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An Efficient Power Transmission Method Using Class E Power Amplifier

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Abstract

Wireless Power Transmission is a technique that transmits power from source to load without any cable. There are many way of power transmission, resonance based power transmission is used now very popularly. This paper presenting the resonance based wireless power transmission with the 96% efficiency. The Matlab simulink is used for simulation and data analysis. The class E power amplifier is used as an inverter circuit for switching the input coil. The graphical analysis gives the idea about the efficiency of the system is higher than other designs. In the simulation load resistor(r load) output voltage is taken as the system efficiency measurement. The spiral coil design study gives the idea of the transmitter and receiver coil design. The pdetool is used to create the spiral.

Key Words:WPT, Pdetool, witricity.

1. Introduction

In 1890 Nikola Tesla finds a technique for powertransfer from one place to another. But this radiative method is not suitable for energy transfer because vast majority of energy is wasted into free space. Directed radiation methods like laser or highly directional antennas can transfer the energy very efficiently. But it requires uninterruptible line of sight and a complicated tracking system in case of mobile objects. Now days, wireless power transmission based researches are again started growing. Unimaginable development of an autonomous electronics makes the researchers to rethink about the wire free transmission. Now a day, different challenges are faced than 1890's [1].The system efficiency depends upon the power transmission from primary to secondary. Omni directional based power transmission provides very low efficiency compared to unidirectional. But the line of sight is needed for unidirectional power transmission system. In the resonant power transmission method, the efficiency is increased because boththe coils have same frequency. In the strongly coupled system, the coils are operated in the coupled resonances. In the journal survey, mention that magnetic coupled coils are more efficient than other power transmission method [2]. It's more suitable for everyday applications because most of the materials do not interact with the magnetic fields.

In the implantable biomedical devices, the wireless power transmission methods are used at present. The biomedical implants are used for diagnosis and treatments, supplying power to these devices are challenging problem [3]. Early days wired methods are used for supply power, now adays wireless methods also used. After the invention of Witricity wireless power transmission technique, it is commonly used in biomedical field. The strongly coupled magnetic resonance method transfer power over a mid range with high efficiency [4]. The same intrinsic resonant frequency exchanges energy efficiently and non resonant objects exchange little energy. The typical Witricity system consists of five sub systems. An RF power source for oscillating the frequency, load, two resonators (source and device), a transmitter and a receiver coils [5].

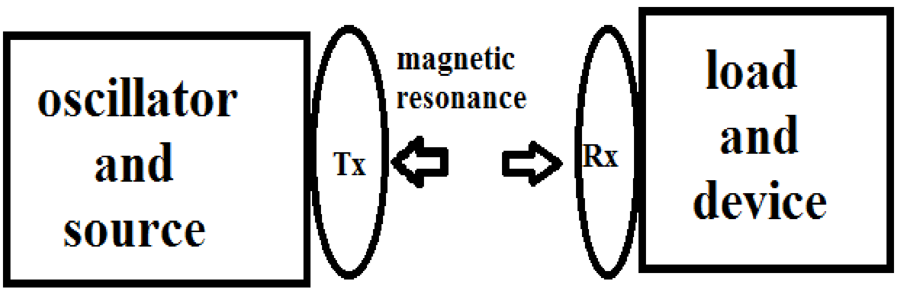

Fig. 1: Block Diagram of Witricity

The RF power source provides energy for the system via transmitter coil. The transmitter and receiver coils are separated within the magnetic resonance range. This range depends upon the frequency and the thickness of the coil used in this system [6&7]. In the conventional inductive methods the power transmission is inefficient when compared to strongly coupled magnetic resonance method. The two resonators are in the mid range proximity then their near fields will strongly couple with each other [8]. This coupling allows transferring the energy focused in a specific frequency from transmitter to receiver with high efficiency. Witricity is a safer method of electrical power transfer between the biological tissues [9&10]. When the magnetic field interacts with living organism only very weekly.In theory, if the source and device have same frequency the resonant LC tank will resonate from the source to receiver coil and it will work like as witricity power transmission system. Here,it is designed that the witricity power transmission system using Mat lab simulation with class E power transmitter. The class E amplifiers are high efficient switching converters. The finite transition time between on and off states of the transistor reduce the switching losses [11&12].

Modules of Wireless Power Transmission System

Mainly there are four modules for wireless power transmission system. They are RF power source with class E power amplifier, transmitter, receiver and load.

