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CREATING A DYNAMIC WIRELESS POWER TRANSFER SYSTEM TO PROVIDE THE CAR WITH ELECTRICITY

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Abstract

The transport industry is transitioning to electrified vehicles because they are more dependable, safe, smart, and environmentally friendly. The next generation of transportation for development of a social and high mobility is electric cars (EVs). The drawbacks of the current conductive or plugin chargers force research on wireless power transfer (WPT) technology for EV charging, which would result in the utmost convenience of owning an EV. A practical charging method that is " independent," "no contact," and "park and charge" is WPT technology. Despite its benefits, this technology hasn't been widely used in the transportation industry. The technology is still relatively costly and inefficient compared to alternative options, which may account for the delay. A new age of electromagnetic fields (also known as resonant inductive coupling) based WPT systems for EV charging is now possible because to ongoing research and development in this area. We suggest an environmentally wireless charging (WC) technology for electric cars that allows WC even when the car is moving along the road. The suggested method is also employed for car charging in mall parking lots and other locations. Also, the proposed charging system might need electricity from wind and solar power plants that have been constructed beside roadways. They are connected to form a hybrid system to supply the WC system with electrical energy produced by solar PV systems.

Keywords: WPT, WC, Solar PV Systems, EV Charging, Wireless Transmission.

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1. INTRODUCTION

A useful, cordless, reliable, appropriate, and all-weather power transmission or charging method is wireless power transfer (WPT) [1]. A receiving coil is included within the car, and a transmitting coil is buried beneath the charging station in a conventional WPT system for EV charging [2]. Generally, it consists of two separate electrical systems that are coupled to one another. This magnetic coupling makes it possible to charge the car battery wirelessly. Since the components are electrically isolated, operating in damp environments poses no safety issues, and such conditions have no impact on how well EV charging works, there are intrinsic advantages.

Since more than 20 years ago [3], inductively coupled WPT systems for roadside electric vehicles have been proposed. However, only a small amount of commercial development has taken place because of the challenges associated with providing an electric vehicle with enough power without compromising the vehicle's manoeuvrability or safety. Due to the high energy consumption of electric vehicles, any reduction in energy efficiency caused by the process of transferring electricity from the source to the vehicle would be noticeable. Though, for WC to become extensively used, under power transfer efficiency must be close to 100%. Extremely high gain for inductive charging is only possible when the sending and receiving coils are virtually in contact. The major challenge with adopting the inductively coupled WPT method for wireless EV charging is the practical necessity that the transmitting and receiving coils be almost in contact and that they be properly aligned. As a result, wireless power transmission systems that are inductively linked have fallen out of favour for EV charging.

The global energy reserves are at an alarming rate, for which replacement of gasoline vehicles by EVs is a partial and accepted solution. As a result, the transportation sector is transitioning to electrified vehicles because they are more dependable, safe, smart, and environmentally friendly. The usage of electric vehicles is seen to reduce car emissions, diversify the fuel supply, and utilise fewer fossil fuels for transportation.

The environmental benefits of transitioning from gasoline to electricity for vehicle propulsion are unquestionably the biggest advantage. The ability to transfer energy over the air without a conduit, which is not possible with hydrocarbon fuels, is another benefit of using electricity. Although all of its benefits, the largest drawback of having an EV is the time and work required to power/charge it. Since the vehicle must be physically connected into a charger at the end of every short trip, the current plug-in or conductive chargers are a big inconvenience for EV owners [6]. In furthermore, during outdoor charging, exposed contacts constitute a safety risk. It turns out that wireless charging is the answer to this problem. The greatest convenience of owning an EV would be wireless charging.

Due to the convenience and safety, WPT through electromagnetic induction has been increasingly important in WPT/charging the electronics devices as well as electric vehicles [7]. WPT technology has several benefits, but it hasn't been widely used in the transportation industry. This delay could be brought on by the technology's continued high cost and worse efficiency compared to alternative technologies. Moreover, for a longer and greater power transmission, electromagnetic field and electromagnetic interference can become severe and should be reasonably reduced. To usher in a new era of wireless charging adoption, further research, and endeavour in WPT for EV charging will be required.

Certain business and academic groups are now promoting the idea of WC for EVs using this magnetic resonance coupling, or so-called resonant inductively coupled wireless power transmission system [7]. Hence, it's clear that the idea of WC based on resonance is becoming popular. Yet only displaying the electrical power being communicated from the charging station to the on-board battery is insufficient to create a workable WC system for an EV. Nevertheless, in less than ideal and realistic EV charging conditions, the architecture as it stands was unable to sustain the maximum power transfer efficiency. Pure EVs require several other challenges to be resolved before a workable resonant inductively coupled WPT system can be mounted on an actual car.

