Implantable cardioverter defibrillator with IOT and wireless charging

[1]T.Vishnu Kumar, [2]D.Sathyakala, [3]Andreena Joseph, [4]V.Suresh Kumar
[1]Assistant Professor, Department of EEE,[2]Assistant Professor, Department of ECE, [3]Assistant Professor, Department of BME, [4]Assistant Professor, Department of EEE
[1]K. Ramakrishnan College of Technology, Trichy, Tamilnadu, [2]Dhanalakshmi Srinivasan Engineering College, Perambalur, Tamilnadu. [3]Rajiv Gandhi College of Engineering, Chennai Tamilnadu, [4]K.Ramakrishnan College of Technology, Trichy, Tamilnadu

Abstract:

Implantable cardioverter defibrillator is a life-saving system powered by batteries that has several features such as controlling heart rhythm, pace making and defibrillation. In order to maintain an appropriate heart rhythm, the ICD may administer tiny electrical pulsing signals and large shocks to the hypertrophic cardiomyopathic person or center of a congestive heart collapse.[1] In order to identify the abnormality the implantable cardioverter defibrillator (ICD) tracks the heart beat and its cycles. Once the ICD senses an abnormality it sends the necessary signals to the heart and maintains its normal operation. At worse cases like arrhythmia, implantable cardioverter defibrillator is designed to produce large shocks that induce fibrillation and allow the normal pulse to recover At worse cases like arrhythmia, implantable cardioverter defibrillator is designed to produce macro shocks that induce fibrillation and allow the normal rhythm to recover. The system tests the exclusive parameters of heart such as precision diastolic and systolic pressures. Since it is possible to drain the ICD battery very easily by incorporating both of these applications, wireless charging technology is introduced in the system to prevent battery replacement surgery including the complications and expenditure involved with the surgery reduces.

I. Introduction

The implantable cardioverter defibrillator is a system that measures heart activity and is sensitive [2]. ICDs have pacing modes, in which the system regularly emits a slight electrical pulse to heart and defibrillation, in which the instrument sends a macro shock to restore natural heart rhythm. By surgery the doctor inserts the ICD below the clavicle of the patient, and below the patient’s neck. The doctor also inserts electrical wires, which bind the ICD with muscle of the heart. It contributes to transmitting the electrical charge to the heart’s muscles, which can also perform the heart's signals and send it to the circuit. The inbuilted automatic sensors in the device are capable of detecting the signals from heart and transmitting it wirelessly to the post-surgery external processing device module; a doctor may use an external programmer to interpret, read datas stored. Working and analyzing such as tracking, defibrillation and pacemakering, wireless communication exhaust the charge of battery much faster than regular pacemakers do. Therefore wireless charging technology is implemented in the system to compensate for the battery drainage problem, so that the battery can be charged wirelessly. Since the wireless mechanism of charging could eliminate the need for frequent battery change, surgery along with the surgery-related risks and costs

II.Proposed System

The currently existing systems are defibrillation, pace making and wireless charging. We are proposing a framework that incorporates all these innovations to make tools extremely useful to the health industry. In certain situations, the modern pacemaker may only send pacemaker signals on demand or continuous pacemakering to the heart [3]. But the pacemaker fails to control the heart rhythm in case of cardiac arrhythmia. Furthermore, the pace making signal will prove fatal even though cardiac arrhythmia. Therefore a defibrillator was mounted in the system that operates in conjunction with cardiac pacemakers. The ICD senses the condition when the heart encounters an arrhythmia, which provides the heart with macro shocks. This shock rearranges the heart beat, fibrillates the heart and maintains its usual beat in place. The computer records the data about the abnormality and is designed to wirelessly transmit the data to the external module of the receiver.

Pacemaker

The Pacemaker is a micro tool to help monitor irregular heart rhythms that is mounted in the abdomen or chest. This system utilises electrical signals to cause the heart to beat at a normal value. Arrhythmia is treated with pacemakers. Arrhythmias are issues with heart beat rhythm. The heart perhaps beat too slow, or too quickly at an abnormal beat during arrhythmia.

A fast heart beat is called tachycardia. A heart beat which is very sluggish is known as bradycardia. Sometimes heart may not be able to circulate enough blood to the body during an arrhythmia. It can cause symptoms like difficulty in breath, exhaustion or fainting. Those who are suffering with severe arrhythmias may affect the vital organs of the body, and also may cause death or loss of consciousness. Some signs of arrhythmia, such as fainting and exhaustion, can be relieved by a stimulant. In addition, a pacemaker may help a person with irregular heart beat regain a more active life.

