

Wireless Power Transfer and Charging

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Abstract - One of the newest and most promising technologies available today is wireless charging of devices. Wireless power transmission (WPT) by resonant inductive coupling is now the most widely utilized technique. Since wireless power transfer does not require traditional copper cables or current-carrying wires, it is one of the most straightforward and affordable methods of charging. A workable design is modeled in accordance with the methodology and principle of operation developed for wireless power transmission via resonant inductive coupling in this research. Since the resonant inductive coupling approach is currently the most straightforward way to wireless power transmission because to its great efficiency and substantial energy transfer capacity. The findings of tests conducted to verify wireless operation will be included in the article. With the help of extra electronics, the electricity delivered will also be used to charge a battery, demonstrating its adaptability and variety of uses. In order to transfer energy as efficiently as possible within a narrow range or in the near field region, this research focuses on the study of wireless power transmission

Keywords- *WPT, Resonant inductive coupling, Charger.*

1. INTRODUCTION

You will most likely need to buy a charger and connect the phone to the wire if you are using an electronic device, such a cell phone, and you need to recharge the battery. However, what if you could charge it without using a wire? indicating a wireless transfer of power. The idea of Wireless Power Transfer (WPT) makes this feasible. Although studies and research have been conducted since the 19th century, this idea has just now started to be put into practice. Engineers are currently working to find ways to improve the efficiency of power transmission over wireless networks while simultaneously finding safe

practices for both people and the environment. Nevertheless, techniques that can be economically successful because they are less expensive. Several electrical businesses are starting to release gadgets that can send electricity wirelessly, however they are still in the early stages. Advances in wireless technologies during the last two decades have sparked a resurgence of related research. The use of Nikola Tesla's concepts and innovations has also raised public interest in wireless power [1]. Therefore, it is worthwhile to investigate the viability of technological implementation. Wireless electricity was developed by a number of scientists and inventors. Their motivations and study methodologies can be discovered by looking at their backgrounds. The innovations created during this period were more sophisticated than anything before seen, resolving difficult issues and creating the fundamental theories that gave rise to contemporary technology. The usefulness and feasibility of wireless power propagation are well-described in these inventors' publications, experiments, and patents. Conduction, induction, and radiation are three common ways that power is transmitted. The transmission of electrical power without the need of a physical conductor is explained by a number of formulas. The way that electromagnetic waves transfer power from a transmitter to a receiver is governed by theories for each form of power transport [2]. WPT is important because it eliminates the need for wires and e-waste, eliminates the need for batteries, is safe and efficient, requires little maintenance, is more effective (when the transmitting and receiving points are in line of sight), can reach remote locations, extends battery life, and does not affect the transmitter circuit in the event of a receiver circuit short circuit. This paper's main objective is to accomplish wireless power transfer inductive coupling between the transmitting and receiving coils in the near field. The ultimate goal is to develop and effectively execute a wireless power transmission system for home use.

2. Literature Survey

Wireless Power Transfer (WPT) is a complex area of contemporary engineering that has its roots in historical scientific discoveries. The main works of literature and underlying theories that are pertinent to this study are summed up as follows:

Nikola Tesla's Vision and Historical Foundations

The idea of wireless electricity is not new; studies and tests have been conducted since the 1800s. Nikola Tesla's ideas and inventions are a major source of public and scientific interest in WPT. Through articles, tests, and patents, early pioneers demonstrated the viability of wireless power propagation and established the basic theories that underpin modern technology.

Fundamental Mechanisms

Transmission, Conduction, induction, and radiation are the three main ways that power can be transferred. The operational distance and type of electromagnetic field employed determine the classification of modern WPT: Power is transferred by electromagnetic waves (far-field) at distances far larger than the wavelength of the carrier wave in radiative WPT. Non-Radiative WPT: Made possible by near-field coupling, in which the wavelength is substantially larger than the operating distance. This comprises: Electric fields and capacitive coupling between metal electrodes are used in capacitive power transfer, or CPT. Power is exchanged between coils using magnetic fields in inductive power transfer (IPT), which is governed by Faraday's Law and Biot-Savart's Law.

