An Improved Novel Wireless power transfer method for Pacemakers

[1]**Mrs.Sritha.P**, *Assistant Professor, Department of EEE, Bannari Amman Institute of Technology, Sathyamangalam,Tamil Nadu, India*

[2]**Mrs.Maheswari.K.T**, *Assistant Professor, Department of EEE, Bannari Amman Institute of Technology, Sathyamangalam, Tamil Nadu, India*

---***---

Abstract— The wireless power transfer for medical implants examines transmitter optimization for wirelessly powering a small implant embedded in tissue. The design of a Wireless Power Transfer (WPT) system based on magnetic resonant coupling, in which the secondary is located inside the body of the human connected to a battery recharge system of an active implantable medical device. Since Wireless Power transfer technology (WPT) gains its popularity in broad range of applications like medical implant systems such as wireless capsule endoscopy. The scope of the project is to implement the Wireless Power Transmission technology for charging pacemakers which is implemented in heart of human body reduces the complexity of the patient. It also minimizes the healthy and safety risk factors and cost as there is no use of transmitting wires. This technology reduces the complexity of the system and makes the system portable.

Key words—WPT, Endoscopy, Pacemakers, and Transmitter

1. INTRODUCTION

The development of Implantable medical devices for sensing the malfunction of internal organs, local stimulation and delivery of drug has played a major role in modern medicine. These devices helps patient to manage a broad range of medical disorders through preventive and post-surgery monitoring. These types of devices depend on Batteries for their DC power for effective function and needs replacement of batteries in due course time. The wireless delivery of power transfer to the batteries has reduced the risks associated with battery replacement and enable miniaturization of the implant. This project deals with the implementation of wireless power transfer especially in case of pacemaker device used in heart problems.

1.1 Structure and Function of Heart

The heart is a highly efficient pump with four chambers. The two chambers on the right side of the heart receive oxygen-poor ('blue') blood from the body and pump this blood to the lungs, where it receives oxygen. The oxygen-rich ('red') blood returns to the left side of the heart, and the two left chambers pump this oxygenated blood to the rest of the body. The lower (major) pumping chamber, called the ventricles, receive blood from the top chambers, the atria, and do the hard work of pumping the blood to the other parts of the body. In a normal heart, the atria contract (squeeze) first, pushing blood into the ventricles. The ventricles then contracts, pumping the blood out to the lungs and the rest of the body. This process repeats at a regular rate, usually around60 to 100 times every minute.

In a normal functioning heart, the pumping action is synchronized by the sino atrial (SA) node or sinus node, which sends the controls the rate of heart by sending electrical signals which makes the contraction and expansion of heart.

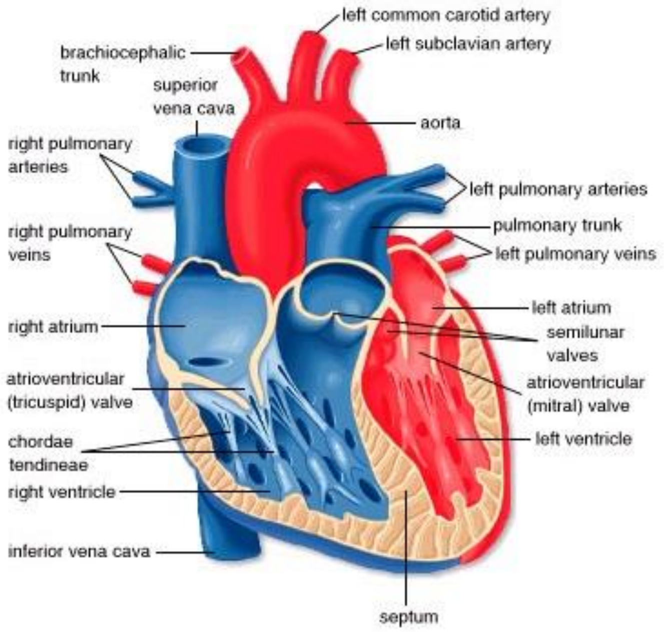


Figure: 1 Structural Diagram of Heart

Unfortunately if sino- atrial node stops, it leads to heart stroke. As the impulse moves away from each chamber of the heart, leads to atrial fibrillation. These arrhythmias can be very serious, causing blackouts, heart attacks, and even death.

