# Telemedicine SMS-Based ECG Monitoring System

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***Abstract-*** In this contemporary world where technology is advancing rapidly, design and development of a continuous remote ECG Monitoring System will be of immense help to modern healthcare. Deploying telemedicine principles, the developed system suggests a practical and feasible solution for continuously monitoring the postoperative conditions of cardiac patients especially the old age. The mobile phone technology which has gained tremendous popularity when used as an inter-link between the patient and the physician or the medical practitioner will be a familiar platform for both of them. Our system proposes the design of a real time, ECG monitoring system via a GSM platform which will include an alert system with a notification mechanism to alert the concern physician of the patient's condition in case of any abnormalities.

***Index Terms-*** ECG; GSM Platform, Mobile Phone; Telemedicine

## I. INTRODUCTION

According to a World Health Organization (WHO) estimate, cardiovascular disease is the faster killer if unnoticed and attended to around the globe hence devastating. [1], with around twenty million people at a risk of sudden heart failure. Some of these lives can often be saved if good and effective health care and cardiac surgery are provided within the so-called golden hour. Therefore, patients who are at risk require that their cardiac health to be monitored frequently whether they are indoors or outdoors so that in case of emergency treatment can be given. [2]. Hence it has become necessary or essential to monitor and alert those who are taking care of the patient or his family physician about the fatal condition that may occur at any instant [3][4]. The use of telecommunications for remote diagnosis is growing very fast, and there are several products and projects within mobile ECG recording using Internet solutions [5], Bluetooth technology, cellular phones [5], WAP-based implementations [6] and wireless local area networks, WLAN and Wireless Sensor Networks [7], [8], [9].

A remote diagnosis system integrating digital telemetry or telemedicine has been developed, using a wireless patient module, a homecare station and a remote clinical station [10].

Some ECG-recording systems, like "Holter-monitoring", are using built-in mobile telephones to send information to the hospital [11], but are mostly used with a recording system that physically has to be carried to the hospital for analysis. In [12], [13] a wireless and wearable electrocardiogram (ECG) sensor transmitting signals to a diagnostic station at the hospital is introduced. An ECG system has been proposed based on mobile platform which transmits abnormal heartbeats identified in a patient-worn unit [14]. Another ECG analyzer system has been developed to monitor, measure, capture, record, and analyze ECG signals on a PDA device carried by the patient [15].A research paper that talks about Decision Support System (DSS) prototype has been provided to deliver an ECG signal to a hand-held device which will be capable of providing remote mobile communication to speed up diagnosis and treatments [16]. In the electrical and computer engineering department of Cornell University, an ECG hardware design has been implemented to monitor and measure the electrical activity of the heart [17]. Another paper presented the design, implementation, and results related to the storage system of medical information associated to the ECG signal [18]. Telemedicine is the use of telecommunication and information technologies in order to provide clinical health care at a distance with effective monitoring [22]. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations.

In this our proposed system, a real-time ECG system that facilitates the monitoring and follows up of the patient's condition is implemented [19]. The electrocardiogram (ECG) is a test that records the electrical activity of the heart [20]. These records hold important information that can be used to monitor and measure how fast the heart is beating and to detect the abnormalities of the heartbeats [21]. The proposed system has good extensibility and can easily incorporate other physiological signals to suit various tele-health phenomenons.

## II. SYSTEM'S DESCRIPTION

### *A) GSM Module*

The GSM Module in the system serves as the receiver and transmitter of the patient's heart data. It digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

### *A. Connecting the GSM to the Microcontroller*

The 8051 Primer board kit is designed in such way that all the possible features of the microcontroller will be easily used. The kit supports in system programming (ISP) which is done through serial port. NXP's 8051 (89V51RD2), 8051 Primer Kit is proposed to smooth the progress of developing and debugging of various designs encompassing of High speed 8-bit Microcontrollers.

