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Variable Frequency on Wireless Power Transfer for Pacemaker using Embedded Technology

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Abstract - ***As the development of implantable devices have become increasingly popular in modern medicine. These devices have a wide range of applications, such as health monitoring, disease prevention, delivery of a therapeutic regimen, biomimetic prosthesis, electrical stimulation of nerve tissue and recording of neural electrical activity are the basis of emerging prostheses and treatments for spinal cord injury, stroke, sensory deficits, and neurological disorders. The development of implantable biomedical devices, the rechargeable battery is applied to improve the life of implantable devices. Inductive transcutaneous power transfer, as a suitable way of charging the implantable rechargeable batteries, is widely used. In this paper, a model of inductive transcutaneous power transfer is set up to descript the relationship with coupling coefficient, load resistance and conversion efficiency.***

Key Words: *Implantable medical devices (pacemaker), wireless power control (microcontroller), Wireless power transfer (coil).*

1. Introduction

Implantable medical devices are usually not long enough, essentially because of the limitation of the battery capacity. Traditionally, primary (non-rechargeable) batteries are used in implantable devices with heavier weight, bigger volume and shorter lifetime compared with rechargeable batteries. Rechargeable battery is the only choice to increase the service life and decrease the annual cost. Inductive power transmission on coupling coils is considered as a suitable way of transcutaneous power supplying. Most of these studies were focused on the optimization of transmission, considering the efficiency and stability of inductive link [1]. The effect of coupling coefficient in inductive link and the circuit design to acquire a better efficiency of inductive. To get a stable voltage or efficiency, many circuits and systems were presented [2-5].

One coil is placed outside the chest and is fed with an electromagnetic field, while monitoring the output on a specifically designed multi-bundle concentric coil to be implanted inside the body [6, 7]. It is assumed that the proposed coil should be easier to implant to the chest wall and is less prone to possible misalignments of the outer and internal coils, easier to isolate with a biocompatible material and most important, the feasibility of a much better heat dissipation scenario [8-10].

1.1 Literature review

A literature review identified WPT for pacemaker that were successfully demonstrated or deployed. We realize that Wireless Energy Transfer & Electricity may play a significant role in the future in the field of Transmission of Electric power. Traditional implantable batteries and percutaneous cords are suffering from low reliability and high infection risk. The WPT is promising way to safely provide more energy or enabled longer life time for pacemaker application.

In these reviews, many kinds of specialized antenna and circuit techniques have been developed to improve the transfer and conversion efficiencies, reduce system size, and promote system stability and so on. Wireless electricity delivered safely, efficiently, and over distance has the potential to in a new generation of medical devices.

2. Wireless power transmission system

2.1 Architecture

Fig. 1 shows the architecture of the Wireless Power Transmissions [13] for pacemaker device .On the left, the power transmitter which is connected to the electrical grid, on the right the power receiver which is integrated into the load device is shown. In both the power transmitter and the power receiver, the key element for signal transfer is represented by a resonant tank, comprising both coupled inductors: on the transmitter side, there is the primary coil; on the receiver side, there is the secondary coil. The signal flow does not only consist of the power signal from the power transmitter to the power receiver, but also of communication data streaming in the opposite direction by Micro-controller [12].

The basic principle involves converting the AC power to DC power using rectifiers and filters and then again converting it back to AC at high frequency using inverters. This low voltage high frequency AC power then passes from primary to its secondary coil and is converted to DC power using rectifier, filter and regulator arrangement.
From power supply transmits a low noise AC signal at 1MHz into space while the **loop coil antenna** of the receiver captures it to convert it into electricity. Output of receiving antenna is to be connected to charging circuitry which converts high frequency AC signal to DC, to get more of output voltage.