1.2 Importance and need for Pacemaker

An artificial electronic pacemaker is a medical embedded device which uses electrical impulses, delivered by electrodes contacting the heart muscles, to regulate the beating of the heart. A typical pacemaker consists of two parts, namely the computer part and the pacing wire. The computer part is featuring the required electronic components and the battery for the power supply. These parts of the pacemaker are contained in a small metal box, usually made out of Titanium. The metal box itself is about the size of a match box. The second part of the pacemaker, called "pacing wire" is pacing the heart's rhythm and used to forward impulses from the computer part whenever a patient's heart needs them according to the predefined discharge rate.

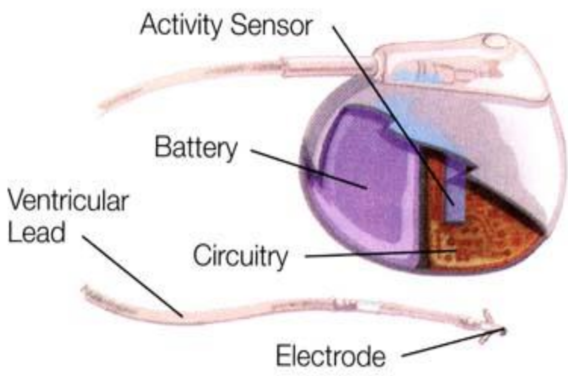


Figure: 2 Diagram of Pacemaker

They are extremely flexible to withstand any twisting and bending caused by body movement. The actual contact to the heart is carried out through a metal electrode on the end of the lead. A lead is serving two purposes. First, the pacemaker monitors the electric activity of the heart and second, it stimulates the heart by electric impulses. Therefore, a pacing wire works as a sensor and actuator at the same time. State-of-the-art pacemakers weigh a little less than 50 grams.

1.2.1Types of Pacemakers

(i) Single chamber pacemakers

Single chamber pacemakers set the pace of only one of the heart s chambers, usually the left ventricle, and need just one lead.

ii) Dual chamber pacemakers

Dual chamber pacemakers set the pace of two of heart's chambers and need two leads. These are more comfortable and use information about the electrical activity of the atria to set the ventricles pumping rate [3].

iii) Biventricular pacemakers

Biventricular pacemakers use three leads, one in the right atrium (one of the top pumping chambers in your heart) and one in each of the ventricles (left and right). Biventricular pacemakers are a newer type of pacemaker and are complex devices.

1.2 Significant parameters of Battery

The lithium/iodine-polyvinyl pyridine battery used as a power source for cardiac pacemaker. The battery chemistry provides a long shelf life and high energy density. Lithium Iodine has two characteristics that make it an excellent power source for cardiac pacemaker applications. (1) The self-discharge rate is very low resulting in a long shelf life. (2) It has a stable voltage through much of the useful life then tapers down in a gradual. Its volume is around 11.2 cm3 & voltage is 2.80v under no load with nominal capacity 2.3 Ah, energy density 530Wh/dm3, 200Wh/kg. It get self -discharge of less than 10% in 10 years.

LITHIUM BATTERY	SPECIFICATION
NOMINAL SIZE	23*45*13.5 mm
VOLUME	11.2 cm3
Weight	30 gm
Density	2.7g/cm3
Lithium area	17.1cm2
Voltage	2.80V under no load
Nominal capacity	2.3A h
Energy	6.0Wh
Energy Density	200W h/kg
Self discharge	<10% in 10 years
Insulation Resistance	>10 Ω from pin to case
Storage temperature	40 or 50Ċ

Table: 1 Parameters of lithium battery

A battery can last about 7 up to 8 years and they are regularly checked by the patient's doctor and replaced when necessary. Most of today's pacemakers can also work as an implantable cardio-defibrillator (ICD), i.e., the pacemaker can also serve as a defibrillator. A defibrillator detects cardiac abnormality and immediately corrects it by causing an electric shock. The procedure of implanting the pacemaker usually takes about 1 hour and most patients are allowed to leave hospital within 1 day after the surgery.

