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# Wireless Power Transfer Technology Using Resonant Technique

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**Abstract.** Wireless power transfer (WPT) is a kind of technology by transferring the electrical energy from a power source to an electrical load without the use of wire or conductor. Nowadays, electricity power is very important in our daily life. People use portable electronic devices to improve their routine work. The portable electronic devices are connected to power socket for their power supply. However, it is not convenient to people due to the length of the wire and they are unable to move far from the power socket. Therefore, the main objective of this project is to investigate a wireless power transfer technology using resonant technique. The proposed model was designed and pre-tested by Multisim. An efficient and compact wireless power transfer using resonant technique was proposed and a wireless power supply system for low power electronic devices was developed. The design of the system is to transfer the low power for electronic devices from transmitter to receiver coils. The input DC power is 12 V and the magnetic field passes through resonator and causes the energy to build up. As the result, the voltage and current of LED (acts as load) are 0.668 V and 0.01 mA respectively with the distance of 5 cm. In order to smoothen the peak voltages, a capacitor and a diode were used as a filter and rectifier respectively in the circuit. Resonance inductive coupling is widely used for mid-range transmission distance due to its simplicity in system design. The optimum distance for harvesting the highest voltage is 3.5 cm apart. The efficiency of power transmitted was 41.6 %. The transmission of power is only affected by the metal made component which is placed near to it. Wireless power transfer is convenient, reliable, low cost, safer and environmentally sound. In conclusion, the wireless power transfer using resonance induction coupling is more efficient if compared with inductive coupling and electromagnetic wave. The power can transfer with a longer distance and safely by using this technique.

## 1. Introduction and Research Review

This section described the history of wireless power transfer, the principle of wireless power transfer, the concept of resonant induction coupling, application of wireless power transfer and the advantages and disadvantages of wireless power transfer by using resonant technique.

WPT is a process to transmit the power from power source to load through an air gap without the use of wire or conductor. Wireless power transfer system can be classified into two categories, they are radiative and non-radiative. For radiative mode, the power is transferred by electromagnetic wave. While for non-radiative mode, the power is transferred by magnetic field which is inductive coupling or resonant induction. The difference between radiative and non-radiative is the amount of frequency that the receiver can obtain after the energy is being transferred [1].



The transmission of electromagnetic wave can be done by passing through air as medium. The energy transfer is radiative in nature and the power is transmitted by the beam of electromagnetic radiation. The frequency range is more than giga hertz (1 GHz - 1000 GHz). The power can be transferred in distance for several kilometres range [2].

WPT is implemented in many different technology applications such as medical devices, electric vehicles, LED lighting, defence system and others that benefit to society in many different areas [3]. It is suitable for electronic devices, convenient and very useful when the connection between power sources to load is limited since the power can be transferred without limiting the mobility of the user. The efficiency of using an inductive resonance coupling to transfer power is higher than using an inductive coupling. It is because inductive resonance coupling can transfer power further compared to inductive coupling. The power transferred at the resonant frequency will increase the efficiency of power transmission if compared with inductive coupling [4].

Besides that, WPT is able to eliminate the failure prone components in order to achieve reliability in electronic system. This technique can reduce the system cost since the technique may power up multiple devices by using a single resonator as source. Furthermore, WPT uses inductive resonance coupling is safer than using electromagnetic wave. Inductive resonance coupling is non-radiative type while electromagnetic wave is radiative type. The impact of radiative will damage human body tissue and hence WPT uses an inductive resonance coupling avoid the harmful radiation absorbed into human body [5].

Project [6] showed a system which a sequence of transmitter coils are placed under the roadway and delivered the power wirelessly to a moving vehicle. From the experiment, the energy could be transferred between two magnetically coupled resonating coils in a complex electromagnetic environment associated with the moving vehicle on the highway with a transfer efficiency of 46.2 % over a distance of 60 cm.