The innovative work to be carried out will address the fundamental hurdles to the widespread usage of wireless charging, the big concern of power transfer efficiency and energy wastage in the wireless charging process under non-ideal practical usage scenarios. It is critical to conduct research and develop a solution for obtaining maximum WPT efficiency under realistic and non-ideal EV charging settings to make the magnetic resonance coupling-based wireless EV charging system more commercially viable. It is extremely needed to outline the following points that hold the promise for future EVs.

The major distinction between the resonant inductively coupled WPT system and the traditional inductively coupled system is in the way power is transferred. Resonant inductive power transmission is a directed coupled, non-radiative, near field WPT technique. The resonant inductively coupled WPT system makes use of the magnetic resonance concept to make it easier for the magnetically connected resonant coils in the intermediate proximity to transmit power to one another [8]. The near fields of the resonant coils will strongly couple when they are activated at their resonant frequency, enabling efficient WPT in a fraction of the time of the typical WPT system decay period. While successfully exchanging energy between items with the same resonant frequency, this technology offers very little assistance with exchanging energy with non-resonant objects. Due to its efficiency, the resonant inductively coupled WPT system has lately gained pace as a potential EV charging solution.

Due to its plenty, cleanliness, and safety in terms of energy conversion processes, solar energy is the most appealing and abundant alternative to conventional energy sources (Jibran and Mudassar, 2016). Several research found in the literature have identified the great technical potential of solar electricity.

Solar PV technology has early been developed in the 1860s, driven by the expectations that coal, as the main conventional energy source will become scarce. However, after the discovery of petroleum in the early 20th century, the developments in solar PV technology became stagnant until the 1970s after which it starts growing rapidly, because of oil embargo (De Santi et al., 2013, Getachew and Björn, 2010). This situation steered the drastic cost decrease of the solar PV technology that resulted in the application of PV technology from remote outer space down to earth. Despite the cost decrease of the solar PV technology in the early 1970s, major interest in the technology did not arise until the 1970s energy crisis, which was accompanied with different suggestions and arguments that turns the attention of the global energy sector to alternative energy sources.

Despite the huge efforts and financing in the solar PV R&D (Research and Development) during the time of global energy crisis, solar PV cells were still relatively expensive compared to the traditional fossil fuels despite huge applications, rapid decrease in price and tax breaks to encourage the utilization of the technology in electricity applications. The solar PV industry stirred up from its stagnant stage after the end of the energy crisis, when heatwaves and drought strike many parts of the globe during the summer of 1988, the blamed that trigger the issue of global warming or global climate change. During this time, massive development is witnessed in the solar PV industry, ranging from the development of new technologies and the conversion efficiencies.

Solar photovoltaic technology is rapidly growing across the globe with development in the installed capacity happening all over the globe. The worldwide growth of solar PV technology is extremely dynamic in such a way that, the estimation of the growth rate is a tricky issue, because of the development witnessing in the installed capacity of solar PV electricity across all countries and regions of the globe as shown in Fig. 2.5. Generally, the worldwide growth of solar PV installed capacity shows an exponential curve between the early 1990s to date.

Solar power is the conversion of energy from the sun to electricity. Among the major developments in converting solar energy into useful energy, the forms include the direct conversion of solar energy to electricity using the photovoltaic effect (Garcia-Lopez et al., 2015).

Another wide application of indirect solar energy conversion is the production of heat mainly in the form of Concentrated Solar Power (CSP). Concentrated Solar Power (CSP) technology indirectly converts solar energy into electricity through conventional steam-driven turbines, using lenses, mirrors and tracking systems to concentrate a large amount of solar radiation into a small beam for heating water to steam (Aymeric et al., 2019; Maruthi and Krishnamoorthy, 2019).

2. METHODOLOGY

The fundamentals of wireless charging are identical to those of transformer operation. There is a transmitter and a receiver used in wireless charging. A 220V 50Hz AC supply is converted into high frequency ac voltage and supplied to the transmitter coil. The receiver coil is broken by the alternating magnetic field produced by the high frequency AC, which causes the receiver coil to produce AC power. The resonance frequency between the transmitter and receiver must be maintained, though, for wireless charging to be effective. Compensatory networks are introduced on both sides to keep the resonance frequencies constant. Finally, the receiver side rectified the AC power to DC and sent it through the battery bank to the battery.

