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Android based Fail Safe Dual Chamber Cardiac Integrated Pacemaker Device using Bluetooth Communication

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Abstract— Population with pacemaker **i**mplants varies by age, sex or race and it is used when heart beats too slowly or when there is irregularity in the beating or there is blockage**.** Artificial cardiac pacemaker is a medical device that uses electrical impulses delivered by electrodes contracting the heart muscles in order to regulate the beating of the heart. This paper presents an integrated fail safe pacemaker which will produces the artificial pulse whenever the missed pulse in being produced by the heart. Unit will function as an advanced dual chamber pacemaker type that can pace both atrium and ventricle and hence functions like a normal heart. The device will monitor the electrical activities of the heart through the cardiac signal ECG of the patient. Device status and vital parameters can be monitored using Bluetooth wireless communication and displayed on an Android Platform.

Keywords- Pacemaker, ECG, Dual Chamber Pacemaker, Bluetooth Communication, Android Platform

I. INTRODUCTION

Pioneering work done by many scientist which helped in the development of advanced pacemakers which benefited patients with extended and enhanced life. Fully implantable pacemaker was developed in the mid twentieth century and it is a medical device composed of a miniaturized electronic circuit and a compact battery. A lead is a very thin, electrically insulated wire that is anchored either into the right atrium or the right ventricle of the heart. The lead transmits the electrical signal to the heart, detects cardiac activity and pass this information to the pacemaker.

Electrical signal travels across the heart and causes the heart to contract and pump blood. . Heart is divided into four Chambers: upper two left and right Atria's and lower two left and right Ventricles. Atria are smaller and are the receiving chambers and ventricles are larger and act as the pumping chambers. Each atrium pumps blood to a corresponding ventricle. The right atrium pumps blood to the right ventricle to provide blood to the lungs. The left ventricle, sourced by the left atrium, is the chamber that pumps blood throughout the body. Natural pacemaker of the heart is called the Sino atrial node (S-A node). It is located in the right atrium wall inferior to superior vena cava. The heart also contains specialized fibers that conduct the electrical impulse from the pacemaker (S-A node) to the rest of the heart and S-A node is responsible for setting the pace of the heart. Electrical impulses leaving the S-A node travels to the left and right atria and cause then to contract and then it travels to the A-V Node. A-V node is the bridge between the atria and ventricles [7]. Electrical signals pass from the atria down to the ventricles through the A-V node and Circulatory system. Electrical impulse goes to the Bundle of his and branches out into left and right Bundle Branches and spreads rapidly using purkinje Fibers to the muscles of left and right Ventricles causing them to contract at the same time. Heart's electrical activity can be measured by placing an electrode on the skin and electrocardiogram (ECG) can measure the rate and rhythm of the heartbeat, as well as provide indirect measure of blood flow to the heart muscle [2].

II. DUAL CHAMBER PACEMAKER SYSTEM

Pacemakers are playing an increasing role in preventing congestive heart failures, Bradycardia, syncope and heterotrophic cardiomyopathy. Pacemakers implanted are biocompatible and long lasting lithium batteries are used. Pacemakers are implanted right under the chest by making an incision or cut. Cardiac Pacing system are of two types namely, single and dual chamber pacing. In a single-chamber system, single lead connected into one of the chambers of the heart, most commonly connected to the right ventricle. Single-chamber pacemakers may be atrial or ventricular. Atrial pacemakers are used where slow heart rate due only to Sino atrial disease. Dual-chamber cardiac pacing is commonly used in children and adolescents and it is done by connecting one lead to atria and another to ventricle and it has added advantage as it more closely resembles the normal physiology of cardiac activation because it maintains the usual synchrony of atrial and ventricular contraction. Dual-chamber pacing reduces the risk of atrial fibrillation, atria ventricular block, stroke, sick sinus syndrome and death compared with ventricular pacing and it improves the quality of life. Dual-chamber pacing improves effort tolerance compared to other methods of pacing.