Inductive Resonant Coupling

Magnetic Resonant Coupling Power Transfer (MRPT) is an important development in IPT. When two magnetically coupled resonant devices have the same resonance frequency, this approach takes place. Efficiency: The maximum amount of energy may be transferred via a resonant channel thanks to resonance. Operation: An oscillating magnetic field is created by a primary coil with an oscillating current. Even at a distance, most of this energy can be absorbed by a second coil tuned to the same frequency. Benefits: MRPT provides greater efficiency and significant energy transfer capacity within a limited range when compared to conventional inductive coupling.

3. WIRELESS POWER TRANSFER TECHNIQUE

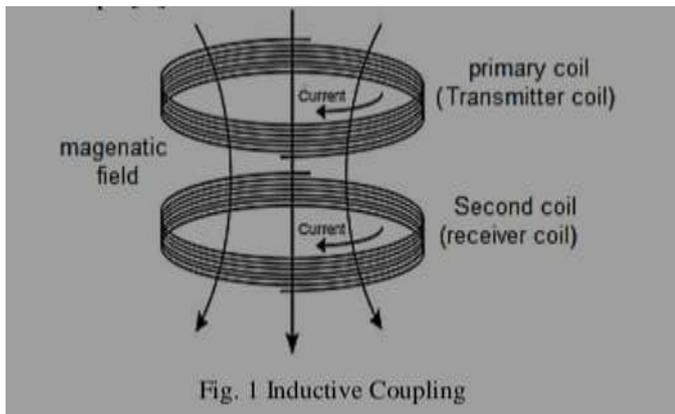
EM fields can be used in WPT systems to transfer power from the transmitter to the receiver. Therefore, based on the shape of the electromagnetic fields and the operational distance between the transmitter and the receiver, WPT can be divided into radiative and non-radiative

approaches. A transmitting antenna can release radiative power in the form of electromagnetic waves that travel a great distance, in which case the operational distance is significantly greater than the carrier wave's wavelength. The ratio of an antenna's size to wavelength determines how much power it can generate as electromagnetic waves. Therefore, the size of the antenna should be equal to or greater than the wavelength in order to transmit power over a long distance.

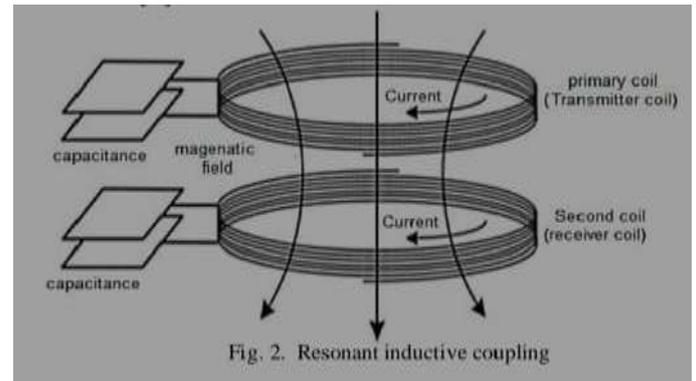
Additionally, a significant amount of energy will be lost and dissipated from the system if the antenna used for radiative power transfer is not highly directive. Non-radiative WPT, in which case the operational distance is much less than the wavelength, can be achieved through near field coupling. Power can be transferred via electric fields in capacitive power transfer (CPT) systems by capacitive coupling between metal electrodes [3][4] or via magnetic fields by inductive coupling between coils. By working mechanisms, WPT systems based on magnetic coupling can be further divided into two types. One form, known as inductive coupling power transfer (IPT), is based on magnetic induction and is governed by Faraday's Law and Biot-Savart's Law. Only short-range transmission (less than the resonator's dimensions), often at the millimeter to centimeter level, is supported by contemporary IPT systems. In relation to IPT. Two magnetically connected resonant devices with the same resonance frequency can exchange energy in a different kind known as magnetic resonant coupling power transfer (MRPT). We concentrated on near field approaches in this work [5].