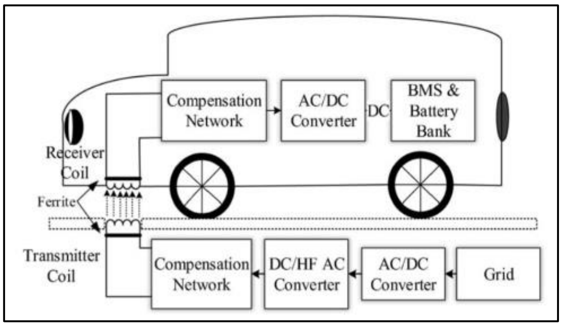

Figure 2.1 Block Diagram

A stationary transmitter transmits energy over the air to the receiver coil in a passing car. By employing DWCS to continuously charge the battery of an electric car while it travels on highways and roads, its mobility could be increased. By doing away with the requirement for substantial energy storage, the vehicle's weight is reduced even more.

A wireless electrical energy transmission prototype has been created; it operates with the 12 V, 50 Hz power source depicted in Figure 2.1. A straightforward step-down converter is all that is needed to change the 220 V supply into 12 V AC. Using a rectifier circuit and a capacitor, 12 V (AV) has really been transformed into 12 V (DC).

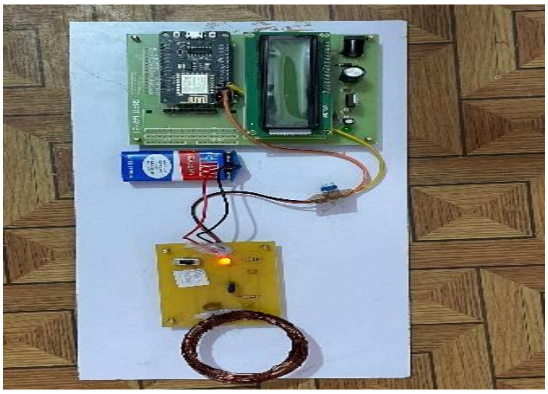

Figure 2.2. The design of wireless transmission

Parameter	Value
Maximum capacity (V)	110V
Cut-off voltage (V)	18V
Fully charged voltage (V)	27.9357V
Nominal discharge current (A)	47.8261V
Internal resistance (ohms)	0.0021818ohms
Capacity (Ah) at nominal voltage	99.4783Ah
Exponential zone [voltage (V), Capacity (Ah)]	[25.929V 5.40432Ah]

Table 2.1 Determined from the nominal parameters of the Battery.

A transistor is additionally included in the circuit to adapt the DC source into AC with increased voltage and frequency. After that, a primary coil with 20 turns and a diameter of 5 cm received the supply. A primary wave with a 5 cm diameter, 40 cycle duration, and the ability to light an LED was used in testing. It also achieved a wireless transmission range of 0.5 to 1 cm, which was extremely short compared to a practical application [11]. According to [12], it was actual minimum distance for WPT. A comparable network for mimicking WPT in the elementary cell was discovered in [13], and it consisted of two 1500 mm diameter by 50 mm height by six wire turn coils. Figure 2.2 depicts the 110 H net capacitance. Q = 100 was used as the setup's quality factor. For varied Center distances, the coupling coefficient (k) was 0.4955 at 200 mm, 0.3581 at 330 mm, and 0.2672 at 400 mm.

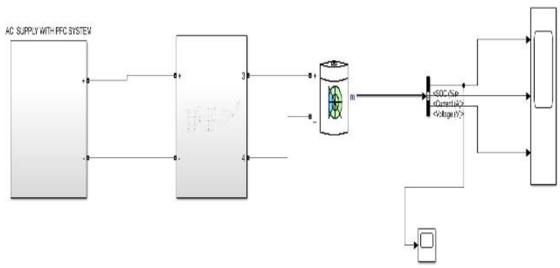

Figure 2.3. WPT Circuit diagram

Figure 2.3 displays a graph of efficiency vs supply frequency for a WPT network with an estimated eminence factor of 100. A supply frequency of 20–22 kHz would yield the most efficiency.

The proposed system has been implemented for effective wireless charging of EVS by transferring the power from the charging station to the on-board battery of EV.

