



International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)

www.iasir.net

Design of ECG and EEG Hardware for Abnormality Identification using LabVIEW

¹Ashok Kumar, ²Shekhar kumar Patra, ³N Natarajan, ⁴S. Aparna, ⁵J Sam Jeba Kumar

^{1, 3, 4, 5}Dept. of E & I, ²Dept of I & C
^{1, 2, 3, 4, 5}SRM University, Chennai,
Tamilnadu, India

Abstract: In this paper we describe the conventional design of ECG and EEG circuits and their software implementation using LabVIEW to carry out medical tests and provide patient-doctor interaction in case of physical absence of the doctor near the patient. In addition, an effort to develop an embedded prototype for abnormality identification is highlighted using LabVIEW.

Keywords: ECG, EEG, NI ELVIS I, LabVIEW™ Platform.

I. Introduction

In this modern era, robots are performing an increasingly important role of enhancing patient safety in the hurried pace of clinics and hospitals where attention to details and reliability are essential. In recent years, robots are moving closer to patient care, compared to their previous role of providing services in the infrastructure of medicine. To develop a robotic prototyping based software programming which would be used for analyzing medical tests like Electrocardiography (ECG), Electroencephalography (EEG) and pulse rate measurement carrying out at a client location. The lack of availability of doctors near the patient and a lower patient to doctor ratio are serious problems faced in India and adversely affect the medical treatment to be provided to people. The doctor has no information about the patient's health condition when he is not physically present near the patient. The robotic system developed herein acts as a medium of communication between the patient and the doctor in case of physical absence of the doctor and also performs medical tests like ECG, EEG and pulse rate measurement when asked by the doctor to do so..

II. Challenge

In the present Technology [1], Electrocardiography (ECG) and Electroencephalography (EEG) have been designed and optimized under different medical circumstances. The most conventional tradeoffs among all of them can be on the software and hardware forefront which stood ahead as the medical world demands compactness and proficiency in the performance.

The challenge faced in this paper was in developing a robotic prototyping based software programming which would be used for analyzing [2] medical tests like ECG, EEG and pulse rate measurement carried out at a client location. The lack of availability of doctors near the patient and a lower patient to doctor ratio are serious problems faced in India and adversely affect the medical treatment to be provided to people. The doctor has no information about the patient's health condition when he is not physically present near the patient. The robotic system developed herein acts as a medium of communication [3] between the patient and the doctor in case of physical absence of the doctor and also performs medical tests like ECG, EEG and pulse rate measurements when asked by the doctor to do so.

III. LabVIEW™ Prototyping

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is a graphical control, test, and measurement environment development package. LabVIEW is a graphical programming language that uses icons instead of lines of text to create programs. It is one of the most widely used software packages for test, measurement, and control in a variety of industries.

LabVIEW™ is one of the most important software platforms for developing engineering applications and can be connected with different hardware systems and also used for running standalone programs for simulating the controller's performance (validating the controller by simulation then implementing it). In addition LabVIEW™ is a graphical programming language that is very easy to learn and has very less work on conventional coding. The time for implementing an application compared to conventional coding is very less which contributes enormously for an industry to test, measure and control an industrial process effectively.

IV. Graphical Programming

To improve the cause of medical treatment, a robotic system is developed herein using NI LabVIEW. The robot is under the supervisory control of the doctor. The doctor controls the robot from a distance and commands the robot. The doctors make the robot move to a particular patient's room and monitor the patient's room through high resolution camera. These images are viewed continuously by the doctor and the doctor also interacts with the patient through the camera. The robot can also be commanded by the doctor to perform medical tests like ECG, EEG and pulse rate measurement. The reports of these tests would be sent to the doctor's computer through TCP/IP protocol. The doctor then analyses these reports and detects abnormalities using LabVIEW. Graphical system design approach solves the problem by enabling user friendly interface. The doctors would find it easy to operate the system and analysis of reports would also be easy.