### *B. Interfacing GSM*

The GSM module is to communicate with the microcontroller and mobile phones through UART. To communicate over UART or USART, one needs three basic signals which are namely, RXD

(receive), TXD (transmit), GND (common ground). GSM modem interfacing with microcontroller for SMS control of industrial equipment. The sending SMS through GSM modem when interfaced with microcontroller or PC is much simpler as compared with sending SMS through UART. Text message may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller i.e., TxD, RxD and GND. In this scheme RTS and CTS signals of serial port interface of GSM Modem are connected with each other. The transmit signal of serial port of microcontroller is connected with transmit signal (TxD) of the serial interface of GSM Modem while receive signal of microcontroller serial port is connected with receive signal (RxD) of serial interface of GSM Modem. The SMS message in text mode can contain only 140 characters at the most depending upon the amount of information collected.

### *C. Interfacing the GSM with the 8051*

To display a text in mobile from 8051 Primer Board by using GSM module through UART, 8051 Primer Board contains two serial interfaces that are UART0 & UART1. The proposed system uses UART0. The GSM modem is being interfaced with the microcontroller 8051 Primer Board for SMS communication. The SMS can be sending and receiving data sharing and situation information and control. The block diagram of this architect is shown in figure 1.

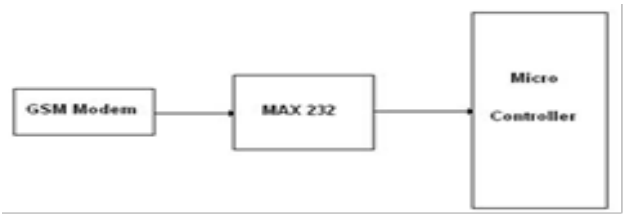


Figure1. Interfacing UART to Microcontroller

### *D. Testing the GSM with the 8051*

The proposed system uses +5V power supply to 8051 Primer Board; connect the +9V adapter with GSM module which is connected with 8051 Primer Board through UART0. Then set up the Hyper Terminal screen, select which port to be using and set the default settings to show some text messages.

The following Commands and sequence of events are performed for sending text message to a mobile phone through GSM Modem interfaced with microcontroller:

1. Select the text mode for SMS by sending the following AT Command to GSM Modem: AT+CMGF = 1. This command configures the GSM modem in text mode.

2.Send the following AT Command for sending SMS message in text mode along with mobile number to the GSM Modem : AT+CMGS =+233232754392 ( this is GSM number been secured for this proposed design configuration). The command sends the mobile number of the recipient mobile to the GSM modem.

3. Send the text message string ("GSM Modem Test") to the GSM Modem This is a test message from UART".

4. Finally Send ASCII code for CTRL+Z i.e., 0x1A to GSM Modem to transmit the message to mobile phone. After message string has been sent to the modem, send CTRL+Z to the micro-controller, which is equivalent to 0x1A (ASCII value).

## III. SYSTEM'S PERFORMANCE

### *A. General Operation Concept*

The power supply is regulated to the Electrocardiogram, Micro Controller and the GSM Module. The ECG reads the patient's heart pulses and transmits it to the Microcontroller. The Micro Controller does all the analysis based on the parameters it has been given. It then transmits the abnormalities based on the analyzed data to the GSM. The GSM Module sends the received information to the Physicians mobile phone. Figure 2 shows the block diagram of the system.