A. Power Transfer via Inductive Coupling (IPT) When two conductors are arranged so that a change in current flow through one wire causes a voltage to be induced across the ends of the other wire through electromagnetic induction, as seen in figure 1, they are said to be mutually inductively linked. The fundamental idea behind wireless transfer is that the transmitter and receiver coils are inductively coupled. A portion of the magnetic flux created by one circuit interlinks with the second circuit, after which two circuits are magnetically coupled and energy is transferred from one circuit to another circuit [6]. Transmitters employ oscillators to change DC electricity into AC current. A magnetic field created by the AC current flowing through the transmitter coil causes a voltage to be induced in the receiver coil. The magnetic field is focused in a compact space between the transmitter and receiver. A rectifier in the receiver transforms AC back into usable DC. The purpose of the voltage regulator is to keep the voltage steady. By coiling

the wire, the inductance effect can be increased. Inductive coupling energy transfer carries a far lower risk of electrical shock, when compared with conductive charging, because there are no exposed conductors. When compared to direct touch, this method's primary drawbacks are its higher resistive heating and decreased efficiency. Inductive charging also requires drive electronics and coils that increase manufacturing expense and complexity. This idea underpins the operation of transformer inverters, electric brushes, and wireless charging pads [7].



B. Power transfer using magnetic resonant coupling (MRPT) Transmitting power between two coils that are set to resonate at the same frequency is known as magnetic resonant coupling power transfer (MRPT), as illustrated in figure 2. When the self-resonant frequency of coils matches the frequency of the AC power supply and the equivalent circuits of high-frequency coils have the lowest resistance, resonance takes place [8]. The resonant path will therefore transmit the greatest amount of energy. Resonant transfer operates by creating a capacitively loaded primary coil ring with an oscillating current. An oscillating magnetic field is produced as a result. Any energy deposited in the coil fades away quite slowly over a very long number of cycles due to its high resonant nature; however, if a second coil is brought next to it, even if it is some distance away, it can absorb the majority of the energy before it is lost. Most of the fields that are employed are non-radial. With lumped capacitors at the coil terminals, magnetic resonant coupling can also be used to transfer power from a large source coil to one or more small load coils, offering a straightforward way to match the coils' resonant frequencies. Radiation and ohm resistance cause losses in this technology [9].



The frequency at which resonant occurs is determined by $f_r = \frac{1}{2\pi\sqrt{LC}}$. As seen in figures 3 and 4, the parallel resonant LC circuit, also known as a tank circuit, transfers the stored energy back and forth between the capacitor and the coil [10].

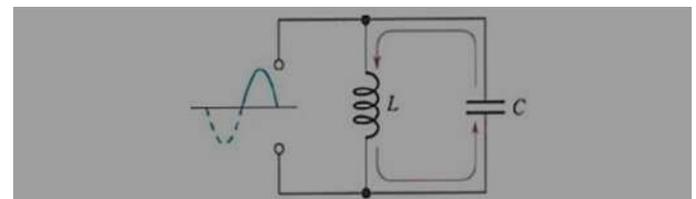


Fig. 3. Tank circuit (The coil de energizes as the capacitor charge)

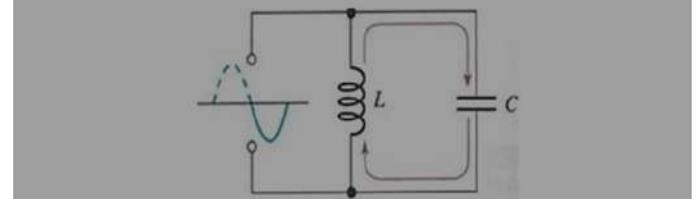


Fig. 4. Tank circuit (The capacitor discharges as the coil energizes)

4. EXPERIMENTAL WORK

The block diagram of near field techniques of WPT is shown in figure 5.