Our focus is on Dual Chamber Cardiac Pacemaker device which will monitor the electrical activities of the heart through the cardiac signal ECG of the patient. In the artificial integrated pacemaker unit, ADC (Analog to Digital Converter) is used for analog to digital signal conversion and the whole unit is powered by a battery source which will provide necessary life to the working of the system .The processor used is LPC2148 ARM Processor and this RISC based computer design approach is preferred here because of its ability to perform high speed wireless communication as in the case of Bluetooth. Host controller interface for Bluetooth communication is UART (Universal Asynchronous Receiver Transmitter) and port 0 is used to transmit and receive data. The output is a pulse with fixed amplitude and duration. The device generates the atrium pulse first and it is followed by the ventricle pulse. LPC 2148 support two types of PWM (pulse width modulation) namely, single edge and double edge modulation and PWM is used to get analog result with digital means. Interfacing of PWM with ARM processor is simple and it generate a pulse pattern at a particular frequency and ADC Signal is used to vary the duty cycle of PWM signal. EEPROM (Electrically erasable programmable read only memory) chip is used to store the patient specific information and it is inbuilt inside the processor unit .It is a user modifiable nonvolatile memory that can be erased and reprogrammed repeatedly .EEPROM chip is interfaced with LPC2148 using I2C (Inter integrated Circuit) and this is a serial bus that provide a communication link between integrated circuits. I2C is a master slave protocol which has clock pulse and data.I2C Controller act the master device and controls the EEPROM Chip which act as the slave device.