V. System Configuration

The system developed consists of the following components:

- ECG and EEG hardware(in house developed)
- Pre-amplifier circuits [4]
- ECG and EEG measurement electrodes [5], [6]
- Power supply unit
- Camera
- National Instruments Educational Laboratory Virtual Instruments Suite I (NI-ELVIS I) for testing of individual components
- NI SbRIO9642 for the final implementation

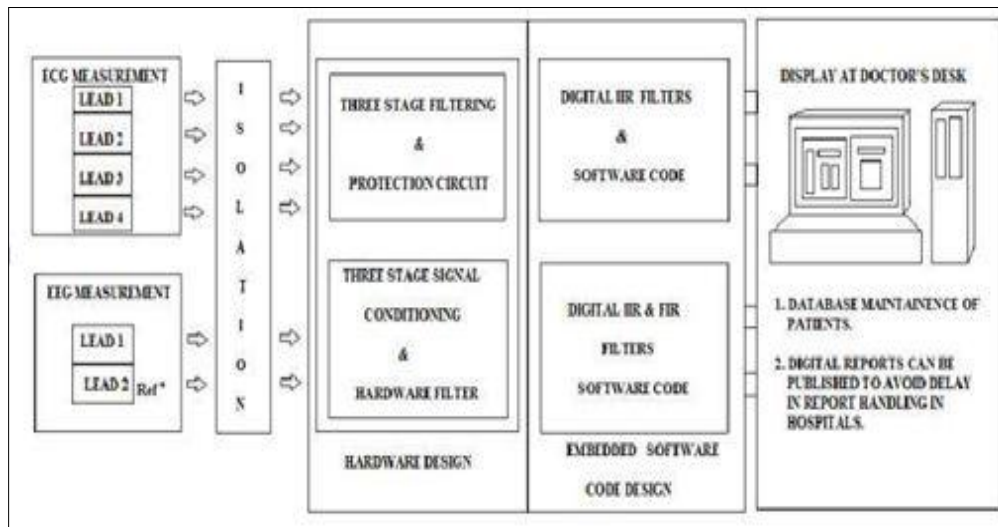


Figure 1: Block diagram illustrating the entire system constituency

The doctor would control the robot's X-Y axis movements through Lab VIEW. Twelve lead ECG [4] analyses are performed in order to determine the accuracy and the programming requirements. The robot conducts ECG testing on the patient when commanded by the doctor to do so and sends the test report to the doctor's computer [11]. The software is programmed to detect abnormalities in the reports arising due to the patient's health condition and report the abnormalities. The software also calculates the patient's pulse rate from the ECG report.

Single lead EEG [9] analysis is performed. The Lab VIEW software at the robot end is programmed to conduct EEG testing. The software is programmed to compare these reports with the standard Delta and Beta waves generated in the EEG testing of a healthy person and detect abnormalities [10], if any.

A. Hardware Design

The ECG and EEG signal conditioning circuits require gain tuning and the design is optimized at hardware level using Multisim software to estimate the design for a real time implementation [19]. It consists of three stage amplification to reduce the distortions of 50 Hz power supply. In addition, frequency analyses are carried out in order to determine the cut-off frequencies of the circuits. The signals are then filtered and sent to the NI ELVIS kit. The software processes the signal and analyses it for the purpose of detection of abnormalities, if any. The pulse rate is also calculated. The figure 2 illustrates the simulation of the three stage amplification circuit designed on Multisim software.

