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Design of Efficient Wireless Charging Pad Deployment and Maximizing the Power Transfer System for an Autonomous Vehicle Charging

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Abstract—Transmission of power without the use of wires or other electrical conductors is concentrated in this paper. Here we explore the possibility of reducing transmission, allocation, and other forms of losses by transmitting electrical energy as microwaves. Microwave Power Transmission describes this method. In addition, it covered the evolution of wireless systems for power transmission and how they connect to the present day by presenting and correlating various features of these systems. Also covered are the fundamentals, pros and cons, and uses of wireless power transmission. As EVs continue to gain in popularity, their arbitrary charging management will put a strain on the future grid. Enabling electric vehicles to become grid-friendly requires precise management of their charging and discharging states. This work presents a multiport DC-DC solid state transformer design for a bidirectional photovoltaic/battery-assisted electric car parking lot with vehicle-to-grid service, taking into account the potential of EVs as energy storage devices. Our suggested technology allows electric vehicles to be charged wirelessly at a parking spot using a grid-to-vehicle and vehicle-to-grid power transfer mechanism.

***Index Terms*—Wireless Charging, Power Transmission, Autonomous Vehicle Charging, Electric Vehicle, Wireless Power Transfer, WPT**

I. INTRODUCTION

A power source can supply electricity to an electrical load via a gap in the air, a process known as wireless power transfer [1]. A wireless power system's foundation rests on two coils: one for transmission and one for reception. Alternating current powers the coil in the transmitter, creating a magnetic field that generates a current in the coil in the receiver. A set of custom-built electronics built within the transmitter convert the DC current flowing from the power supply into AC current at higher frequencies, allowing the device to achieve its job.

A magnetic field is created in the transmitter by energizing a copper wire coil with the alternating current. A second coil, called a receiver, may be made to conduct an alternating current if it is brought close enough to the magnetic field. After that, the electronics in the receiver transform the AC power back into DC power, which is usable [2]. A medium, a receiver, and a transmitter are the three main components of any wireless power transmission system [3]. Both short and large distances can be used for power transmission. So far, three techniques have been developed forshort-range transmission:

(i) The use of electromagnetic induction for powertransmission is known as inductive coupling.
(ii) To transfer energy between coils by means of inductionwhile they are in a resonance state.
(iii) To ionize the medium, in this case air, in order to transmitelectricity.

Two approaches have been suggested for transmission across vast distances:

(i) Microwave transmission: In the microwave spectrum, shorter wavelengths are used to transport electricity across vast distances.
(ii) Laser transmission: This method involves transferring energy to a solar cell by use of a laser beam that has been converted from electricity.

A. *INDUCTIVE COUPLING*

Two wires are called inducers of electromagnetic induction. A magnetic coupling is formed when a portion from the magnetic flux of one circuit connects with another circuit in wireless transmission. This allows energy to be transferred coming from one circuit towards the other [4][5]. A fundamental aspect of this technique is the inductive coupling of the transmitter and reception coils. One way that transmitters transform DC current into AC current is by using oscillators. Upon passing alternating current

(AC) through the transmitter coil, a voltage is induced in the reception coil due to the creation of a magnetic field.

The area between the transmitter and receiver is quite tiny, and there is a concentrated magnetic field there. In order to use DC power, a receiver includes a rectifier which converts AC power into DC. The purpose of a voltage regulator is to keep the voltage steady. The action of inductance could be enhanced by winding the wire in a spiral pattern. Since no exposed conductors are involved in inductive coupling energy transfer, the danger of electrical shock is significantly reduced compared to conductive charging [6].

B. RESONANT INDUCTIVE COUPLING

In resonant inductive coupling, two coils are adjusted to resonate at an identical frequency and power is sent between them [7]. At resonance, the impedance of the comparable circuits of the coils at high frequencies is minimal, and the self-resonant resonance frequency of the coils is equivalent to the frequency of the AC power source. At that point, the resonant route will have communicated the maximum amount of energy. A capacitive-loaded main coil is made to ring using an oscillating current in order for resonant transfer to function. An oscillating magnetic field is produced by this. Due to its high resonance frequency, the energy stored in the coil depletes slowly over many cycles. However, if another coil is brought close to it, it may absorb most of the energies before it depletes, regardless of how far away the second coil is. Most of the fields that are used are not radiation fields. Utilizing lumped capacitor at the coil terminals, a simple way to match the resonant frequencies among the coils may be achieved, allowing magnetic resonant coupling to transfer power between a large source coil to one and tinier load coils. Ohmic resistance and capacitive smart card radiation from induction cookers are the sources of losses in this process. Several of these battery-operated, wireless resonant induction devices run on milliwatt of electricity. Some use lower kilowatt power levels, while others use greater ones [8].