2. LITERATURE SURVEY

One of the major drawbacks in the implantable device is the charging of batteries. The batteries can last only up to 5-6 years. The replacement of batteries can be done only by the surgical procedure.

With the advancement of technology, alternatives can be used for surgeries. To recharge the battery, body energy harvesting techniques may be employed. Some of the power sources are heartbeat, blood flow inside the vessels, movement of the body parts, and the temperature of body (heat). Various types of sensing devices are employed to sense the energy from body parts. The piezoelectric and semiconductor coupled nano wires are used to convert the mechanical energy into electricity. The nano generators are used to convert the hydraulic energy in human body to electrical energy. Another way is to use bio-thermal battery which generates electricity from the body heat using multiple arrays of thermoelectric generators built into an implantable chip. These generators exploit the well-known thermocouple effect. For the bio-thermal device to work, it needs a 2°C temperature difference across it. But there are many parts of the body where a temperature difference of 5°C exists – typically in the few millimeters just below the skin, where it is planned to place this device. Optimizing the transmitter for power transfer efficiency can enable the efficient power delivery by reducing the temperature of tissue [5]. But this system produces lot of heating to the tissues.

The theory and development of resonant coils which works on the magnetic coupling and EMI is often used for transmitting power and data to the implantable device. Electromagnetic interference (EMI) can be defined as any signal, either biologic or non-biologic, that falls within a frequency range that can be detected by the implantable device. If we transmit the power in low frequencies, the tissue will not absorb the power effectively. Further if the power range is increased, it will lead to the increase of temperature in tissue. The wireless link between the transmitter and receiver is based on inductive coupling. Since the wave length is much longer than the transmitter and receiver needs the optimization techniques. Due to this the fields can be redistributed in tissue by the appropriate choice of transmitter.

The device uses both inductive and radiative transmission of power to function. A transmitter sends radio waves to a coil of wire inside the body, which produces enough charge to power tiny devices. However, it was assumed large wire coils were necessary to cope with substantial amounts of charge, but it is found that power can shoot through human tissue at up to 1.7 billion cycles per second at high frequencies. In this high-frequency range, we can increase power transfer by about 10 times over earlier devices. This means that the size of the implanted antenna which receives wireless power was shrunk by ten times, and the same current was transmitted. In context, one millimeter coil can generate over 50 microwatts of power at the team's optimum frequency, but a standard pacemaker only needed 8 microwatts.

3. PROPOSED TOPOLOGY

3.1 Block diagram of proposed system

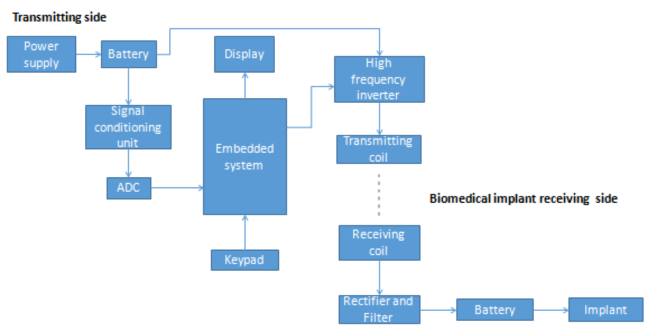


Figure: 3 Block Diagram of Proposed Method

3.2 Principle Of Operation

- Electromagnetic induction principle is used where there is a transmitting and a receiving side.
- The dc power is given to various blocks for operation. Embedded system is used for controlling the operation. The dc power is converted to ac using high frequency inverter and is transmitted using coils.
- The transmitted ac is again converted to dc and stored in the battery located in the pace maker.