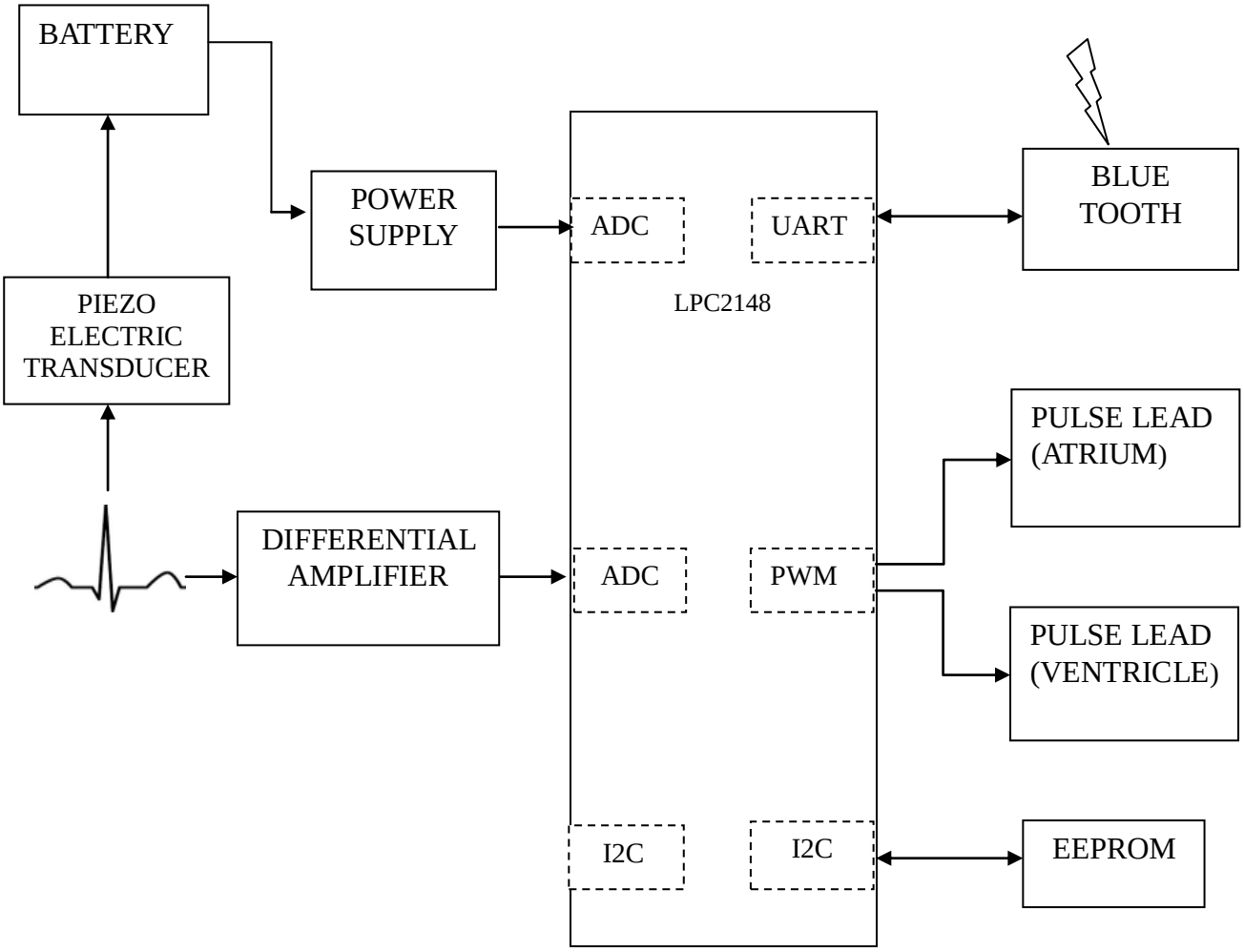

Figure 1. Integrated Artificial Pacemaker Unit

Failure safe rate responsive cardiac pacemaker device could be monitored and configured by a doctor using a secured wireless communication and Bluetooth is used for monitoring and displayed on Android mobile. Bluetooth is used because it is low power, low cost, short ranged radio link for communication between mobile devices .Because of its low power consumption, its range is limited to 10 m. Range can be increased to 100 m by employing a scatter net topology or a higher powered antenna [1]. Android platform is the most widely used operating system on smart phones and hand held tablet devices and it helps in enhancing the mobility of doctor and it provide support for the Bluetooth network stack, which allows a device to wirelessly exchange data with other Bluetooth devices. The application framework provides access to the Bluetooth functionality through the Android Bluetooth APIs. Android mobile has features such as integrated SMS (texting) functions, options for saving the data on the device or data streaming function These features will help clinicians to monitor patients efficiently and therefore improve the quality of service.

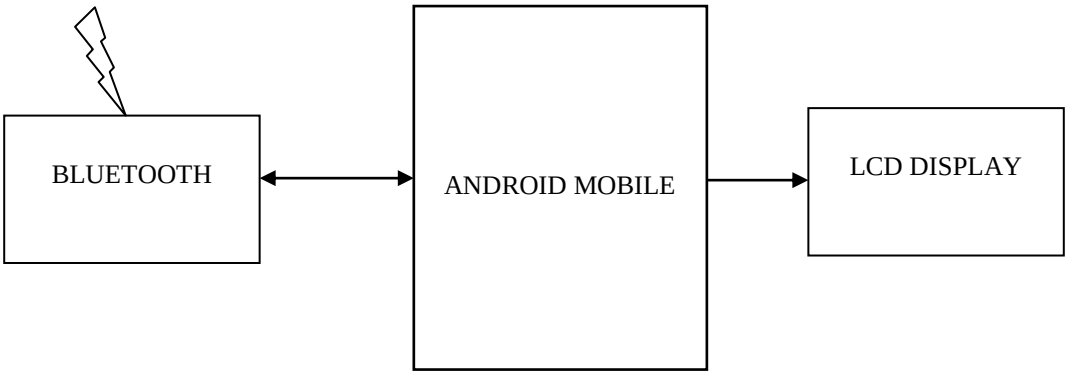

Figure 2.monitoring unit

III. SYNTHESIS RESULTS AND DISCUSSION

Synthesis is done using Proteus ISIS (Intelligent Schematic Input System) software with Keil µVision. Proteus software is easy to install and virus free and easy to use in laptops. Proteus PCB design combines the ISIS schematic capture and ARES PCB layout programs to provide a powerful, integrated and easy to use suite of tools for professional PCB Design. All Proteus PCB design products include an integrated shape based auto router and a basic SPICE simulation capability as standard. More advanced routing modes are included in Proteus PCB Design Level 2 and higher. The Keil C Compiler provides more features and allows in writing ARM application in C and have the efficiency and speed of assembly language. Language extension in the compiler gives you full access to all resources of ARM. The complier translator translates C source file into reliable object module which contain full symbolic information for debugging with µVision debugger. The µVision IDE and Debugger are the central part of the keil development tool chain.