C. AIR IONISATION

Energy transfer via ionization of air has become the most difficult method. The air is ready to start disintegrating when an electric field gets extremely strong, at around 2.11MV/m. The ionization of the air occurs when the electric field separates the surrounding air into positive ions as well as electrons. Ionization does not imply an increase in the number of positively charged atomic nuclei or ions or electrons. As a result of ionization, the distance between electrons along with positive ions is larger than it was in the initial atomic or molecule structure. The separation/stripping is significant since it greatly increases the electrons' mobility compared to their previous state. Thereby, the ionized air is substantially more conducting than the non-ionized air that came before it. By the way, any substance may be considered an excellent conductor of electricity if it allows the electrons to pass freely through it [9].

D. MICROWAVE TRANSMISSION

What we term "microwaves" are actually electromagnetic waves with wavelengths measured in centimeters, and this technique is known as "microwave transmission" [10]. A DC rectifier, which converts microwave energy into direct current electrical power, and an electromagnetic radiation source are the two main components of a microwave receiver that allows for wireless energy exchanges via microwaves. Both the sending and receiving devices must be directly in front of each other. Transmission and reception of data can only take place in a line of sight propagation scenario, where the sender and receiver stations are directly across from one other, unimpeded by any physical barrier. The transmitter transforms electrical energy into microwaves and sends them across a distance to the receiver, which uses a rectenna to transform the microwaves to electrical energy. It is not possible to directly convert AC into a microwave within a transmitter. The first step is to use an oscillator to transform it to DC. The DC output from the rectenna is transformed into AC in the receiver. The problem with microwave power beaming is that, because of the directionality limits imposed by diffraction, the aperture sizes needed for space applications are often rather large. It is well-established that microwaves may be used for wireless high power transmission.

E. LASER TRANSMISSION

The term "laser" refers to a type of optical amplifier that uses the stimulated emitted of electromagnetic waves to produce light. The coherent emission of light is what sets a laser apart from other light sources. A laser may be precisely targeted with spatial coherence. The process by which a laser generates radiation is known as stimulated emission, and it involves drawing energy from atomic or molecular transitions. One method of transferring power is by using a laser to concentrate light on a photovoltaic cell. Power beaming is the common name for this process since it involves directing energy in a beam onto a receiver that may then transform it into electrical energy.

II. RELATED STUDY

The use of wireless power transmission might encourage more people to purchase and utilize electric vehicles, which could speed up the shift from gas-powered automobiles to zero-emissions vehicles and solve the issue of electric vehicle charging periods [11]. To ensure their durability and prevent them from becoming obstacles, the major WPT circuits must be included in the pavement structure. Pavement materials have the potential to hinder WPT's resonant induction coupling process, leading to a decrease in charging power as well as effectiveness. By measuring the magnetization effectiveness of different pavement raw materials with a vibrating sample magnetometer, we were able to get insight into how the kind and thickness of pavement materials impact the WPT. Using the magnetic circuit model, we were able to determine the effective permeability ratings of three commonly used pavement materials: AC-13, SMA-13, and PCC. Ansys Maxwell was used to simulate the pavement materials, main and secondary coils. After inserting the coils into the pavement materials, we measured their self- inductance and mutual inductance. The output power as well as gearbox effectiveness of WPT were calculated using theoretical mathematical calculations. The results showed that the resonant circuit was detuned and the output power was lowered when gearbox media, such pavement materials placed among the main along with secondary coils, enhanced main self-inductance, supplementary self-inductance, and mutual inductance. By adjusting at the high-frequency voltage to match its resonance frequency, we were able to increase the WPT's output power. There was also a mathematical basis for the design of WPT pavement in the form of calculation formulae for resonance frequency, output power, as well as effectiveness following the addition of pavement materials[11]. Out of the three materials tested, AC-13 produced the most power.