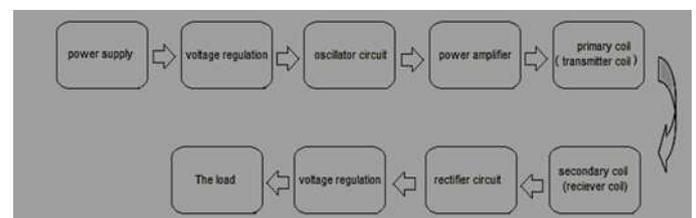


Fig. 5. Block diagram of transmitter and receiver wireless power transfer

1) Power Supply: The WPT transmitter circuit, which consists of an oscillator circuit, a power amplifier, and a transmitter coil, is powered by a DC voltage from the power supply. 2) Voltage Regulation: The primary function of an IC regulator in a circuit is to maintain the precise voltage that the power supply follows. When using an IC regulator, the capacitor is often linked in

parallel to both the input and output terminals. Capacitors are used to check for massive changes in both the input and output filters. In the meantime, the input and output level's little period spikes are checked by the bypass capacitors. The small period pulses are bypassed directly into the Earth by means of bypass capacitors, which are primarily of modest values. 3) Oscillator Circuit: In this research, we used the timer 555 as an oscillator, which is a circuit that transforms DC signals into AC signals at a desired frequency. The NE555 monolithic timing circuit is a very reliable controller that can generate precise oscillation or time delays. One external resistor and capacitor are used to accurately control the time in the time delay mode of operation.

Two external resistors and one capacitor are used to precisely manage the duty cycle and the free running frequency for a steady oscillator operation. The output structure can source or sink up to 200mA, and the circuit can be triggered and reset on falling waveforms.

4) Power Amplifier: The transmitter coil is driven by the power amplifier, which amplifies the ac signal from the oscillator circuit. The power amplifier was an IRF 540 N-Channel Power MOSFET with specifications of 33A, 100V, and 0.040 Ohm. 5) Transmitter Coil: An electromagnetic coil is a wire or other electrical conductor that has a coil, spiral, or helix shape. Figure 6 illustrates how Ampere's law causes a circular magnetic field to surround any conductor when current flows through it. The coil form has the benefit of strengthening the magnetic field generated by a specific current. A strong field is created in the center of the coil by the addition (superposition) of the magnetic fields produced by the individual wire turns.

A stronger field is created and sent to the receiver coil with more wire turns [11]. 6) Receiver Coil: As seen in Figure 1, Faraday's law of induction causes a voltage to be induced in a conductor, such as a wire, when an external magnetic flux changes. Because the field lines cross the circuit more than once, wrapping the wire into a coil increases the induced voltage. 7) Rectifier Circuit: This circuit supplied the load by rectifying AC voltage into DC voltage.

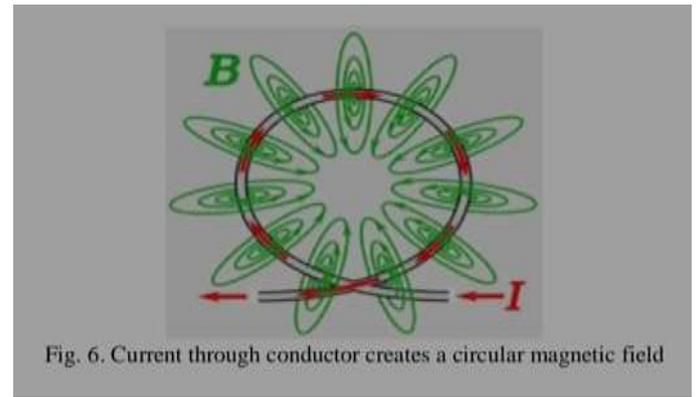


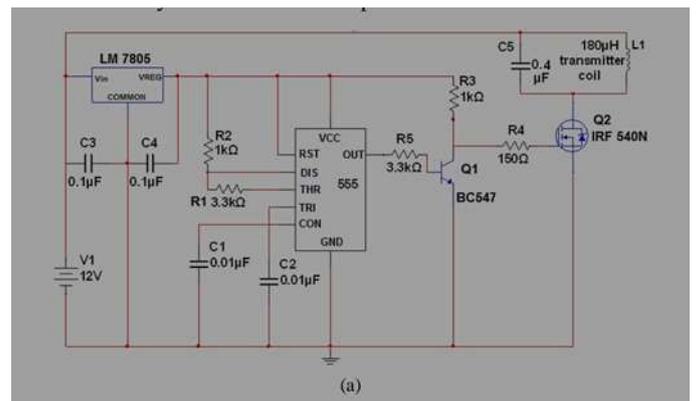
Fig. 6. Current through conductor creates a circular magnetic field