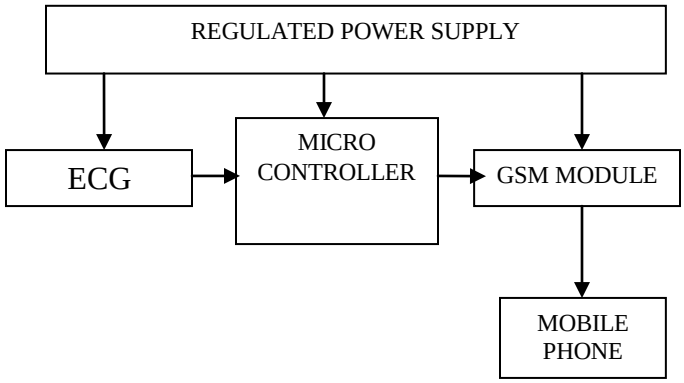


Figure 2. Block Diagram of ECG monitoring System

### *B. System's Overview and Flow Chat*

Like any embedded system, the proposed application has a hardware aspect and a software aspect. The software part is developed based on the flow chart in figure 3. In the application, the objective is to transmit the warning of arrhythmia as data format. As stated in the medical documents [25], the heart normal rhythm at rest is between 50 and 100 bpm (beats per minute). Therefore, the system reads from the data transmitted by the ECG, per the parameters given, (that is less than 50bpm: bradycardia, and more than 100bpm: tachycardia]. Per this algorithm, the software enclosed in the microcontroller will trigger the Physicians mobile if any abnormality is detected.

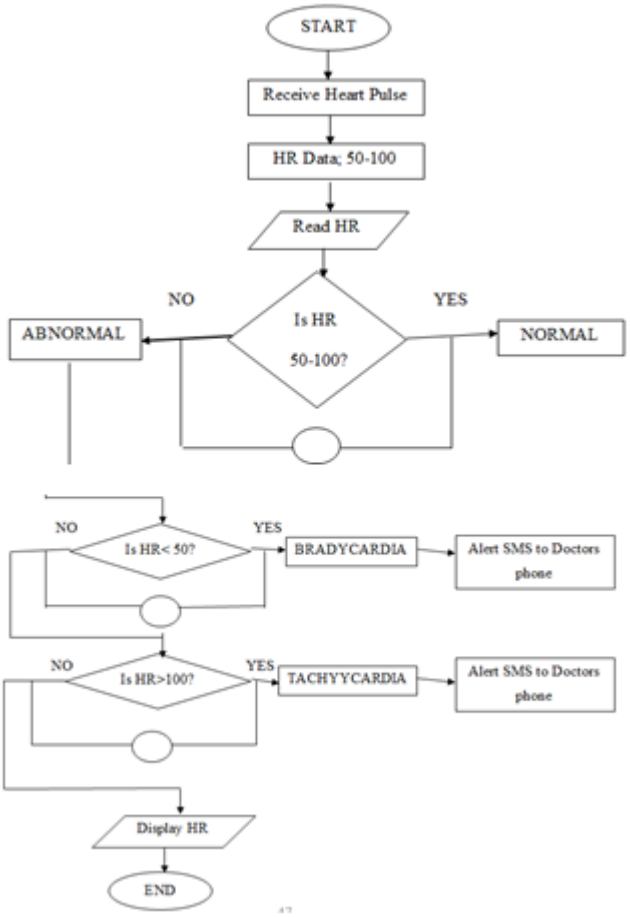


Figure 3.Flow chat of the system

### *C. Simulation of project design*

The design of the Electrocardiogram Monitoring System via GSM platform was simulated using National Instrument Multisim 11.0, software for designing and simulating the Electrical circuit as well as checking the accuracy and efficiency of the circuit design.

### *D. Results and discussions*

The system went passed various stages in designing and was simulated. Figure 4 shows circuit simulation between the ECG and the microcontroller and figure 5 also shows the circuit simulation between the GSM and the main controller. The Interfacing GSM module with 8051 program is very simple and straight forward, which send a message to mobiles from 8051 Primer Board through GSM module by using UART0. Some delay may occur when a single data is sent to mobile through UART. After amplification, the signal goes through a 27C64-20L micro-controller which has a crystal to generate a frequency for the micro-controller. The 27C64-20L micro-controller receives the signals in an analogue form and converts it into digital signals for a PIC16F87 micro-controller to analyze the values. The programmed PIC16F87 micro- controller detects abnormalities and sends to the 8051 micro-controller which is synchronized with the GSM to send the result to the concern physician.