Wireless power transmission (WPT) using magnetic induction technology could rescue individuals from hazardous circumstances requiring cables [12]. We improve the inverter's power transfer efficiency between the coils by using field effect transistor switching made of metal oxide semiconductors. This higher frequency allows the battery to be charged more quickly and efficiently. This will make driving an electric vehicle more enjoyable. Charging time, range, and price may all be easily controlled with WPT for electric vehicles. In the WPT age, progress has been rapid in recent years [12].

This research introduces a new control method to improve the transfer efficiency of dynamic wireless chargers for electric vehicles (EVs) [13]. Because the analogous impedance on the receiving side increases as the battery system's charge level changes, charging impacts transfer efficiency. In order to provide the most effective transmission, the receiving end is equipped with impedance control circuitry that monitors the optimization impedance. Optimization impedance is, however, defined by the coupling coefficient. This work is the only one that predicts the coupling coefficient online from the other side, as it changes depending on the position of the EVs. A prototype of a 1.5 kW dynamic charging device is being built in the laboratory. In the studies, the greatest transfer effectiveness of 94.14% was reached when electric vehicles were queued up in the charge lane. The proposed control system adds 6% to the already 91% transfer efficiency when the misalignment is 30% [13].

This study introduces a wireless power transmission system that charges electric cars via magnetic resonant coupling and operates at low frequencies with excellent efficiency [14]. In an effort to keep things simple, we propose a wireless power transfer technique that uses two coils. Both the transmitter and receiver coils of the WPT system have been meticulously designed to improve quality parameters and coupling coefficient. We use a three-dimensional finite element technique to look at how misalignment, coil radius, and coil parameters affect system performance and turns. A compensation circuitry is painstakingly constructed and tested to ensure the most efficient transmission of electricity. We examine the relationship between the coupling coefficient and the system efficiency as well as the resonance frequency. We compare and analyze two different compensation systems based on input power, output power, and compensation voltage of capacitors stress. At last, we test the system under different spacing and misalignment conditions to see how well it performs. Power transmission efficiency is still greater than 95% even when they are misaligned [14].

Powering electric vehicles without an external connection to the utility grid is possible with solar-powered charging infrastructure [15]. Wireless charging, made possible by wireless power transfer technology, offers several benefits, including decreased emissions, safe operation, and cheap maintenance costs. With WPT technology, there is no need to physically connect the device to the automobile, which greatly reduces the hazards and difficulties of traditional charging methods. When applied to EVs, WPT has the potential to decrease charging time, range, as well as costs. Inductive, capacitance, resonant, along with highway power transmission arrangements are all discussed in this chapter. In this lab, we built a tiny wireless charging prototype using inductive power transfer technology. The results of the experiments have been made public in order to demonstrate the system's practicality right now [15].

III. METHODOLOGY

There has been a recent uptick in interest in wireless charging by inductive power transfer due to the increasing popularity of electric and driver-less cars. With grid-to-vehicle efficiencies above 90% in some of these applications, wireless charging is now on par with conventional plug-in methods. There have been reports of high power testing achieving efficiency of up to 95% under optimal alignment conditions. Wireless charging is perfect for autonomous applications since it allows vehicles to charge themselves, which increases their autonomy. This is because it is friction-less and convenient. Most uses for autonomous vehicles place a premium on minimization of size, weight, and power usage. Even with their great power density, lithium-ion batteries generally can't always handle continuous use for extended periods of time before needing a charge. Other situations, such with drones, further limit the capacity for energy storage due to the weight requirements for the vehicle. The amount of time an autonomous vehicle may stay on the road is also constrained by the charging pace of its batteries. To get around these problems, autonomous charging uses a transmitting coils track to let the car charge itself on a specific power transfer coil when it's in standby or even constantly, like in a dynamic application.

Because there are no moving parts or cords involved in wireless charging, it is naturally more dependable and saves you the trouble of lugging about bulky plugs and wires. For situations when being physically touched is risky because of water, including in outdoor applications or an autonomous underwater vehicle, wireless power allows for longer duration of autonomy. The following figure Fig.1 describes the block diagram of transmitter and receiver.