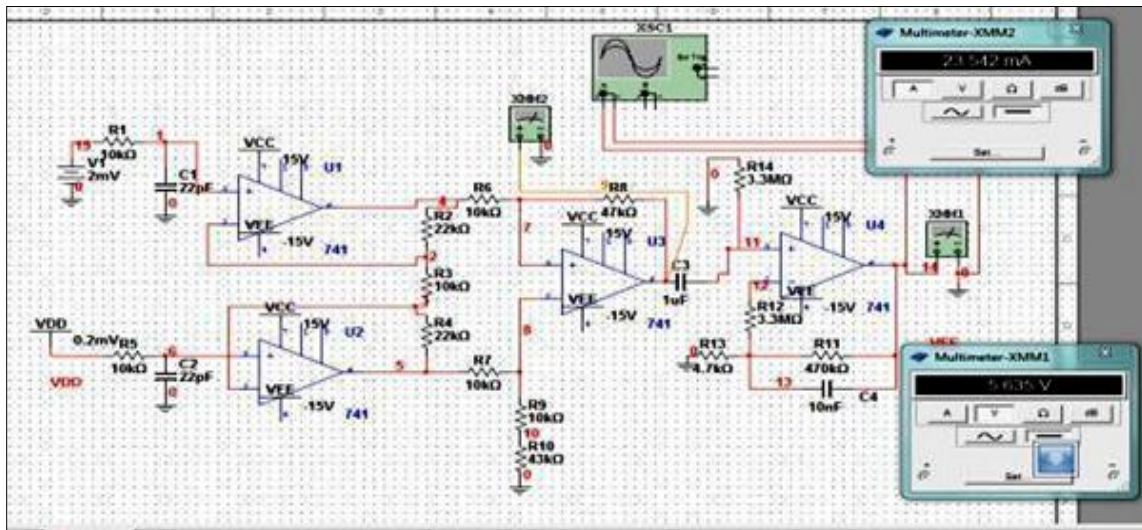


Figure 2: Simulation of the ECG hardware circuit using Multisim software

B. ECG Electrode Analysis

The standard 12-lead ECG can be derived from the orthogonal Frank lead configuration by the inverse Dower transform [4], and can be useful in many circumstances [18]. Furthermore, the six chest leads (V1 to V6) can be derived from leads I and II by Einthoven's Law [14]. However, the quality of derived leads may not be sufficient for analyzing subtle morphologic changes in the ECG (such as the ST segment). For instance, significant differences in QT dispersion between the Frank leads and the standard 12-lead ECG have been reported [12]. Kligfield points out, there is no consensus regarding which lead or set of leads should be routinely used in QT analysis, in part due to the varying definitions of the end of the T wave, which produce differing results on differing leads [13].