[7] proposed a WPT technology using resonant inductive coupling to print the circuit spiral coil. This project analyzed the relationship between the induced voltage and distance of resonating inductance in a printed circuit spiral coils. The shape of the spiral coil was analyzed so that it is efficient for transferring high powers.

[8] proposed a 3D ICs WPT to transfer power efficiently using resonant inductive coupling. This system used smaller coils to achieve higher power transfer density. The proposed technique is a promising solution for smaller form factor due to its shortening interconnection of parallel processing.

[9] proposed a wireless power transfer system with UAV-based. The system allows a UAV to fly to remote locations for charging. There are a transmitter on the UAV and a receiver wireless sensor node for power transmission.

At last, wireless power transfer sounds environment friendly since it can eliminate the need for disposable battery. Therefore, a small scale of WPT was proposed for power transfer to power up electronics devices with 12 V DC supply. However, there are some drawbacks for this system. The WPT system uses resonance enable to cover only a medium range of distance. The efficiency of the inductive resonance coupling drops when the distance increases between the transmitter coil and receiver coil.

## 2. Methodology

### 2.1. System design

The outcomes of the experiment are gathered and used to develop a WPT system using resonant technique. The whole system was developed and discussed in the form of schematic diagram.

### 2.2. Schematic diagram of transmitter system

Figure 1 shows the schematic diagram of transmitter system. The transmitter consists of resistors, ultrafast diode, Zener diode, inductor, MOSFET (n-channel), capacitor, and primary coil. The input was connected with 12 V as DC power supply. Zener diode (12 V) and resistor (10 k $\Omega$ ) were connected in parallel with the supply voltage, pin gate and pin source of the MOSFET so that the voltage does not exceed 10 V.

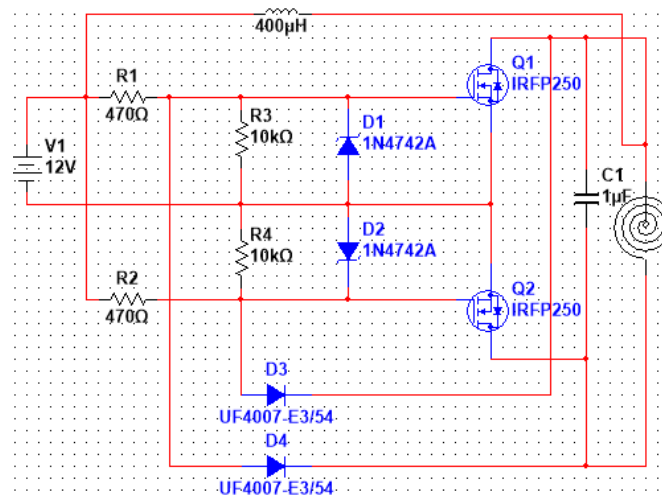


**Figure 1.** Schematic diagram of transmitter system.

### 2.3. Construction of transmitter

The input power to the system is a DC supply with 12 V. The transmitter produces magnetic field to the receiver, passes through the resonator and causes energy to build up in it. Energy oscillates at the resonant frequency between the inductor and the capacitor, later degenerates in the resistor.

### 2.4. Schematic diagram of receiver system

Figure 2 shows the schematic diagram of receiver system. The receiver consists of receiver coil, capacitor and bridge rectifier. The bridge rectifier is used to convert voltage from AC to DC, the diode is allowing the flow of current in one direction only and the capacitor is used to smoothen the voltage.

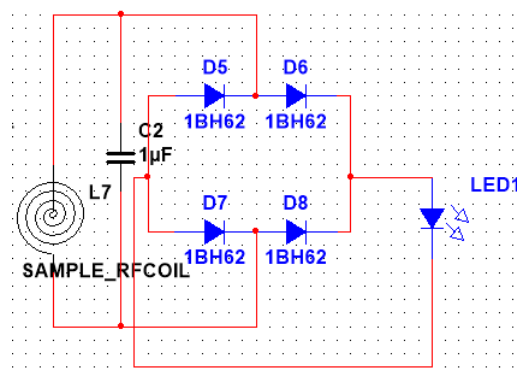


**Figure 2.** Schematic diagram of receiver system.

### 2.5. Construction of receiver

The current flows in the resonant coil is greater than in the primary coil. In order to smoothen the peak voltage, capacitor is used as a filter. Meanwhile, a diode is used as a rectifier in the circuit.