Simulation output of the proposed system is the indication of the heart beat sensor in safely working human heart .In a normal working human heart, heart rate at rest is around 72 beats per minute (bpm). It works on the principle of light modulation by blood flow through finger at each pulse. Heart rate is simply measured by placing the thumb over the subject's arterial pulsation, and feeling, timing and counting the pulses usually in a 30 second period. Heart beat sensor is designed to give digital output of heart beat when a finger is placed inside it. The digital output is connected to micro controller unit directly to measure the Beats per Minute (BPM) rate. when heart pumps a pulse of blood through blood vessels, finger becomes slightly more opaque so less light reached at the detector. With each heart pulse detector signal varies this variation is converted to electrical pulse. It consists of LED (light emitting diode) and LDR (light detection resistor) which are placed parallel to each other. During the operation of the switch which act as the sensor, switch is closed first for 30 sec and blood volume is measured which is the indication of measurement of heart beat of the person.

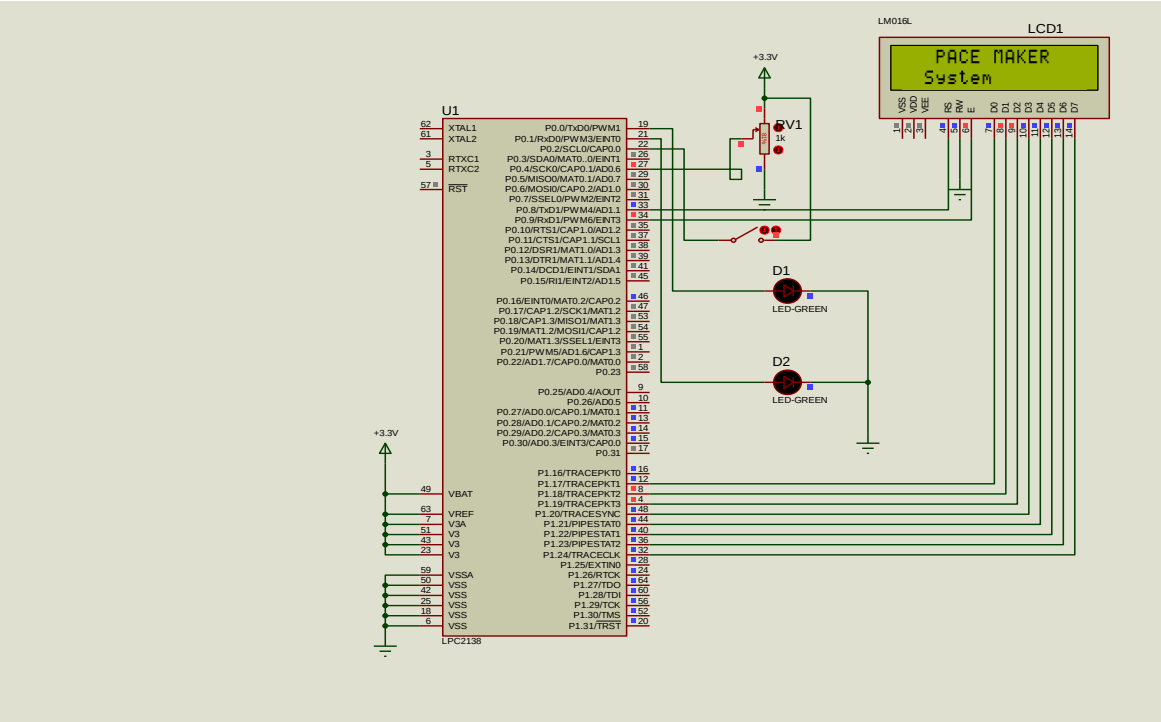

Figure 3. Simulation output of pacemaker system

ICLM358 as the Heart Beat Sensor and heart beat sensor unit consists of an infrared transmitter LED and an infrared sensor photo-diode. The transmitter-sensor pair is clipped on one of the fingers of the subject. The LED emits infrared light to the finger of the subject. The photo-transistor detects this light beam and measures the change of blood volume through the finger artery. This signal, which is in the form of pulses is then amplified and filtered suitably and is fed to the processor unit for analysis and display. The processor unit counts the number of pulses over a fixed time interval and thus obtains the heart rate of the subject.