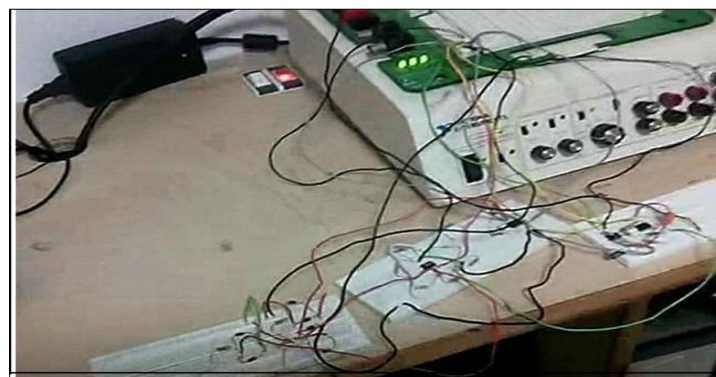


Figure 3: Hardware setup for signal acquisition

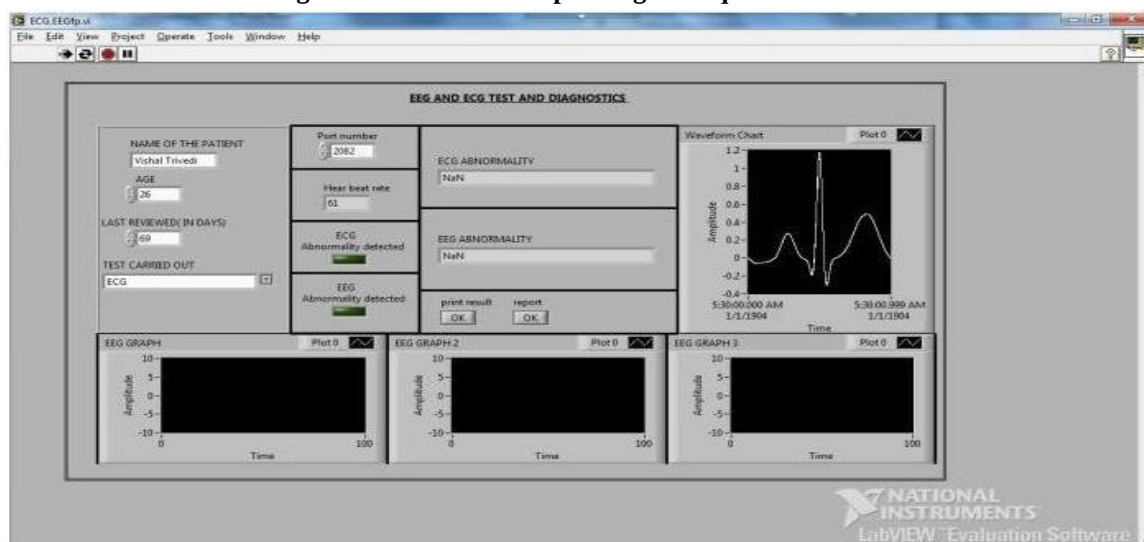


Figure 4: Front panel of the EEG and ECG testing setup with NI ELVIS-1

In general, it seems sensible to assume that we should use as many maximally orthogonal leads as possible. Above this, as many extra leads as possible should be used, to increase the signal-to-noise ratio, noise rejection and redundancy. However, the anisotropic and non-stationary dielectric properties of the human torso (due to respiratory and cardiovascular activity) mean that spatial oversampling is often required to give an accurate evaluation of clinical features. In other words, multiple leads in similar locations (such as V1 though V6) are often required. The design considered for a the 12 lead ECG here is based on the Wilson circuit arrangement .The advantage of this method relies on the simplicity in construction of the circuit and the effective grounding using the right leg driver circuit arrangement .The buffers provided at every filtered output ensures to avoid the loss of information during data acquisition using embedded hardware.

C. Software Implementation

The front panel shown in figure 4 illustrates the observations made during a test run for ECG [13]. The program intends to maintain a database of the persons registering for the sort of testing recommended by the doctor. The development of this prototyping includes a report generation at the user interface to be filed for reference too. Thus, different displays are provided to enhance the scanning ability of the signal received and random modulation with symptoms of diseases observed, if any.

The block diagram illustrated in figure 5 is a subvi program which is executed for computational organization to identify the physical relationships of each of the wavelets [12]. The noise frequency of ac supply is considered for the prototyping point of view which must be tackled in the real-time interfacing [17]. The block diagram shown in figure 5 explains a sub VI which selects the human EEG signal range and determines the output analysis to be carried out [15], [20]. As seen in figure 6, the EEG analysis can't be affirmed with a single lead and hence a provision for three outputs to be read at a time so as to extricate flaws in the judgment.

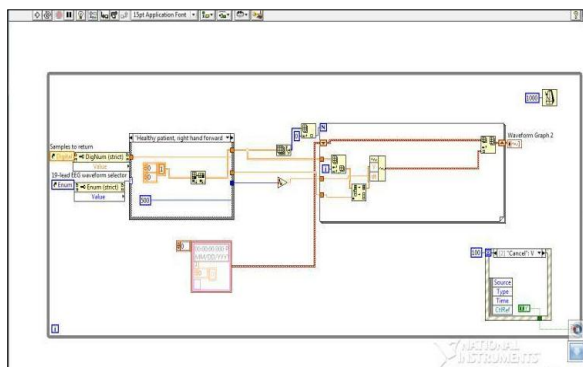


Figure 5: Block diagram of the subVI developed for ECG development

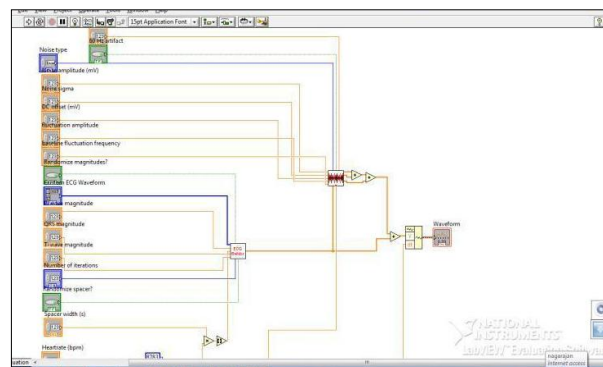


Figure 6: Block diagram illustrating the EEG analysis

D. Abnormalities aimed for detection

- Heart rate measurement under severe conditions of bradycardia and tachycardia.
- Wolf-Parkinson syndrome.
- Detection of fascicular blocks.
- Non-specific intra ventricular disorder.
- Malignant ventricular arrhythmias.
- Premature atrial and ventricular contractions. Atrial fibrillation
- Analysis of EEG signals of a sleeping, anaesthetic and coma patient.
- Influence of Benzodiazepines.

E. Benefits of using Graphical System Design Approach

- Ease of programming.
- Advanced troubleshooting and signal manipulations
- Rapid prototype board designing and interface with NI-ELVIS.

VI. Conclusions

The developed virtual instruments (VIs) were incorporated with a human interface to validate results to support a dedicated test bed for implementation at SRM University premises, which would bring in a revolutionary and agile system to reality encompassing and fulfilling the needs of the country.

Acknowledgment

We wish to thank SRM University, Kattankulathur for funding the project. The project won National Level 5th in National Instruments Embedded System Design Contest named “NI Yantra 2010”. The project was displayed at Indian Science Congress held in January, 2011 at SRM University, Kattankulathur among delegates.