### 2.6. Schematic diagram of transmitter and receiver system

Figure 3 shows the schematic diagram of transmitter and receiver system. The circuit is combined with transmitter and receiver circuit and separated by a transmission gap as medium between them. The transmitter coil generates magnetic field that induces voltage in the receiver coil through the transmission gap. The current flows in a transmitter coil is coupled with a resonant LC receiver coil.

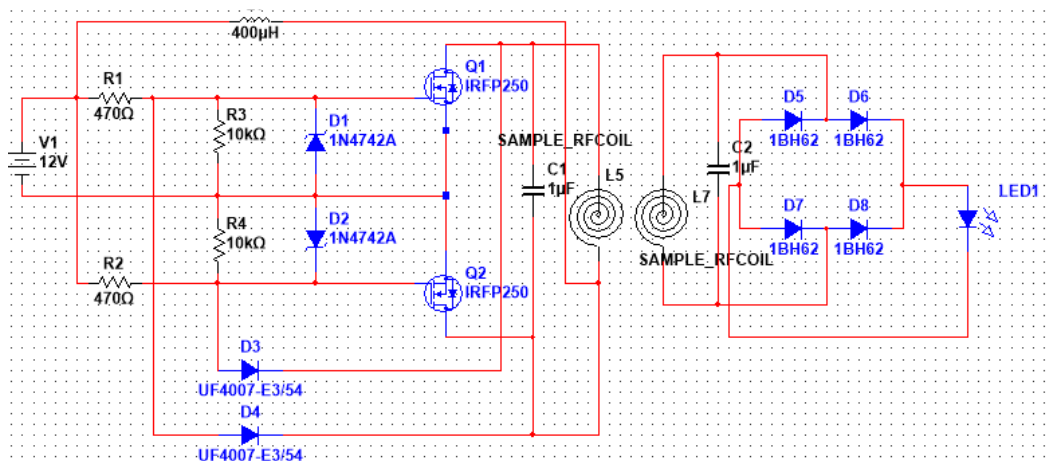


**Figure 3.** Schematic diagram of proposed system.

### 3. Result and Discussion

#### 3.1. The voltage and current of LED with different distance

The experiment was carried out by measuring the voltage and current of LED with different distance. The result was recorded in Figure 4. The voltage increased from 0.631 V to 1.164 V when the distance increased from 0.0 cm to 3.5 cm. The gap between transmitter coil and receiver coil caused the magnetic field loss. Since, the magnetic field cancelled with each other and reduced the magnetic field, therefore, the voltage was low when the distance at 0.0 cm. The highest measured voltage was 1.164 V with the distance of 3.5 cm. Then, the voltage decreased from 1.164 V to 0.668 V due to the increased of the distance from 3.5 cm to 5.0 cm. The longer the distance, the lower the voltage. The highest measured current was 0.47 mA when the distance was at 0.0 cm. The current decreased from 0.47 mA to 0.01 mA due to the increased of the distance between the transmitter coil and receiver coil. The results can be concluded if the longer the distance, the lower the current that will be produced.