1. RF Power Source

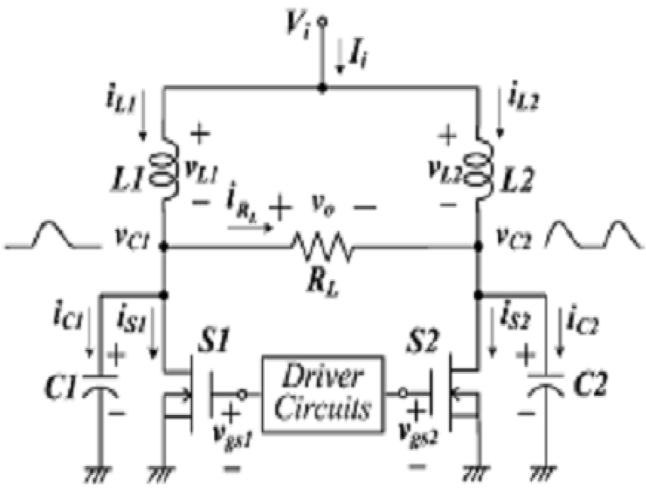

Fig. 2: Basic Push Pull Class E Power Amplifier

The simulated RF power source module has a power source with class E power amplifier.A RF power source utilizes a pulse generator, a DC power supply and class E power amplifier based on two MOSFETs. In the class E power amplifier, the supply voltage is connected to ground via a large capacitor to prevent RF signals leaking into the supply. In this amplifier, a capacitor added in between the transistor and ground and uses a defined inductor connected to the supply voltage. The serial LC compensates and swings back the current into parallel LC circuit. In this stage current going through the transistor is zero and it's in the off condition. The damping oscillation due to coil has been adjusted so that some time later the energy from inductor is gone into the coil, but the energy in both capacitor peaks at the original value to in turn restore the original voltage. Fig (2) shows the basic push pull class E power amplifier, it contains two MOSFET, two inductor and load resistor. Instead of load resistor in the witricity using a power transmitter coil. The driver circuit drives the MOSFET to switching properly without any loss. Switches S_1 and S_2 are complementarily activated to drive periodically at operating frequency $f = \frac{\omega}{2\pi}$.

2. Power Transmitter & Receiver

Three phase transform inductance matrix type is used as the power transmitter and receiver coil in the simulink. The position sequence and mutual reactance are given by

$$X_1(i,i) = \frac{V_{nom\ i}^2}{Q1_i}$$

$$X_1(j,j) = \frac{V_{nom\ j}^2}{Q1_j}$$

$$X_1(i,j) = X_1(j,i) = \sqrt{X_1(i,i).X_1(j,i) - X1_{ij}^2}$$

The self inductance and mutual inductance are computed from the voltage ratios, the inductance component of no excitation current and the short circuit reactance at nominal frequency.

3. Load

The series RLC load block connected as a load in the system and it provides a linear load. The RLC load is a combination of resistor, capacitor and inductor. It exhibits constant impedance at the specified frequency. The power absorbed by the load is proportional to the square of the applied voltage. Nonzero elements are only displayed in the output measurement display. It enables the resistor values and disables all other parameters for the simulation. The capacitor voltage and inductor current set as the option as initial. The parameters have no effect on the block if the reactive power is equal to zero. The output load voltage measured in between the load resistance.

2. Simulation Result

Class E power amplifier based amplifier circuit has used as an inverter circuit for simulation of power transmission. Pulse generators are used for switching the power amplifier. The fig (3) explained the output efficiency. The input voltage is 100V in simulink and the output voltage is 96v. That means the system provides 96% efficiency, compared to the other design proposed work provides more efficient.