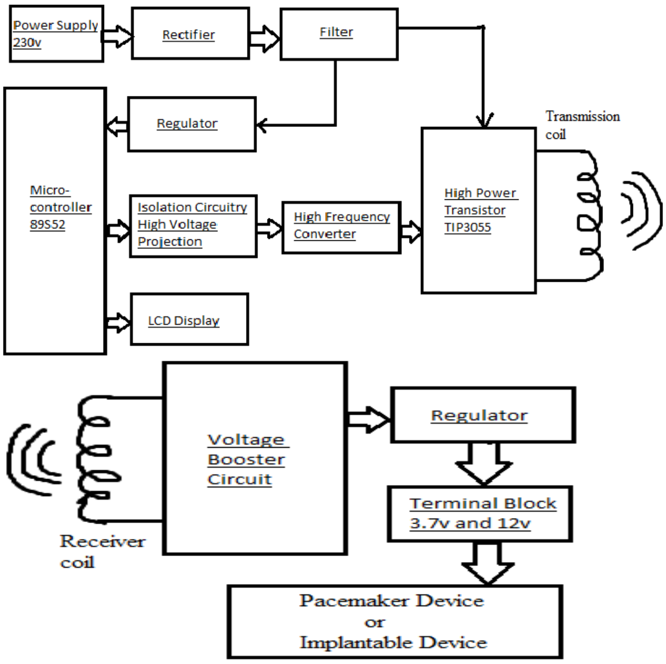

Fig -1: Architecture of WPT

The impedance of a small loop is inductive. The radiation resistance can be increased by adding more turns to the loop. We can also significantly increase the radiation resistance of a loop by placing a suitable piece of Ferrite material inside the loop.
Voltage Booster circuit is to be connected which rectifies as well as doubles the voltage present at input, number of stages used is directly proportional to number of times voltage booster. Finally required output is to be taken at multi stage voltage booster end.
The smoothing can then be improved by adding additional stages of capacitor–resistor pairs. While the voltage is smoothed, as described above, current will flow through the bridge only during the time when the input voltage is greater than the capacitor voltage. This non-sinusoidal current leads to harmonic distortion and a poor power factor in the AC supply. In a practical circuit, when a capacitor is directly connected to the output of a bridge, the bridge diodes must be sized to withstand the current surge that occurs when the power is turned on at the peak of the AC voltage and the capacitor is fully discharged. Sometimes a small series resistor is included before the capacitor to limit this current, though in most applications the power supply transformer's resistance is already sufficient. Output can also be smoothed using a choke and second capacitor. The choke tends to keep the current (rather than the voltage) more constant. Due to the relatively high cost of an effective choke compared to a resistor and capacitor this is not employed in modern equipment. It is a three pin IC used as a voltage regulator. It converts unregulated DC current into regulated DC current.
The capacitor filter is also used where the power-supply ripple frequency is not critical; this frequency can be relatively high. By doubling the frequency of the rectifier, you reduce the impedance of the capacitor by one-half. This allows the ac component to pass through the capacitor more easily. Remember, the smaller the XC of the filter capacitor with respect to the load resistance, the better the filtering action. The largest possible capacitor will provide the best filtering. Remember, also, that the load resistance is an important consideration. If load resistance is made small, the load current increases, and the average value of output voltage decreases.
The Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. One is scanning and controlling. Controller checking transmission ready or not and control the power. The amount of transmitted power is controlled by varying the frequency and duty -cycle of the full-bridge stage.
Full-bridge arrangement to achieve full-wave rectification. Frequency (up to 1MHz) wave can easily travel through the media but it also loses some energy. So our key objective is to rectify the circuit and to rectify the waves at the low cost. And also we have to make the detection more sensitive. As we know that bridge rectification is more efficient than the single diode we use this for the better performance. We use the shottky diode to get the batter impedance. The output of bridge rectifier has two output devices one for pacemaker 3.7v and other for any device which is drive on 12v DC.
Power converters have a lot of protective circuitry in addition with circuit to reduce noise. In fact, it is for safety regulation. Any power-conversion circuits use a transformer to isolate the input from the output, which prevents overload of the circuit and user injury. As mentioned due to an advantage of getting more voltage at output than the input voltage booster circuit is chosen to be used.
Complementary Silicon Power Transistors TIP3055 are designed for use in general purpose power amplifier and switching applications.
Air-core transformers used at low frequencies, such as 60 hertz and 400 hertz, require a core of low-reluctance magnetic material, usually iron. Most power transformers

are of the iron-core type. An electromagnetic coil is formed when a conductor is wound around a core or form to create an inductor or electromagnet. In our set-up : Primary coil- two 9 turns in parallel – 9 cm diameter, Secondary coil- 36 turns, 9 cm diameter.