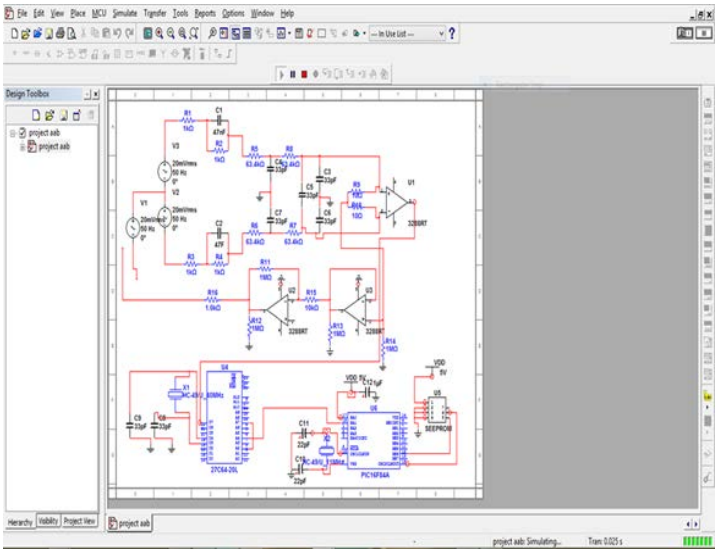

Figure 4; Simulated Circuit between the ECG the Microcontroller

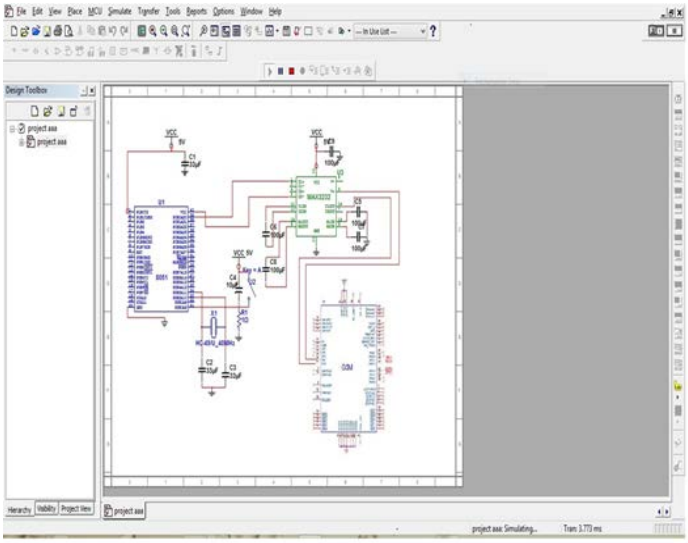

Figure 5; Circuit Simulation between the GSM and the Main Controller

## IV. CONCLUSION

The proposed designed system as simulated can be conclude that it is able to transmit the patient's heart rate during critical period to the doctor's mobile phone. Besides, should the doctor not be present at the hospital, he will receive a SMS on his mobile phone in case any of the parameter of the patient goes beyond the normal range. The leads of the ECG must stick properly to the patient, which is nearest to the chest side of patient. So that the correct ECG reading and signal transmission could be obtained. To facilitate immediate response by the doctor to attend to the patient promptly in the case of any emergency situation, the signal strength of the GSM mobile should always be strong.

## REFERENCES

[1] P.E Ross, "Managing Care Through the Air," IEEE Spectrum, December 2004, pp 14-19(2004)

[2] "Atlas of Heart Disease and Stroke," WHO, September 2004.

[3] D. Bottazzi, A. Corradi, and R. Montanari, "Context-aware middleware solutions for anytime and anywhere emergency assistance to elderly people," IEEE Communications Magazine, vol. 44, no. 4, pp. 82–90, 2006.

[4] P. Giovas, D. Papadoyannis, D. Thomakos, et al., "Transmission of electrocardiograms from a moving ambulance," Journal of Telemedicine and Telecare, vol. 4, pp. 5–7, 1998.

[5] George R. Schwartz, C. Gene Cayten; George R. Schwartz (editor). Principles and Practice of Emergency Medicine, Volume 2, Lea & Febiger, 1992, pg.3202, ISBN 0-8121-1373-X, ISBN 978-0-8121-1373-0.