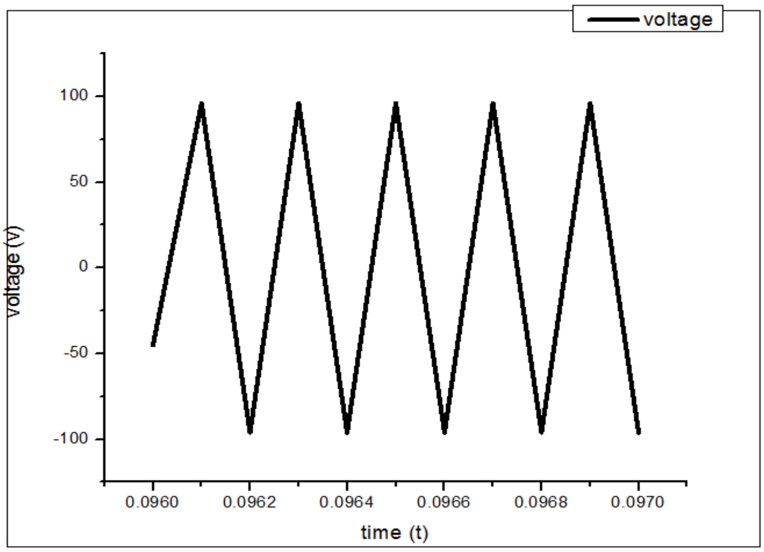

Fig. 3: R Load Output

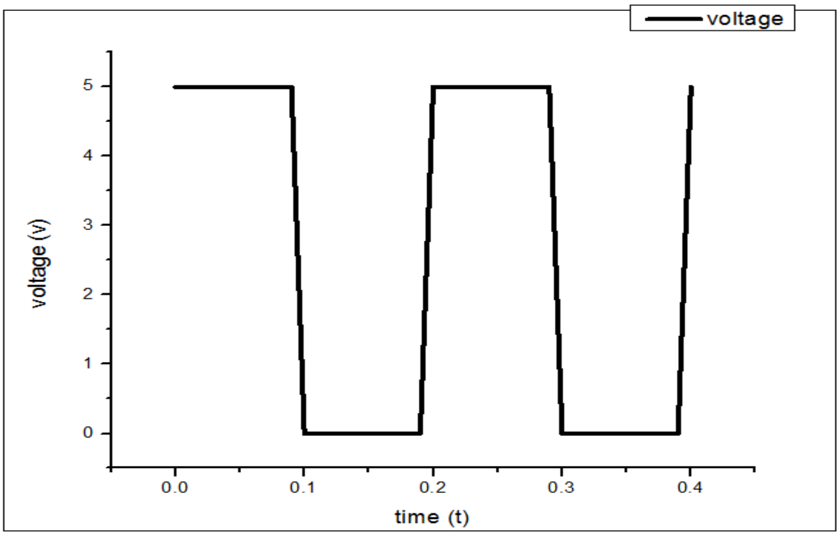

Fig. 4: Switching Voltage

The inverter switches operates simultaneously with 5V. The switching of inverter sharpens the input signal. The resonance based inductance input is conducted to the output coils with same resonance frequency. The output valuesare shows that the system provides high efficiency. The frequency based spiral coil are designed for the resonant response study. The spiral is a very popular geometry in a resonant coupling method. The inner and outer radius and the number of turns are defined by using spiral. Express the geometry by its boundary points and the values are imported to the pdetool. The inner radius is 0.05 and outer radius is 0.15, the number of turns are 6.25 respectively. These values are the basic values for spiral design.

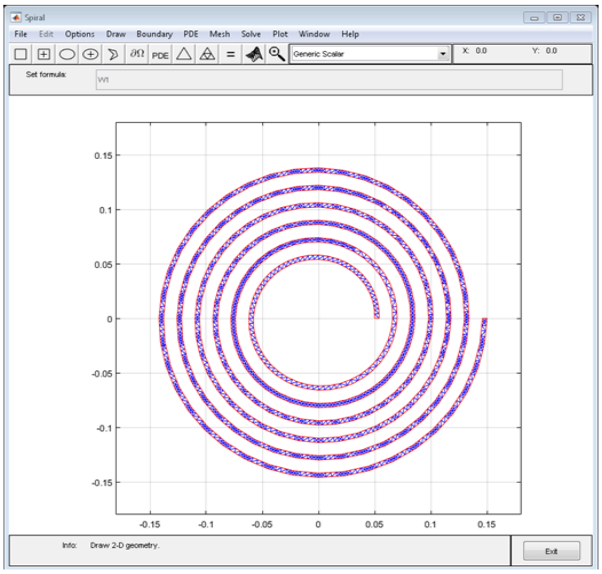

Fig. 5: Spiral Coil Using Pdetool

3. Conclusion

A wireless power transfer system for biomedical implants using resonant inductive link method is presented. The class E power amplifier based design is used for power transmission. Matlab simulink is used for simulation design and circuit analysis. Measurement results demonstrate power transmission of 100v with 96% power transmission efficiency. This power is sufficient to drive many electronic devices. The R load voltage represents the output voltage and it shows how much voltage is received in the load device. The system provides more efficient output power than other designs. The spiral coil is designed for the transmitter and receiver using pdetool. The spiral is a very popular geometry in resonant coupling type wireless power transfer system for its compact size and highly confined magneticfield. The spiral is defined by its inner and outer radius, and number of turns.

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