Defibrillator

A medicular treatment for cardiac dysrhythmias that endanger life, especially non-permeate ventricular tachycardia and ventricular fibrillation is known as defibrillation. A defibrillator provides a shot of electrical current to the heart. This deenergises a substantial amount of muscle in the heart, relieving the dysrhythmia. Therefore, the bodies own pacemaker is able to restore regular sinus rhythm in the heart's sinoatrial node [7]. Synchronized electric cardio version is an electrical signal given to the heart rhythm in synchrony. Even though the person may still be in critical condition, cardio version generally focus to end poorly permeate cardiac dysrhythmias, like supraventricular tachycardia.

Integration of Pacemaker defibrillation.

Defibrillator and Pacemaker are two separate instruments before implantable defibrillator cardioverters were invented. Pacemaker is an autonomous tool in this proposed program that produces pace making signal which is continuous square wave, and defibrillator provides heart muscle stimulation that helps to combat fibrillation [4]. When incorporating both the defibrillator and pacemaker, the person has much more chances of recovery from heart failure relative to other non-ICD patients.

Wireless charging

An ICD's operating device consists of a battery that must be changed in about every 14 years at least. If this ICD has been introduced to a 10-year-old patient with the latest technology, then the cell or battery must be changed at least more than three times (consider a minimum life span of 40 years). The expensive of battery or cell replacement surgery is high and the surgical risk is also very high. So with respect to the current system, the key change in the new program is the introduction in charging the implantable cardioverter defibrillator wirelessly

III. Block Diagram

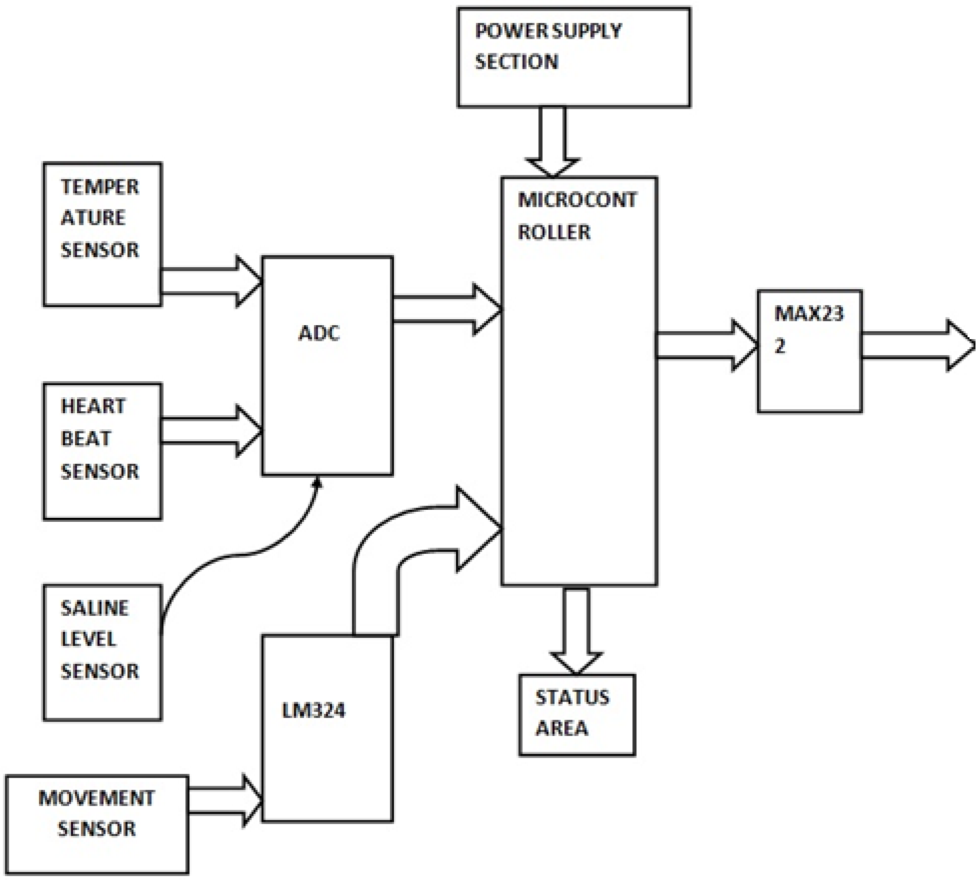

Figure 1: block diagram

Design of coil

The main component of the entire unit is transmitter and receiver coils, which determines if the machine is working well. We constructed a bi-layer coil to make the two inductive coils more closely coupled together. The bi-layer coil has fourfold inductance relative to the monolayer coil, and just half the resistance of the single layer coil. The two-layer coil then has twice the power factor (p.f) of the single layer winding, hence the elevated coupling of both winding.