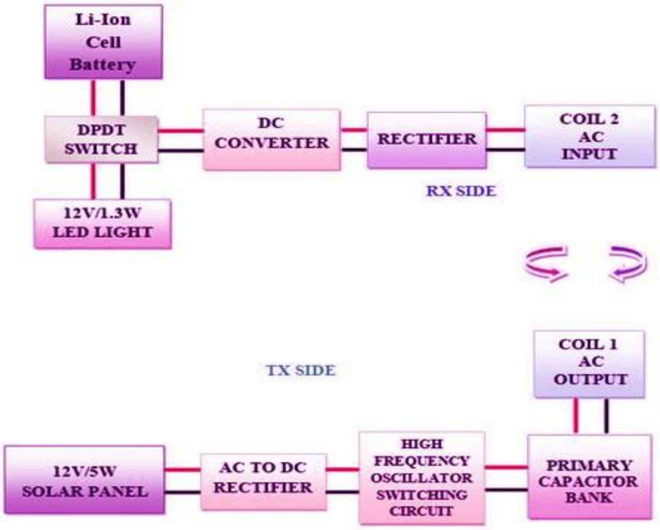

Fig.1 Block Diagram

Inductive coupling, a form of wireless power transmission, is an efficient alternative to the traditional wire method for transmitting electrical current from one location to another. In places where running wires would be impractical or impossible, wireless power transmission offers a viable alternative. Depending on the range, electromagnetic wave transmission, short-range coupling, or resonant induction are used to transfer the power. The goal of this project's inductively coupled mobile charging circuitry for wireless power transfer is to wirelessly charge a low-power device. The process involves applying alternating current (AC) to a resonant coil, which subsequently transfers the charged current to a resistivity load. The objective of this study is to develop a fast and efficient technique for charging a low- power device by inductive coupling, eliminating the requirement for wires. The following figure Fig.2 shows the illustration of an inductive coupling-based wireless power transfer circuit.

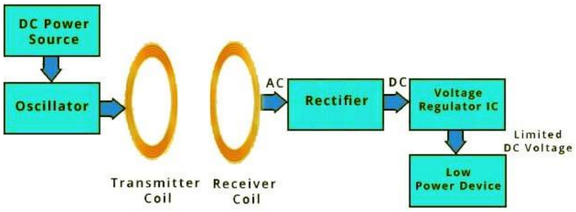

Fig.2 Illustration of an inductive coupling-based wirelesspower transfer circuit

The inductive coupling mechanism is a key to this system's wireless charger. Our goal in developing this inductive coupling concept is to enable the wireless charging of low- power gadgets like mobile phones, cameras, remote mice, and other such items. This wireless power transmitter’s part includes a transmitter coil that changes the low-frequency DC power signal from an oscillator into a high-frequency AC power signal. Through the process of induction, this high- frequency alternating current would generate an alternating magnetic field within the wireless power transmission coil, allowing for the transmission of energy.

The energy is received by the receiver coils in the wireless power reception section as an induced alternating voltage (DC) by means of a rectifier. This AC voltage is then transformed from the coils by use of induction. The last step is for the rectified DC voltage to be supplied to the load via the voltage controller. In other words, charging a low-power battery via inductive coupling is the primary purpose of the wireless power receiving portion.

Two primary parts make up this project: the wireless power transmitter and the wireless power receiver. A wireless charger circuit's transmitter part includes an oscillator, a DC power supply, and a transmitter coil. The oscillator circuit receives its input signal from a DC power source, which supplies a steady DC voltage. The DC voltage is sent into the oscillator, which then supplies the transmitting coil with AC power at a high frequency. The transmitter coil is energized and produces a magnetic field that alternating inside the coilas a result of the extremely high frequency AC current.

(a) DC Power Source: A rectifier circuit transforms the alternating current (AC) voltage into a direct current (DC) signal, and a step-down transformer lowers the supply powerto an acceptable level.

(b) Oscillator Circuit: Our project makes use of a customized oscillator circuit. This circuit makes it easy to get the transmitter coil to oscillate at a high current. The wireless power transmitter's oscillator circuit is shown in the following figure Fig.3.

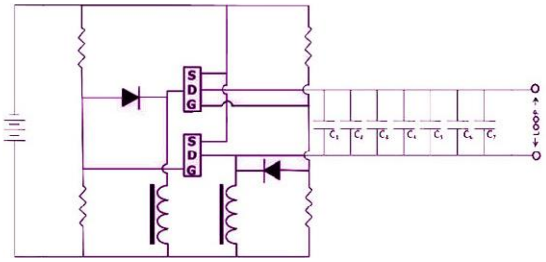

Fig.3 Transmitter Section Circuit

A rectifier circuit, voltage regulator IC, and receiver coil make up the receiver part. A magnetic field is generated by the alternating current (AC) that flows through the transmitter coil. The receiver coils of a wireless charger is able to create current flow and induce an alternating current voltage (AC voltage) when it is placed at a certain distance from the transmitter coil, thanks to the electromagnetic field that extends from the transmitter coil. For charging low-power devices, a rectifier system in the receiver portion transforms the alternating current (AC) into direct current (DC), and the voltage regulator integrated circuit (IC) contributes to maintaining a steady, limited, controlled output voltage to the load. The receiver section's circuit is shown in the following figure Fig.4.