5. IMPLEMENTATION OF WPT CIRCUIT

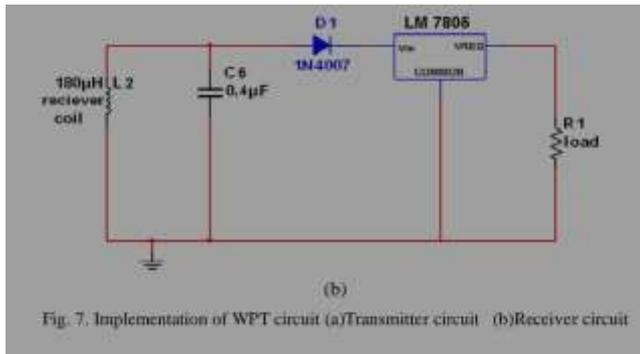
The WPT circuit implementation is depicted in Figure 7. A stable multivibrator oscillator (NE 555) produces a square wave with a frequency of 18.9 KHz, as seen in figure 8, after the voltage regulator (7805) supplies the oscillator circuit with regulated voltage 5 Vdc. This frequency may be computed using the following equation.

$$f_c = \frac{1}{1.1(R1+2R2)C1} = 18.9\text{KHz}$$

The power amplifier is made up of transistors Q1 (BC547) and Q2 (IRF540N), which are used to drive the primary coil and create electromagnetic flux, which is then transported to the secondary coil in the receiver portion of the WPT circuit by amplifying the AC signal with a frequency of 18.9 KHz.

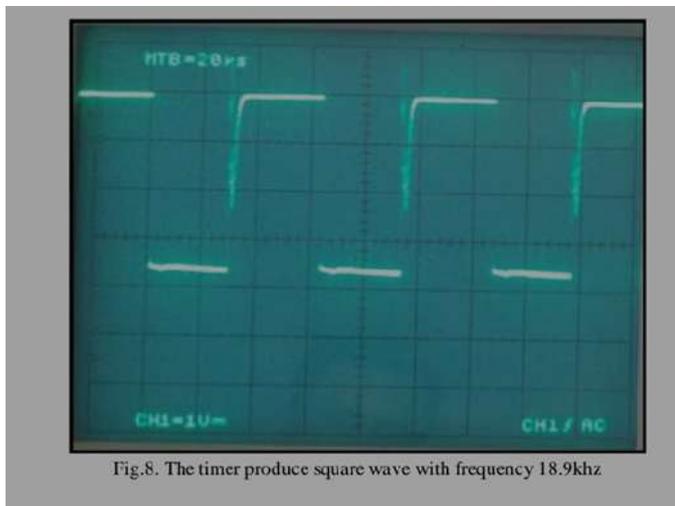


(a)



(b)

Fig. 7. Implementation of WPT circuit (a)Transmitter circuit (b)Receiver circuit



6. RESULTS AND DISCUSSION

The WPT practical circuit, installed at the electrical engineering department's circuit laboratory, is depicted in Figure 9. The output voltage and current of the received circuit were measured, and the findings are shown in Table I. We utilized a WPT circuit to charge the battery of a mobile phone (Samsung S1) at various distances between the transmitter and reception coils.

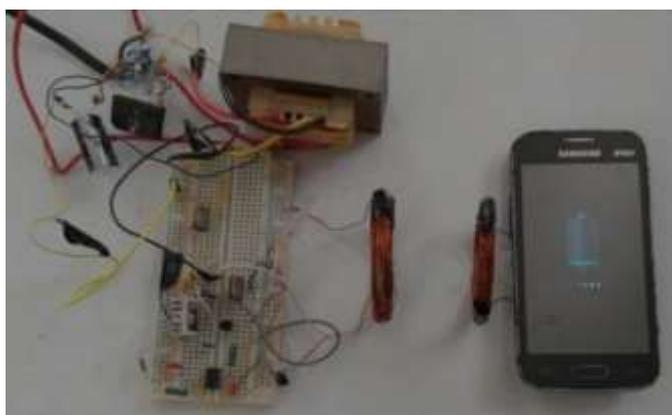


Fig. 9. The Practical circuit of WPT

Table I: The output voltages, current, power at different distance between transmitted coil and received coil