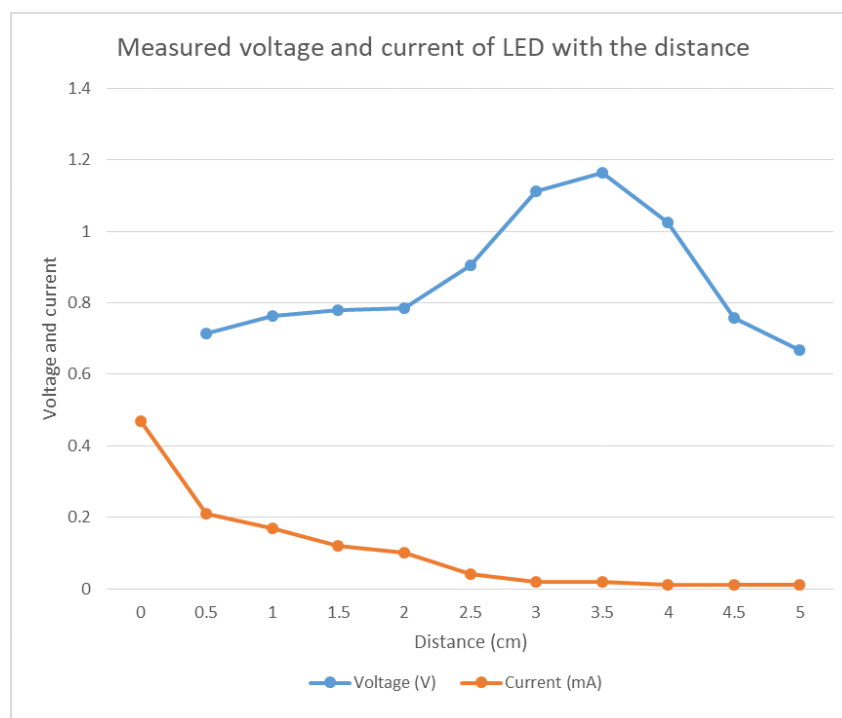


**Figure 4.** Measured voltage and current of LED with distance.

### 3.2. Obstacles between transmitter coil and receiver coil

Experiment was carried out by varying the obstacles in the gap between transmitter coil and receiver coil in order to evaluate the reliability of the WPT technique. Distance between transmitter coil and receiver coil was set by 1.5 cm. Objects such as paper, plastic and aluminium were used to fill in the gap. The result concluded that the wireless power can transfer when the paper and plastic were filled in the gap between the transmitter coil and receiver coil. However, the power transmission was interrupted when the aluminium was used as a medium. The magnetic field is not feasible to cross the conductor like aluminium because the signal will be absorbed by the conductor and caused lost. Table 1 and Figure 5 show the result of the obstacles between transmitter coil and receiver coil.

**Table 1.** Performance of power transfer obstructed by different materials.

| Obstacle type | Performance of wireless power transfer |
|---------------|----------------------------------------|
| Paper         | Yes                                    |
| Plastic       | Yes                                    |
| Aluminium     | No                                     |

The low cost WPT technology was accomplished in the form of prototype. The developed prototype supplied with 12 V DC source, and able to power up a controller (5 V) to switch on a LED with direct contact and up until 5 cm apart. This technology can be implemented onto higher scale of power consumption electronic components as long as by increasing the power supply.



**Figure 5.** Result of the obstacles (left) paper, (middle) plastic and (right) aluminium between transmitter and receiver coil.

### 4. Concluding remarks

A proposed WPT technology was developed with power transfer efficiency of 41.6 % (transmitted 12 V, received 5 V). The technology carried out a wireless power transfer with 5 cm apart. In order to put into possibility of higher power consumption unit, the voltage supply can be increased, and hence, the distance apart between transmitter and receiver will be increased.

The potential applications of this project in the view of WPT are for low power electronic devices like charging the low voltage battery, lighting up the led or bulb and so on. Some potential applications of WPT are convenience and safer to the users. Power cords bring risk of shock and can cause fires. WPT can eliminate traditional charging systems. The low voltage battery can be charged without the need of plugging into the socket. The battery of mobile phone, camera and iWatches can charge wirelessly. Besides, this system also can be used for LED lighting. This method can eliminate the need of batteries to lighting up the LED since they can be powered directly by using wireless electricity.

Future work will be focused on increasing the scale of the prototype, by:

- increase the input voltage so that the receiver can obtain higher voltage.
- increase the diameter of insulated copper wire for bigger gap.
- increase the number of turns of insulated copper wire for longer transmission.
- use voltage booster to boost the voltage before transmission.

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