We are highly obliged to be a part of this project which endeavours students to have a broad spectrum of innovation irrespective of the branch being trained at.

References

- [1] Berke Erem (8323) and Serkan Yazıcı (10276), Project 2Report for EL 473 – Biomedical Instrumentation, FALL 2009 – 2010.
- [2] Christine Moran, Leslie Goldberg, Yuheng Chen, —Collecting and filtering live ECG signal Connexions module: m18957, Version 1.1: Dec 17, 2008 1:56 am US/Central.
- [3] Drew, B. J., et al., Practice Standards for Electrocardiographic Monitoring in Hospital Settings: An American Heart Association Scientific Statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young: Endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses, *Circulation*, Vol. 110, No. 17, 2004, pp. 2721–2746.
- [4] Edenbrandt, L., A. Houston, and P.W. Macfarlane, - Vectorcardiograms Synthesized from 12-Lead ECGs: A New Method Applied in 1792 Healthy Children, *Pediatr. Cardiol*, Vol. 15, 1994, pp. 21–26.
- [5] Gurbinder Kaur, —Design and Development of Dual Channel ECG Simulator and Peak Detector, Department of Electrical and Instrumentation Engineering, Thapar Institute of Engineering & Technology, Deemed University, Patiala – 147004, June 2006
- [6] Gaetano Gargiulo, Paolo Bifulco, Mario Cesarelli, Mariano Ruffo, Maria Romano et al., - An ultra-high input impedance ECG amplifier for long-term monitoring of athletes, Dipartimento di Ingegneria Elettronica, Biomedica e delle Telecomunicazioni, Federico University of Naples, Italy; 2School of Electrical and Information Engineering, University of Sydney, Australia, 2 July 2010.
- [7] Gerald Ulrich, Charité, Book of Psychiatric encephalography.

Articles in conference proceedings:

- [8] Ivan W. Selesnick and C. Sidney Burrus, - Generalized Digital Butterworth Filter Design, *IEEE Transactions on Signal Processing*, VOL. 46, NO. 6 June 1998.
- [9] Internet, -Reference notes on ECG and EEG, <http://iopscience.iop.org/1742-6596/76/1/0120>—unpublished.
- [10] Juha Virtanen, Shield arrangement for ECG Lead wires, US Patent, US 7,260,428 B2, and Aug 21, 2007.
- [11] Jeffrey Groeger, Saul Miodownik, - Electrocardiograph system, 4, 957,109 Sept 1990.

Articles in a journal:

- [12] Kligfield, P., - QT Analysis: Problems and Prospects, *International Journal of Bioelectromagnetism*, Vol. 5, No. 1, 2003, pp. 205-206.
- [13] Macfarlane, P. W., S. C. McLaughlin, and J. C. Rodger, - Influence of Lead Selection and Population on Automated Measurement of QT Dispersion, *Circulation*, Vol. 98, No. 20, 1998, pp. 2160–2167.
- [14] Madias, J. E., - A Comparison of 2-Lead, 6-Lead, and 12-Lead ECGs in Patients with Changing Edematous States: Implications for the Employment of Quantitative Electrocardiography in Research and Clinical Applications, *Chest*, Vol. 124, No. 6, 2003, pp. 2057–2063.
- [15] Mudit Jain, Snigdha Chaturvedi, Varun Mithal, - Detection of Abnormalities and Diseases in ECG Data, Term report, Dept of Computer Science and Engineering, IIT Kanpur - 208 016 INDIA, November 8, 2008.
- [16] Robert Lin, Ren-Guey Lee, Chwan-LuT seng, Yan-Fa Wu, Joe Air Jiang, - Design and implementation of wireless multi-channel EEG recording system and EEG clustering method.
- [17] Rahman Jamal, Mike Cerna, John Hanks, - Designing Filters Using the Digital Filter Design Toolkit, National Instruments, Application Note 097
- [18] Riekkinen, H., and P. Rautaharju, - Body Position, Electrode Level and Respiration Effects on the Frank Lead Electrocardiogram, *Circulation*, Vol. 53, 1976, pp. 40–45.[9]
- [19] William H. Righter, - ECG Signal Conditioner Electronic Circuit Diagram.mht, 5,191,89, 10 March 1993
- [20] William Tatum, Aatif Husain, Selim Benbadis, Peter Kaplan, MD, - Handbook of EEG interpretation, Demos Medical Publishing.mht.