2.2 Pacemaker

A pacemaker is the small device that is implanted under the skin. The pacemaker continuously monitors your heart, and if it detects a slow heart rate, it sends out small undetectable electrical signals to correct it. Pacemaker helps your heart beat more regularly. It does this with a small electric stimulation that helps control your heartbeat. Your heart has its own internal electrical system that controls the rate and rhythm of your heartbeat. Pacemakers use low-energy electrical pulses to overcome this faulty electrical signaling.

2.3. System Block Diagram

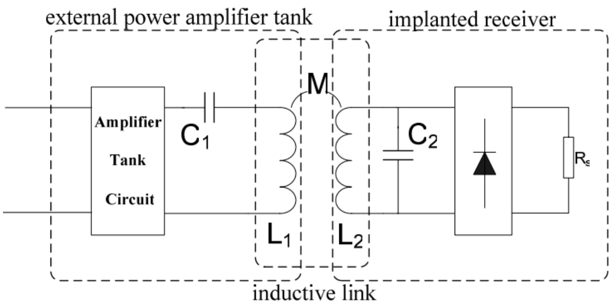

Fig -2: Block diagram of the WPT

As shown in Figure 2, Faraday's law of induction is a basic law of electromagnetism that predicts how a magnetic field will interact with an electric circuit to produce an electromotive force (EMF). The basic topology of wireless power transformer consists of three parts: external power amplifier tank circuit, wireless inductive link and implanted receiver. Magnetic field for inductive link. The receive coil in receiver can gain power from the magnetic field. Due to the employment of mutual inductance (M in figure2) in inductive link, there are leakage inductances in both sides. Both the external power amplifier tank circuit and the receiver were added capacitors in series or in parallel with the coil in order to compensate the leakage inductances. To get a higher voltage in the primary coil, a capacitor in series (C1in figure2) is employed in the external circuit. In the receiver, both the series and parallel capacitor were suggested in many articles. In our experiment, a capacitor in parallel (C2in figure2) is employed, and the load get power after rectifier [11].

3. Result Analysis

From the results of experiment, a higher mutual inductance or coupling coefficient should be applied for higher conversion efficiency. As energy efficiency largely depends on the load resistance, it should be concerned that the variation of load and optimization of it. The resistance converter would be employed for a higher efficiency. Focusing on consumption of energy, that most of consumption is consumed on parasitical resistance of external circuit, major on primary coil’s parasitical resistance. So, the most useful and straight method for increasing energy efficiency is to reduce parasitical resistance of external circuit. Energy efficiency largely depends on the load resistance. One useful and straight method of increasing energy efficiency is reducing parasitical resistance of external circuit.

4. Challenges

Thus, providing power to medical implants has been one of the most challenging problems in the system design involving implantable devices. The technical challenges presented by the battery and charging system. The size of the device is limited to about 3 mm in diameter; batteries on this scale have very small charge capacities. The smaller capacity means that the device needs to be designed so that it uses as little current as possible and so that its battery can be recharged wirelessly.

5. Future scope

In future research can be done to increase the distance by considering various parameters like frequency, transmitter and receiver coil size. Research can also be done to increase the efficiency. In future all electronic devices like phones, laptops, electric vehicle, Wi-Fi hotspots, harsh� environments and implantable device all are charge in same time and any place like home, in car, office, in parking garages, at fleet depots, all through wireless chargingWPT.

6. Conclusion

Wireless power transfer has the ability to enable a wide array of medical devices by powering or recharging them safely, efficiently, and over distance. The benefits of using this technology to improving the productivity and safety of patients and healthcare professionals, to improving the reliability and safety of rechargeable medical devices.
For long-term implantation, batteries present a problem due to their size, mass, potentially toxic composition, and finite lifetime. Wireless power transfer (WPT) has distinct advantages over these traditional approaches in enabling implants to operate for an essentially indefinite period of time without the risks of battery replacement surgery or infection from percutaneous wires and allowing the

implants to be drastically miniaturized because of the elimination of batteries.

A variable frequency less then 1MHz wireless power transfer system with a rectifier and wireless power control for biomedical implants is presented. The measured maximum received power and receiver efficiency are 200mW and 92.6%, respectively.

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