Voltage	Current	Power	Distance
4.98v	421mA	2.09w	0
4.9	400mA	1.96w	0.5cm
4.60v	320mA	1.47w	1cm
4.30v	250mA	1.07w	1.5cm
4.10v	220mA	0.90w	2cm
4.02v	160mA	0.64w	2.5cm
4.01v	100mA	0.40w	3cm
3.99v	70mA	0.27w	3.5cm
3.98v	20mA	0.079w	4cm
3.97v	12mA	0.047w	4.5cm
3.96v	1mA	0.0039w	5cm

Figure 10 shows that the current dropped as the distance between the transmitter and receiver coils rose, indicating a loss of power. Figure 11 shows the relationship between battery charging time and level; we reached full charging at 140 minutes.

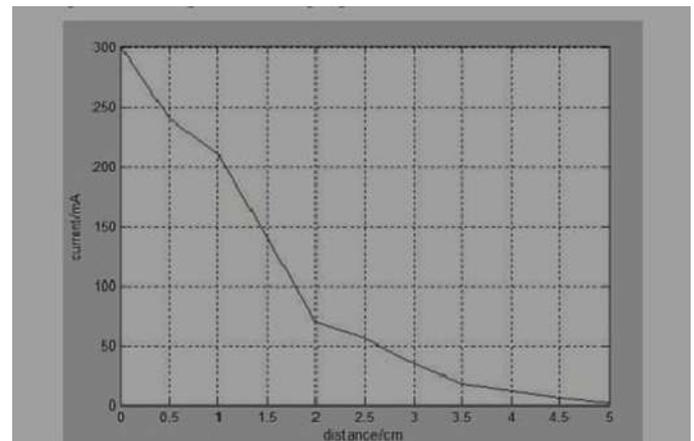


Fig. 10. output current vs. the distance between transmitter and receiver coils

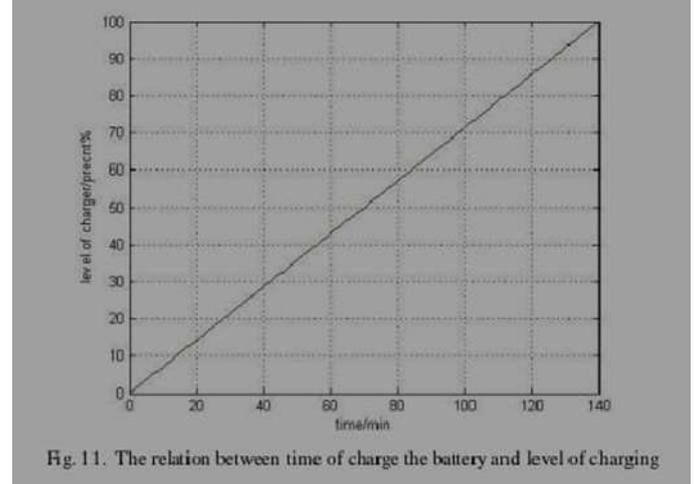


Fig. 11. The relation between time of charge the battery and level of charging

7. CONCLUSION

According to this study, the most promising method for wirelessly powering devices with high efficiency over a few centimeters is the resonant inductive coupling WPT. In the coming years, resonant inductive coupling WPT—which is safe for both people and the environment—may become the norm for charging the majority of portable electronics. Therefore, we advise researchers to concentrate on this technology. Despite this, high voltage transmission cables are being replaced by microwave power transfer. Many studies need be conducted to identify a safe solution that could allow the use of microwaves for long-distance high power transmission due to health issues. In summary, the electronic transmitter circuit transforms the mains voltage into a high-frequency AC (alternating current) signal that is transmitted to the transmitter coil. A magnetic field is created by the ac current passing through the transmitter coil, and this field may spread to the reception coil. After that, the magnetic field creates a current that runs through the receiving device's coil and is transformed into direct current (dc), which can power the load.

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