3.3 Methodology of Proposed System

- In the present day medical technology, pacemaker is used to control abnormal heart rhythms. This device uses electrical pulses to prompt the heart beat at a normal rate. It has a battery which has to be replaced after a specified time. This project aims at the charging of the battery using wireless technology.
- In this system embedded system plays a major role. This system consists of two sections one is a transmitting side and another one is biomedical implant receiving side.
- Transmitting side consists of embedded system, Battery, SCU, ADC, High frequency inverter, Display, Keypad, Transmitting coil and power supply. Biomedical implant section consists of Receiving coil, Rectifier & filter, implant and Battery.
- The keypad signal is given through an embedded system. Embedded system programmed to receive a signal from keypad, when embedded system is activated to the High frequency inverter.
- High frequency inverter is used to control a high frequency inverter. In this high frequency, inverter acts as battery supply that changes direct current (DC) to alternating current (AC). HF inverter is given through transmitting coil.
- Voltage sensor senses voltage level of the battery is sensed by the analog sensing units. This signal is given to Signal conditioning unit. SCU is used to reduce the voltage level which is tolerable to the embedded system. The signal from the SCU is given to the ADC. ADC is used to convert the analog signal to the digital signal. The digital signal is given to the embedded system. Embedded System is programmed like display the battery voltage measurements value.
- A wireless power transfer system for the biomedical applications is usually composed of a power transmitter outside of the human body and a power receiver inside of the body or patched on the human skin.

- The wireless power is transferred from the power transmitter to secondary power antenna through air without any electrical wire.
- The function of the receiving coil is to receive the wireless power and given through rectifier and filter. Rectifier and filter is used to convert AC to DC signal and remove noise to stored battery.
- Battery is connected through powered medical implanting devices. Power supply is used to given the power on all entire units in the components.

4. RESULTS & CONCLUSIONS

4.1 Schematic diagram of proposed system

The schematic diagram of the proposed system is shown in the below figure. The main components used in the power supply unit are Transformer, Rectifier, Filter, and Regulator. The 230V ac supply is converted into 12V ac supply through the transformer. The output of the transformer has the same frequency as in the input ac power. This ac power is converted into dc power through the diodes. Here the bridge diode is used to convert the ac supply to the dc power supply. This converted dc power supply has the ripple content and for the normal operation of the circuit, the ripple content of the dc power supply should be as low as possible. For this purpose filters are used. The dc supply is given to the Microcontroller circuit. The coding for the microcontroller is written in Embedded C. voltage sensors sense the voltage of the battery. The wireless power is transferred from the power transmitter to secondary power antenna through air without any electrical wire.

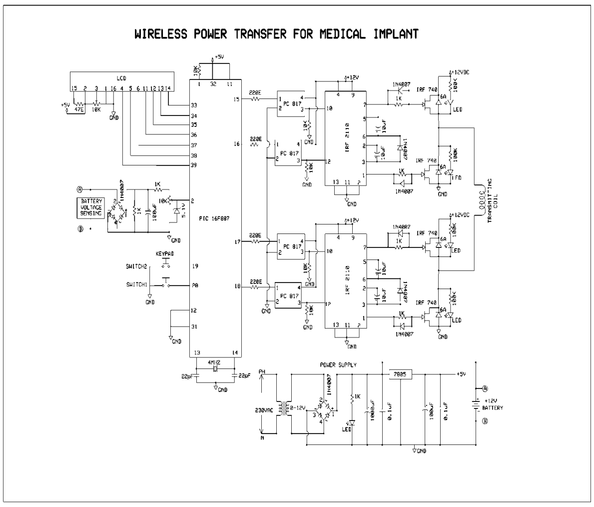
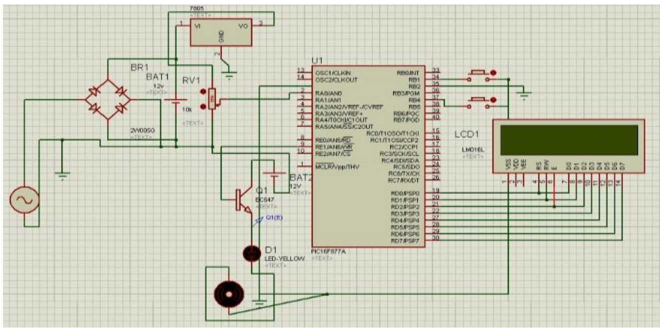


