Labview Based Automated External Defibrillator

* Tehreem Hamid, * Hassan Ali, ** Ghulam Mustafa, *** Tahir Qadri and * Zia MohyUd Din

***Abstract*—In today's era when precise, accurate and time efficient systems are in great demand, automated techniques supersede manual practices. As a need of time, we introduce a wireless, automated, cost effective, yet reliable and efficient system of fluid dispensing. Our prototype system can dispense varying amounts of fluids in milliliters (maximum 1L) as per demand of the user. It uses the principle of time based fluid dispensing achieved through the built-in timer property of the AT89C51 microcontroller. To satisfy the principle used and verify the system's accuracy, fluids of varying viscosities were dispensed and monitored. The experimental results of the wireless fluid dispensing system when tested showed linear relationship between the dispensing time and desired volumes of fluids having differing viscosities. The added feature of wireless control using HM-TRP series transceiver module along with on-site control via a keypad eliminated the need of physical presence of operator within the range of 10 meters in order to make the system operational. This system can be used in pharmaceutical and beverage industries as well as in different laboratories for dispensing and filling volumes of fluids with varying viscosities.**

***Index Terms*—ECG amplification, Defibrillation, Ventricular fibrillation, Lab VIEW software, high electric shocks.**

I. INTRODUCTION

A normal heart beats 60 to100 times per minute in order to pump blood to the body but this pumping action requires electrical conduction. A Human heart is capable to generate electrical impulses which follow a conductive pathway made up of specialized cardiac muscle fibers, basically the whole process comprises of repolarization and depolarization of atriums and ventricles which causing the heart to contract rhythmically. When the heart rhythms occur irregularly the condition is called arrhythmia. Among the main causes of cardiac arrest is ventricular fibrillation in which ventricles of the heart quiver very rapidly and irregularly thus causes uncontrolled myocardial contraction. This fibrillation is one of the main causes of irreversible heart tissue damage or death. To treat ventricular fibrillation a therapeutic device defibrillator is used to deliver high electric voltages to the heart which causes depolarization of abnormal contraction of the heart muscles and against obelized normal conduction of the heart’s electrical impulse and thus normal activity of heart can be restored with proper delivery of shocks.

Batelli et al proposed that low electric current can cause ventricular fibrillation and high electric current can stop ventricular fibrillation [3]. Doctors use different types of defibrillators, which include external defibrillators and implanted defibrillators. But these defibrillators sometimes failed to restore the cardiac functions due to the charging and discharging failure or by inadequate device operation by paramedical staff. It has been confirmed from previous researches that early defibrillation is very important because immediate defibrillation can result in increasing the survival rates of more than 90%, as cardiac arrest leads to a 10% reduction in survival each minute, so early treatment of patient is very vital [4].

LabVIEW based automatic external defibrillator works on direct current (DC) voltages, the first direct current (DC) defibrillator was introduced by Bernard Lown in 1960, allowing treatment outside hospitals for the first time [5]. A defibrillator generates about 50 Joules to 100 Joules of energy when electrodes are applied directly to the heart (internally) and <200 Joules when applied from the surface of skin. Since a large amount of energy is required for the restoration of the heart rhythm, so an automatic defibrillation system designed in such a way that energy and high voltage losses can be reduced. Main components of the automated external defibrillator are capacitor, inductor and a variable auto transformer. Unlike regular defibrillators, an automated external defibrillator requires minimal training to use. It automatically diagnoses the heart rhythm via ECG machine and determines if a shock is needed via LabVIEW, therefore it is highly feasible for patient who requires urgent care in case of a sudden cardiac arrest and the unavailability of a physician at that time. Another main advantage is that, this system is cost efficient. In general, an automated external defibrillator costs about $3000 and with shipping and duty costs, it can go up to $5000. LabVIEW based defibrillator has cost about $800, which is easily affordable for developing countries. As in Pakistan, about 63.4% of population is in the rural areas [6], which make a huge part of the population deprived from the quick action required for proper treatment in such a critical condition. By the time the patient has access to a defibrillator, it becomes too late.

* Department of Biomedical Engineering, Sir Syed University of Engineering & Technology,
** PCSIR Laboratories Karachi,
*** Department of Electronic Engineering, Sir Syed University of Engineering & Technology.

In order to reduce these failures automatic external defibrillator is designed to assist the doctors in this severe emergency condition that decides automatically whether to provide defibrillation to a patient or not. Automatic external defibrillator is associated with an ECG amplification circuit that amplifies the signals of ECG whereas LabVIEW software analyses the amplified ECG signals and activates the charging of defibrillator on detecting preset peak threshold. Hence electric shock is discharged across the chest by pushing the button when action is desired so that patient is provided with proper dosage of electric shock within instant duration.