[6] D. H. Lea, J. L. Johnson and S. Ellingwood, "Telegenetics in Maine: Successful clinical and educational service delivery model developed from a 3-year pilot project", Genet Med, vol. 7, (2005), pp. 21-27.

[7] J. J. Coelho, A. Arnold and J. Nayler, "An assessment of the efficacy of cancer genetic counseling using real- time videoconferencing technology (telemedicine) compared to face-to-face consultations", Eur J Cancer, vol. 41, (2005), pp. 2257-2261.

[8] Center for Telemedicine Law, "Telemedicine reimbursement report", Office for the Advancement for Tele- health, HRSA, (2003) June.

[9] T. Samaras, S. Karavasiliadou, E. Kouidi, et al., "Transtelephonic electrocardiographic transmission in the preparticipation screening of athletes," International Journal of Telemedicine and Applications, vol. 1, pp. 1–4, 2008.

[10] I. Romero Legameta, P. S. Addisson, N. Grubb, C. E. Robertson, K. A. A. Fox, and J. N. Watson, "Real-time classification of ECGs on a PDA", IEEE Trans. Inform Technol. Biomed., vol. 30, pp. 565–568, 2003.

[11] C.-N. Chien, H.-W. Hsu1, J.-K. Jang, C.-L. Rau1, and F.-S. Jaw, "Microcontroller-based wireless recorder for biomedical signals", in Proc. 27th IEEE Ann. Conf. Engin. Medicine and Biology, Shanghai, China, 2005.

[12] Hjelm, N. M. (1 March 2005). "Journal of Telemedicine and Telecare". 11 (2): 60–70. doi:10.1258/1357633053499886.PMID 15829049.

[13] JJ Moffatt (February 2011). "Barriers to the up-take of telemedicine in Australia – a view from providers". The University of Queensland, School of Medicine.

[14] Arch. Dis. Child. 91 (12): 956–9.doi:10.1136/adc.2006.099622. PMC 2082971. PMID 17119 Strehle EM, Shabde N (December 2006). "One hundred years of telemedicine: does this new technology have a place in paediatrics?"071

[15] Did You Know? New Insights Into A World That Is Full of Astonishing Stories and Astounding Facts, Reader's Digest, Reader's Digest Association Limited, 1990, pg.189,ISBN 0-276-42014-4, ISBN 978-0-276-42014-6.

[16] Hoffman, Jan (25 September 2011). "When Your Therapist Is Only a Click Away". New York Times. p. ST1.

[17] "Statewide Partnership Provides Mental Health Assessments via Telemedicine to Patients in Rural Emergency Departments, Reducing Wait Times, Hospitalizations, and Costs". Agency for Healthcare Research and Quality. 2013-12-04.

[18] "Videoconferencing Enhances Access to Psychiatric Care for Children and Adults With Mental Illness in Rural Settings". Agency for Healthcare Research and Quality. 2013-12-04.

[19] "Reunion '10 award winners". Union College. Retrieved 25 July 2013.

[20] Nordrum, I; Engum, B; Rinde, E.; et al. (1991). "Remote frozen section service: A telepathology project to northern Norway.". Hum Pathol 1991: 514–518.

[21] Harper, Douglas. "cardio-". Online Etymology Dictionary.

[22] Walraven, G. (2011). Basic arrhythmias (7th ed.), pp. 1–11

[23] Masters, Jo; Bowden, Carole; Martin, Carole (2003). Textbook of veterinary medical nursing. Oxford: Butterworth-Heinemann. p. 244. ISBN 0-7506-5171-7.

[24] Moyer VA (2 October 2012). "Screening for coronary heart disease with electrocardiography: U.S. Preventive Services Task Force recommendation statement.". Annals of Internal Medicine157 (7): 512–8. doi:10.7326/0003-4819-157-7-201210020-00514. PMID 22847227.

[25] "Summary of Medical Standards". U.S. Federal Aviation Administration. 2006. Retrieved 27 December 2013.

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