IV.Circuit connection

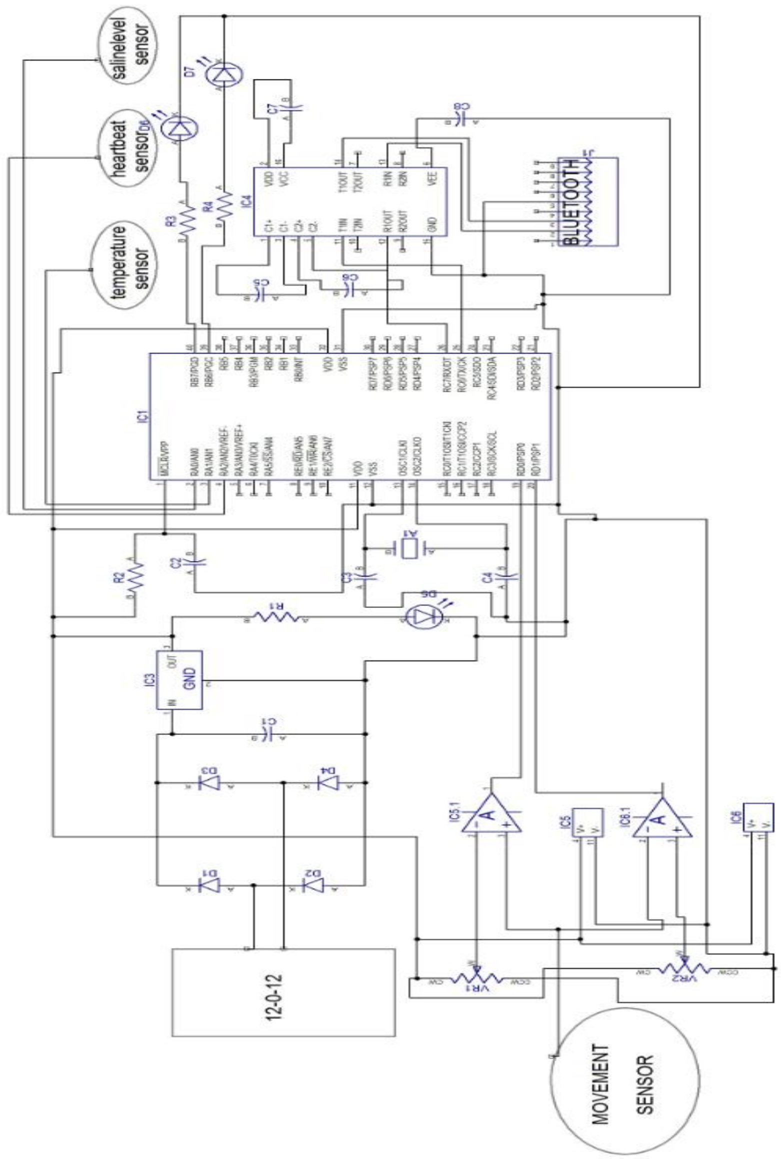

Figure 2: circuit connection

Circuit design

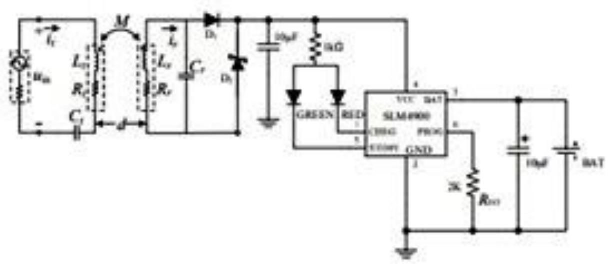

Figure 3: Circuit of the wireless charging

The connections of Wireless Charging circuit are shown in Fig. 2. An 8 mm air gap separates both the main and secondary coils. The entire apparatus constructed with four sections. The important component is the battery which is energy source, contains a signal amplifier and a signal generator which gives the device with a A.C voltage of 200 kHz.