II. MATERIALS & METHODS

A. Basic Idea

The core idea behind the LabVIEW based automatic external defibrillator is to design such a system that can automatically detects the heart rhythm and also determines the condition of ventricular fibrillation then deliver high voltage electric shocks across the patient's chest suffering from ventricular fibrillation. So the system is designed with the synchronization of three main parts, an ECG amplification circuit which amplifies the ECG signals from patient's heart, then sends the information to the software LabVIEW, where the condition of ventricular fibrillation is determined on detecting the amount of peaks, if it exceeds the preset peak threshold value (i.e. 200 peaks), the defibrillator begins to charge, once it is charged completely then electric shocks are ready to provide the patient just on the push of button.

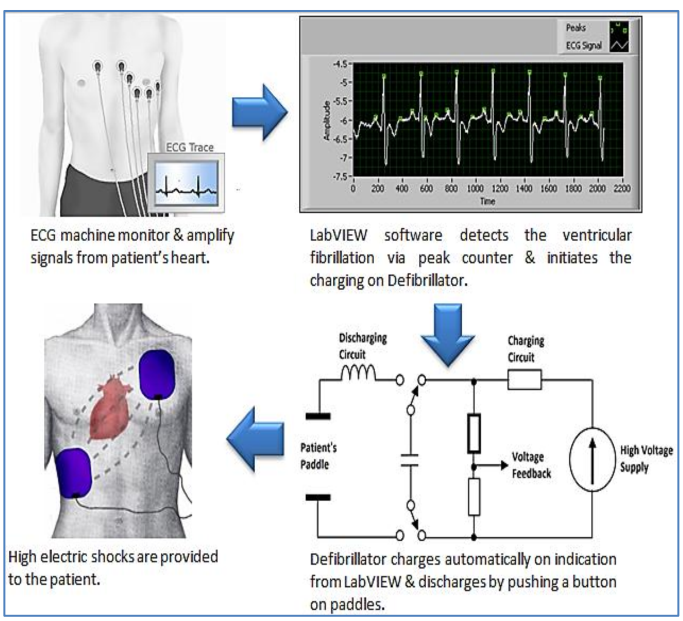

Fig. 1. Basic idea of the research.

B. Amplification Circuit Design of ECG

An ECG amplification circuit is designed in order to intensify the signals measured from heart that is generally ranges from 0.15 to 0.5 Hz which are very challenging to examine. So the circuit is implemented in such a way that electrodes are connected to the patient's body, one at right arm, one at left arm while one electrode is connected to the right leg as driven electrode, that carries ECG information towards the Instrumentation Amplifier with gain of 2 in order to stabilize the incoming ECG signals, the signals are then travel to the High Pass Filter (of 0.5 Hz) that eludes the baseline wondering and then towards the Notch Filter (50 Hz) for eliminating noise of line frequency (i.e of 50Hz). From Notch Filter ECG signals moves on the way to Main Amplifier with gain set of 100, then lastly to Low Pass Filter (of 250 Hz) in order to avoid the motion artifacts and high frequency noise. Thus, an amplified, noise-free and stabilized signal is achieved at the completion of ECG Amplification Circuit. The amplification circuit is further interfaced with LabVIEW software, where the detection of Ventricular fibrillation carryout.

C. Defibrillation System Design

Defibrillator is interfaced with LabVIEW using DAQ board that triggers the charging of defibrillator by switching the relay on detection of Ventricular fibrillation. The system of defibrillator is distributed into three segments, a power supply, a charging system and a discharging system. A power supply is designed by keeping in mind the need of high energy voltages that would be provided to the patient. Hence, power supply comprises of high voltage auto transformer that steps up AC line voltages to 2700V with a current of 300mA. Since defibrillator is operated on DC voltages, so a rectifier is used that converts 2700V AC into 3800V DC (as DC= 0.707AC).

The charging section consists of a high voltage rating charging relay (DPDT) about 13KV and 10A, which is used for switching in order to charge the capacitor. A capacitor of 34µF with a 5.4KV voltage rating is used to store the high amount of energy by the charging circuit. The whole process of charging takes about 13 sec.

The calculations about the amount of energy that is delivered to the patient is done by using the relationship,

$$\text{Energy} = QV/2 \tag{1}$$

And the time required for capacitor to be charged is denoted as,

$$T=RC \tag{2}$$

The discharging portion consists of a discharging relay with ratings of 10KV-80A. At the occurrence of ventricular fibrillation, the discharging relay switches, causing the capacitor to discharge within few milliseconds. For release of high energy shocks paddles are used consist of a push button, placed in the Anterior-Anterior form, i.e. on the patients sternum and apex of heart. Thus, on pushing the button, high energy shocks of about 214.6J of energy with Vpk 3486V are diffused to the patient's heart, usually higher than the required range as the human torso resistance (i.e. 50Ω).

D. Hardware interfacing mechanism via Lab VIEW

The synchronization of Automatic External Defibrillation system is done by means of LabVIEW software, to which the signal from ECG amplification circuit is interfaced by using USB-NI6008 DAQ (Data Acquisition) board that allow the transfer of Analog data into computer through ADC at input channel and also carry digital information from LabVIEW to the Defibrillator via DAC output channel. The process of automation is carry out by designing a Peak Detector via programming skills in LabVIEW software, which continuously counts the number of peaks of incoming ECG signal at preset threshold value i.e. 0.4. According to which if the number of peaks exceed 200 peaks per minute, indicates that there is Ventricular fibrillation. Thus, on detection of ventricular fibrillation LabVIEW decides to deliver the signal to DAQ device that in turn switches the defibrillator relay automatically to initiate the charging mechanism.