ARM LPC2148 is used to sense the heart beat and the red high intensity light emitted by LED initially falls on LDR. When the finger is placed in between LED and LDR so that there exists some systolic pressure. LED emits IR rays which are travelled through finger and blood flows with arteriole pressure. Whenever systolic pressure is applied, normal pressure of blood flow is disturbed at fingertip which is high and IR rays penetrate through blood and are received by LDR. The signals are analog which are converted into digital by ADC (Analog-Digital Converter) and the sensor unit works under low power DC input of 5V which is controlled by a mini transformer. The intensity of light penetration decreases if the blood is pumped into the finger .If the blood is not pumped then the light intensity is high .This high and low light intensity helps to measure heartbeat of the person.

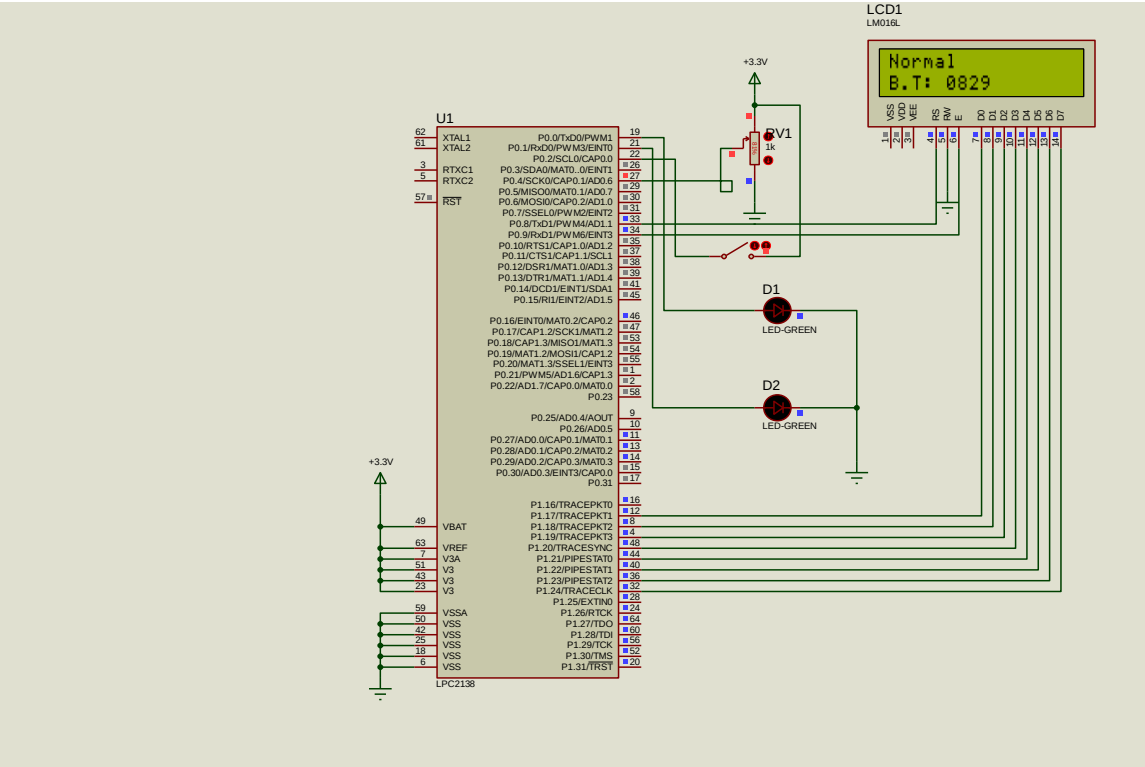

Figure 4. Simulation output of pacemaker system for Normal working Condition

Simulation output of pacemaker system of a normally functioning human heart which pace both atria and ventricle and Body temperature parameter is also indicated.