The other part consists of the coupling winding and their balancing sub circuit, the system has been in series-parallel combination model. This model is very easy to adjust for getting higher voltage in the secondary side. The other part consists of a zener diode and a schottky diode to rectify and for the last part to be a 5V DC power source. The main last component is the charging circuit of IC SLM4900 and its sub circuit and it can recharge a single 4.2V Lithium-ion battery.

Selection of Battery

The battery charging process shouldn't last too long because of the heating of the coils and the patient's psychological condition. In addition, 30 minutes could be sufficient so the Li battery capacity should be selected considerably [5],[6]. From the data, the 0.95Ampere Hour one-chamber Li pacemaker battery could last 10.5 years and the 1.4Ah two-chamber pacemaker lithium battery could last 11.5 years. We have therefore finally chosen a 1060 mAh Li battery and intend to recharge the cell or the battery when its remaining charge declines to 75%. The longevity of the battery is shown in equation 8766 L = Q I Del where I is the pacemaker's current production, normally 10µA, L is longevity of the battery. From the above equation our battery's 20 per cent power will last for 2, 39 years. Should not "imply" and "infer" the ambiguity.

The two coils are constructed from printed circuit board (PCB), making their inductances stable and simpler to account for. The transmitter coil is the standard plane circle design, while the receiver coil needs to match the pacemaker’s surface, so its form is different. Additionally, the receiver coil applies the special flexible print circuit, which can bend in 360 °, so that it can match the pacemaker’s surface better.

Charging curve

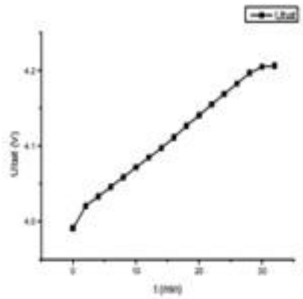

Figure 4: Charging curve

The power source frequency was 200 kHz, and Li battery initial voltage was 3.8912V. The input voltage Vin, calculated in the experiment, was 26.5V and the current input I was 4.7A .The battery charging curve is displaced in Fig., The entire cycle lasts up to 30 to 32 minutes, and the battery voltage rose from 3.8912V to 4.2060V, to the estimate..

V. Conclusion

This work concentrate on a single ICD, and thus offers just a limited snapshot of the evolution and scope of ICD innovations and more general implantable medical devices. Nonetheless, we assume this snapshot is important to evaluate the current ICD modernization trajectory. The avoidance of costs, time and uncertainties was the key aim as we establish multi-technology integration. The big problem from which the patients die worldwide is the heart disease. More development and application of this technology would have an immense effect on patients suffering from serious heart diseases.

Reference:

[1] L. G. Robinovitch, “Resuscitation of electrocuted animals. Choice of the electric current and method used and application to human beings. Experimental study of the respiration and blood pressure during electrocution and resuscitation,” *J. Ment. Pathol.*, vol. 8, no. 2, pp. 74–81, 1907

[2] W. Greatbatch and C. F. Holmes, “History of implantable devices,” *IEEE Eng. Med. Biol. Mag.*, vol. 10, no. 3, pp. 38–41, 1991.

[3] L. A. Geddes and E. E. Bakken, “Who first performed cardiac pacing: Why, when and where?” *IEEE Eng. Med. Biol. Mag.*, vol. 26, no. 3, pp. 77–79, 2007.

[4] L. A. Geddes, “A short history of the electrical stimulation of excitable tissue. Including electrotherapeutic applications,” *Physiol.*, vol. 27, no. 1, p. 47, 1984.

[5] V. S. Kumar, S. Arunraj and A. N. Ali, "Hybrid battery charging system for electric Vehicles," 2017 International Conference on Intelligent Sustainable Systems (ICISS), Palladam, 2017, pp. 314-319.

[6]Dr.A.Rajkumar, R.JaiGanesh, V.SureshKumar, T.VishnuKumar and T.RamKumar,” Implementation of High Efficient Single Input Triple output DC-DC Converter,” Biosc.Biotech.Res.Comm. Special Issue Vol 13 No (3) 2020 Pp-48-55

[7] D. C. Schechter, *Exploring the Origins of Electrical Cardiac Stimulation.* Minneapolis, MN: Medtronic, Inc, 1983.