(iv) Light Emitting Diodes
semiconductor light source is the **(LED):** One type oflight-emitting diode, or

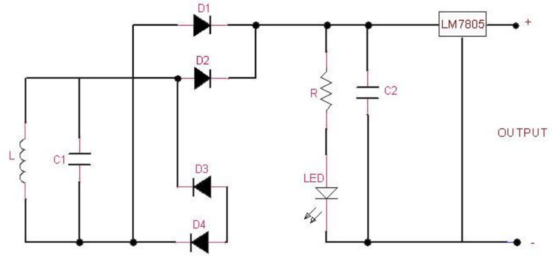

Fig.4 Receiver Section Circuit

The parts of a power supply are as follows:

(i) Voltage Transformer: Transformers, whether voltage or potential, are static electromagnetic devices that change the voltage level of an input voltage by winding wires. There are two windings in a transformer: one that receives input voltage and one that produces the converted voltage. The following figure Fig.5 shows the voltage transformer.

Fig.5 Voltage Transformer

(ii) Diodes: Diodes are electrical components having two terminals and an asymmetric conductivity. The resistance of current flow within one direction is low, preferably nil, LED. A growing number of gadgets are using LEDs as general illumination, and they are also employed as indication lamps. The following figure Fig.8 describes the light emitting diodes.

Fig.8 LED

(v) Lithium-Ion Battery: A battery consists of interconnected cells that are situated in groups. A liquid electrolyte, a positive electrode (the cathode), and a negative electrode (the anode) are the three primary components of a cell. The following figure Fig.9 shows the elements of a lithium-ion battery.

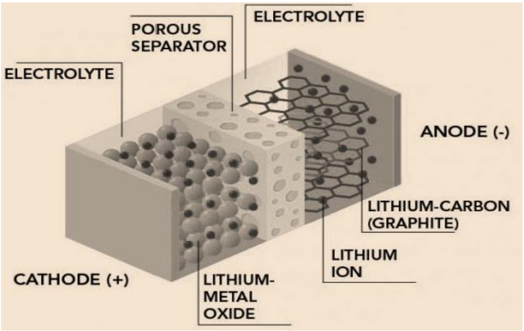

Fig.9 Elements of Lithium-Ion Battery

(vi) Solar Panel: A solar panel is an array of solar cells that, when placed in a proper location may collect enough sunlight to power a home's electrical system or even heat water.

whereas in the other direction it is great, ideally infinite.

Crystalline semiconductor material having a p-n junction attached to two electric terminals is the most typical form of semiconductor diode nowadays. The anode and cathode of vacuum tube diodes are two electrodes. The following figure Fig.6 shows the diodes.

Fig.6 Diodes

(iii) Resistors: A resistor is an electrical component with two terminals that passively implements electrical resistance. The following figure Fig.7 shows the resistor. Usually, 6×10 photovoltaic solar panels are assembled into a photovoltaic (PV) module. The photovoltaic arrays of a business or domestic photovoltaic system are made up of photovoltaic modules. This system uses solar energy to produce and distribute electricity. Typically, modules are rated between 100 to 365 watts based on their DC power output under conventional test settings. The following figure Fig.10 shows the solar panel.