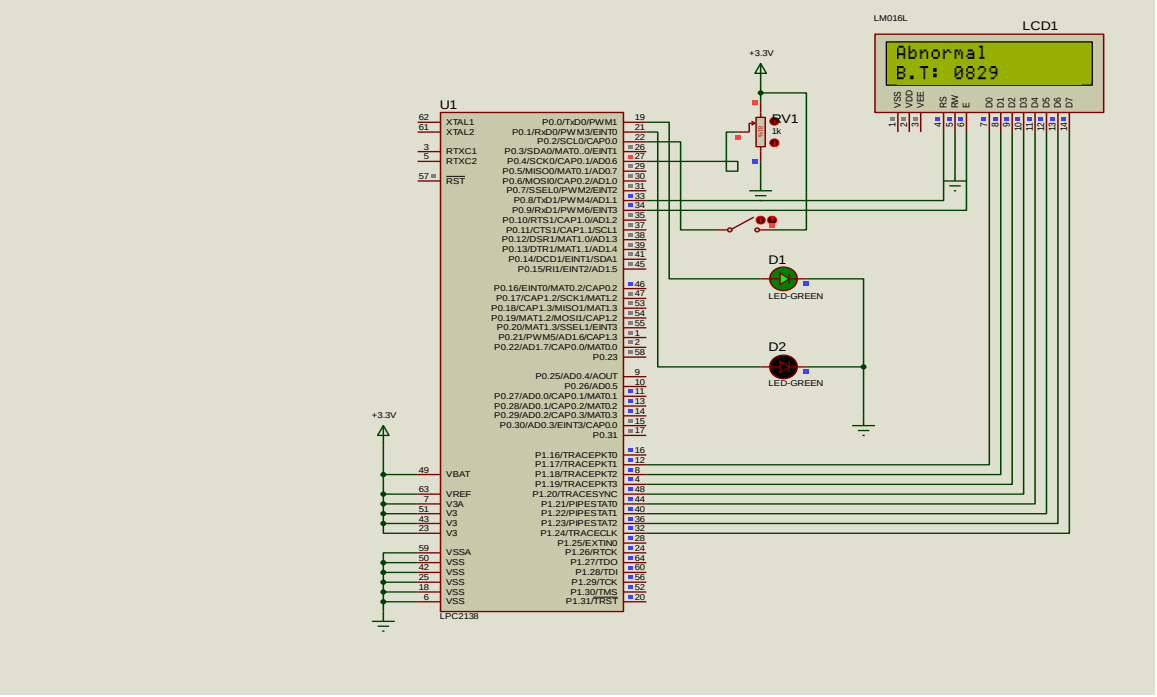

Figure 5. Simulation Output of pacemaker system for abnormal condition

During the operation of switch, if the switch is not closed for the ample needed time, it results in abnormality in pulse reading. In order for the heart beat sensor to read the pulse of a person, it requires the person to place it for a minimum of 30 seconds to detect the blood flow

IV. CONCLUSION

In this work, the design of a fail-safe dual chamber rate responsive cardiac pacemaker is implemented that can be configured and monitored by the doctor by secured wireless communication method. The unit will monitor the electrical activities of heart and it will maintain an adequate heart rate, if the heart's natural pacemaker is not fast enough, or there is a block in the heart's electrical conduction system. The simulation of pacemaker system is done under normal working condition of human heart and under abnormal condition and body temperature parameter is also noticed. The implementation detailed are synthesized using the Proteus ISIS with keil µVision. Heart beat sensor is used to measure the heart rate and it is designed to give digital output of heart beat when a finger is placed inside it. This digital output can be connected to ARM processor directly to measure the Beats per Minute (BPM) rate.

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