. and Biol Engg. vol. 45, (9), pp: 877-885, 2007.

[3] G. Singh, I. Singh, "Android OS based wireless data acquisition system via bluetooth" Int. J. of Research in Engg. & Tech. vol. 03 (06), Jun-2014.

[4] R A. Gaykwad, "Op-amps and Linear Integrated Circuits", IVth ed., Prentice-Hall, New Jersey, U.S.A, 2001, ch8, pp 359:363.

[6] I. Reyes, H. Nazeran, M. Franco, E. Haltiwanger, "Wireless photoplethysmographic device for heart rate variability signal acquisition and analysis" 34th Ann. Int. Conf. of the IEEE EMBS 2012

[7] P. S. Pandian, K. Safeer, P. Gupta, D. Shakunthala, B. Sundersheshu and V. Padaki "Wireless sensor network for wearable physiological monitoring" J. of Net., vol. 3(5) 2008.

[8] M. Rajput, S. Pai, U. Mhapankar "Wireless transmission of biomedical parameters using GSM technology", Int. J. of Emerging Sci. and Engg," vol.1(9),pp. 2013

[9] A. Hussain, I. Çankaya "Heart Rate Monitoring and PQRST Detection Based on Graphical User Interface with Matlab" Int. Jou. of Inf. and Elect. Engg.vol.5 (4), July 2015

[10] HU Jun-da, YE wei, ZOU Wen bin "Portable Ambulatory Electrocardiogram Monitoring System Based on Bluetooth" International Conference on Networking and Digital Society, 2009, pp 72-74