Fig.7 Resistor

Fig.10 Solar

IV. RESULTS AND DISCUSSIONS

When it comes to microcontroller-based designs, Proteus is the programme of choice for simulation. Its widespread compatibility with microcontrollers is a major selling point. Programmes and embedded designs may be easily tested using this tool, making it ideal for electronics hobbyists. For micro- controller programming behavior, utilize Proteus Simulation Programme. You may skip the circuit simulation in Proteus and go straight to the printed circuit board design process. Using Proteus VSM and the VSM Studio IDE, this article will teach you how to run an interactive simulation using a microcontroller. Practical usage of the IDE and simulator will be the main focus, with reference books providing more extensive treatment of each topic. If you are unfamiliar with sketching in ISIS, you should spend some time going over the lesson content in the ISIS reference handbook. This tutorial does not cover schematic input. After a brief introduction to running the simulation in the VSM Studio IDE, we'll dive into Proteus's measuring and debugging capabilities. We must begin by configuring our project in the VSM Studio integrated development environment (IDE). Using a virtual development board makes the process considerably easier: (a) Launch the VSM Studio IDE and go to the File Menu. Then, choose 'New Project.' (b) Locate the "PIC16F1 Evaluation Board" under the "Demonstration Projects" subsection. Press the button that appears next. (c) Recheck and double-check that the data entered into the controller selection window is accurate. At last, to preserve the system, click OK. If a compiler displays with a "not installed" suffix even if it is really installed, click the compilers option on the right after which click the check all option in the dialogue forms that follows. When you run this, VSM Studio and Proteus will be able to identify and set up your compiler. The ISIS Design File, along with all the source and header files, should now be visible in the VSM Studio project tree. Following the system's transition to VSM Studio, you may access the project's source or header data by doubling-clicking on an item in the tree. One may get your hands on Microchip Technologies' standard firmware code for their F1 Evaluation board hardware demo project by visiting their website. When you progress, you'll have access to features like editing firmware and using the IDE's normal tools. Before making any changes, though, we'll complete the simulation route in Proteus. The following figure, Fig-11 represents the proposed hardware circuit design of the simulation and it consists of solar panel, MOSFET, rectifier, batteries and so on.

The following figure, Fig-12 represents the proposed simulation model, in which it is clearly developed by using the support of intelligent hardware simulator tool called Proteus.

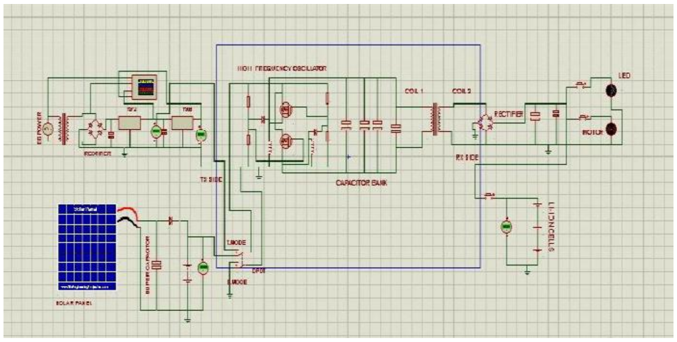

Fig.12 Simulation Outcome

The following figure, Fig-13 represents the proposed hardware outcome, in which it consists of wireless power transmission unit, reception unit, transformer for power supplyto transmitter and so on.

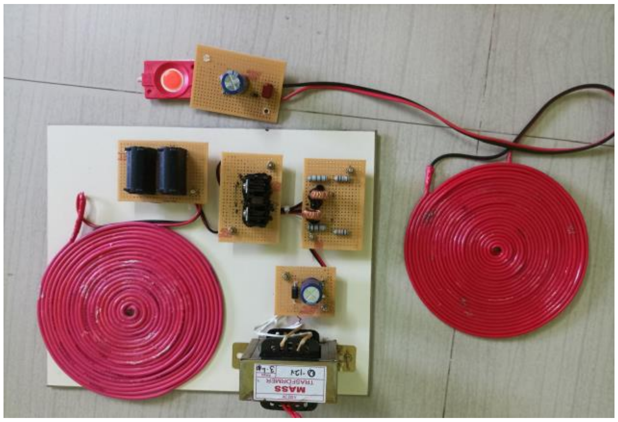

Fig.13 Hardware Output

V. CONCLUSION AND FUTURE SCOPE

In this system, the idea of wireless power transfer in introduced. Recent technical applications that enhance human lives in the modern world have been covered. There are now three competing new standards for wireless power technologies. Therefore, several factors, including needed influence, geographical distance, substrate, implementation, difficulty, and expenses, determine the technology choices. This idea outshines all previous discoveries and inventions in terms of the potential for easy power transfer with little losses. Power may be sent instantly from the source to the receivers across great distances without the need for expensive lines. Wireless power transmission might be a part of the infrastructure of future cities. One example is the possibility of wireless charging for electric vehicles while they are in motion; this would make electric transportation more practical by eliminating the requirement for dedicated charging stations.

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