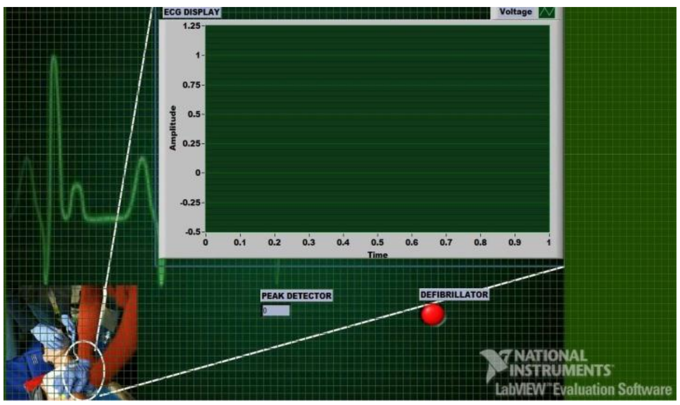

Fig. 2. LabVIEW based program

III. Results And Discussions

When a person undergoes sudden cardiac arrest, chances of survival decrease by 7 to 10 percent for each minute, so defibrillation must be provided within 5 minutes of onset in order to restore the person's survival. In early 1970s, Dr. Arch Diack, Dr. W. Stanley Welborn, and Robert Rullman developed several prototype AEDs [7]. These AEDs empower people to respond to a medical emergency more quickly and readily when they require defibrillation. Unlike regular defibrillators, automated external defibrillator requires minimal training to use. It automatically diagnoses the heart rhythm and determines if a shock is needed or not.

The LabVIEW Based Automatic External Defibrillator system fulfills all the possible features for the feasibility and assistance of physicians and doctors by automatically detecting the heart rhythms, determining the condition of ventricular fibrillation and initiating the charge mechanism of defibrillator automatically, that discharge by pushing a button to deliver high electric shocks by adhesive electrodes across the patient's chest suffering from ventricular fibrillation. The system was designed in synchronization of ECG amplification circuit, LabVIEW software Defibrillator. The system is tested on the stimulator and optimum results are achieved, 214.6J of energy with Vpk 3486V which are the most favorable dosage of electric shocks, as <200 joules of energy is ideal to provide the patient suffering from cardiac arrest.

Also LabVIEW based automatic external defibrillator require less or minimal personnel training for the application of electric shocks. Furthermore, the system is less expensive also as most of the developing countries need to import such critical care equipment at huge expense.

IV. Conclusion

LabVIEW based Automated External Defibrillator is proved to be one of the most useful and assistive system in this era of health emergencies and critical care. It effectively determines the cardiac arrest condition and provides appropriate dosage of electric shocks automatically at proper timing. Also cost efficient for most of the people in rural or developing areas. In United States electronic voice is used to prompt the user through each step. Visual prompts have also been in some areas. Further advancement could also be made in the system in order to serve the best outcome to the human health. Future enhancements are required to test the implemented system on human subjects.

References

[1] Lown B, et al. "Comparison of alternating current with direct current electroshock across the closed chest". Am J Cardiol. 1962;10:223.

[2] Pakistan: An Evaluation of the World Bank's Assistance, World Bank, Independent Evaluation Group (IEG),2006

[3] Diack AW, Welborn WS, Rullman RG, et al. An automatic cardiac resuscitator for emergency treatment of cardiac arrest. Med Instrum. Mar-Apr 1979;13(2):78-83

[4] Eftestol T, Sunde K, Steen PA. "Effects ofinterrupting precordial compressions on thecalculated probability of defibrillation successduring out-of-hospital cardiac arrest".Circulation; 3, 2002

[5] Trayanova N, "Defibrillation of the heart:insights into mechanisms from modellingstudies". Experimental Physiology91 (2): 323–337, 2006.

[6] Wells, Lisa K., and Jeffrey Travis. LabVIEW for everyone: graphical programming made even easier. Prentice-Hall, Inc., 1996.

[7] Li, Yongqin, et al. "A comparison of defibrillation efficacy between different impedance compensation techniques in high impedance porcine model."Resuscitation 80.11 (2009): 1312-1317.

[8] Li, Yongqin, et al. "Defibrillation delivered during the upstroke phase of manual chest compression improves shock success*." Critical care medicine 38.3 (2010): 910-915.

[9] Tang, Liang, et al. "Post- Shock Synchronized Pacing in Isolated Rabbit Left Ventricle: Evaluation of a Novel Defibrillation Strategy." Journal of cardiovascular electrophysiology 18.7 (2007): 740-749.

[10] Gorup, Žarko, DušanŠTajer, and Marko Noč. "Signal analysis systems for optimal timing of electrical defibrillation." Electrotechnical Conference, 2000. MELECON 2000. 10th Mediterranean. Vol. 2. IEEE, 2000.