Figure: 4 Schematic Diagram of proposed System

4.2 Results of stimulation circuit

Pacemaker uses electrical impulse to regulate the beating of heart or to reproduce the rhythm of the heart beat. It will promote the pulse to the heart rate that is slow. The 5V battery gets operated only when the heart beat rate gets lower. The normal heart has 60 to 100 beats a minute .If the ratings go below this then the battery gets operated correspondingly it will initiate the transistor and it consumes around 1.5V. The LED consumes about 1V. And finally the motor that is the pacemaker operate at 2.5V. The human body can withstand upto 110v to 220v depends on body condition of the person.



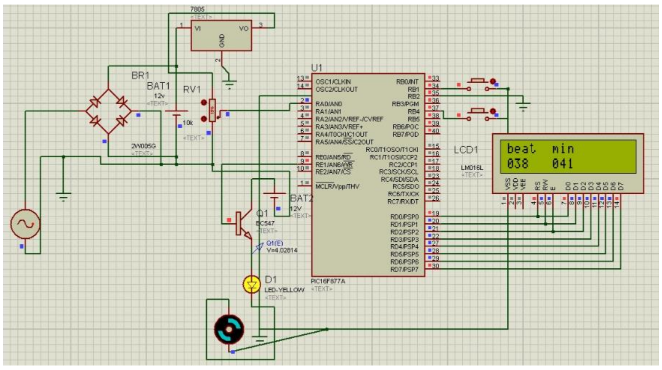


Figure: 5 Simulation Diagram of proposed System

4.3CONCLUSION

This project results in efficient design of artificial pacemaker to enhance the heart beat without using transmitting wires. Thus, it reduces the human burden to a larger extent as the device need not be replaced once it is embedded inside the human system. It is also very economical in the receiver point of view. So, this technology has a best scope in the future which can be implemented in medical technologies.

REFERENCES

1. Chiao.M, Mirabbas. & S RamRakhyani.A,Feb2011,"Design and optimization of resonance-based efficient wireless power delivery systems for biomedical implants," IEEE, vol. 5, pp. 48 –63.

2. http://anatomyofthefoot.com/diagram-of-heart-valves.html

3. Dr. morris kesler, "Highly Resonant Wireless Power Transfer: Safe, Efficient, and over Distance", Witricity Corporation, 2013.

4. Thomas Roy Crompton, "Battery reference book", Newnes, 2000 - Technology & Engineering

5.http://web.mit.edu/newsoffice/2011/power-fromvibrations-0914.html

6. Qazi Saeed Ahmad,Tarana A.Chandel,Saif Ahmad, "Wireless Power Transmission to Charge Pacemaker Battery"

7. Donaldson N.N. and Perkins.T,Sep 1983, "Analysis of resonant coupled coils in the design of radio frequency transcutaneous links," Med. Biol. Eng. Comput., vol. 21, pp. 612–627.

8. Ghovanloo.M and Jow.U Sep 2003, "Design and optimization of printed spiral coils for efficient transcutaneous inductive power transmission," IEEE Trans. Biomed. Circuits Syst., vol. 1, pp. 193–202.

9. Hochmair.E.S.,"System optimization for improved accuracy in transcutaneous signal and power transmission," IEEE Trans. Biomed. Eng., vol. 31, pp. 177-186 .

10. I. C. Forster, "Theoretical design and implementation of a transcutaneous, multichannel stimulator for neural prosthesis applications," J.Biomed. Engng., vol. 3, pp. 107–120, Apr. 1981.