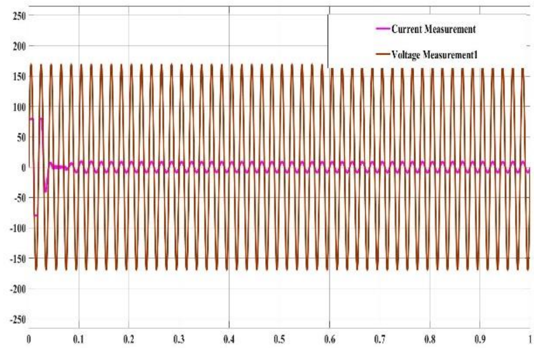

Figure 2.4. Graph for efficiency versus frequency for WPT network

These findings also suggest that the vertical distance between the coils, which is determined by the structural spacing, has an impact on the power transfer efficiency of the WPT system. The best frequency range for maximising power transfer effectiveness changes depending on how far apart the coils are from one another. When there is a greater physical separation gap between the coils, the power transmission efficiency is reduced. For smaller physical spacing between the coils, the optimum frequency area is wider, and for larger vertical separation distances, it is shorter. This might be a result of the transmitting and receiving coils' enhanced coupling coefficient and decreased mutual inductance. It explains how to construct an effective WPT system for EV charging by considering an optimal frequency range corresponding to their physical distance.

It has been found that as the number of coils turns varies, so does the optimal frequency band consistent to the powerfully attached region. This may be because various turns of a fixed coil size experience a varied intrinsic loss rate, which results in a different ohmic and radiative loss with respect to frequency.

3. RESULT AND DISCUSSION

The design of a dynamic WC system is followed by an experiment to measure system output with the upgraded charging mechanism which is shown in Figure 3.1.

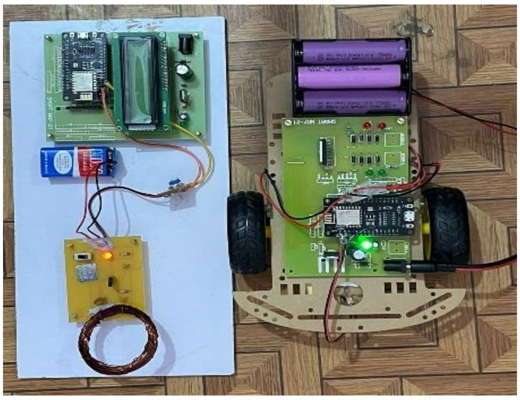

Figure 3.1. WPT network Simulation

The functional model for WPT is shown in Figure 3.1. It runs on 18 V AC at a frequency of 20 kHz. It has SMPS that turn the 220 V, 50 Hz input supply voltage into 12 V, DC. SMPS output supply was then fed into a DC-AC converter.

This DC to AC converter provided us with an output source of 18 volts AC along with a 20 kHz high frequency square wave. Figure 3.2 shows how the output supply was routed through two 100-watt low pass filters.

Parameters	**Value**
Input DC Voltage	12 V
Output AC Voltage	0-160 V – 220 V – 380 V and AC 18 V
Transmitter coil inductance	168 µH
Receiver coil inductance	168 µH
Transmitter tuning capacitance	330 nF
Receiver tuning capacitance	330 nF
Load Current	0.35 A
Output Frequency	20kHz

Table 3.1 Specification

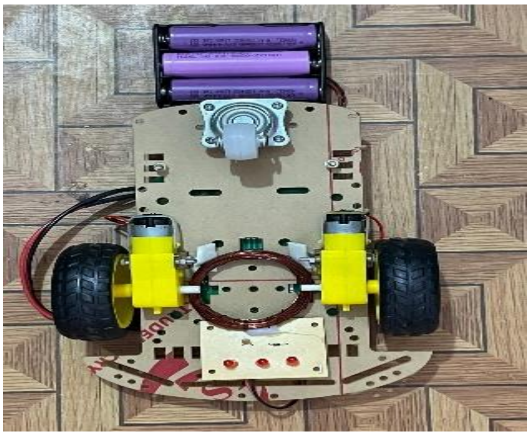

Figure 4.2. Output supply

Parameter	Value
Nominal voltage (V)	24V
Rated capacity (Ah)	110Ah
Initial state of charge (%)	60%
Battery response time (S)	30S

Table 3.2 Battery Specification

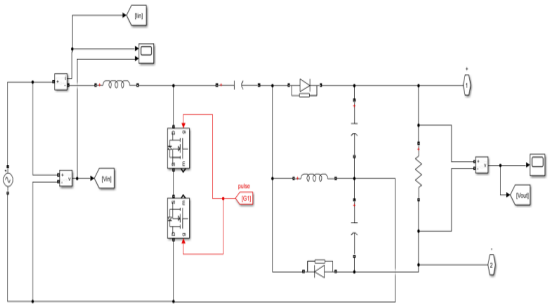

Figure 3.3. AC supply with PFC System

Parameter	Value
Peak amplitude (V)	120*1.414V
Phase (deg)	0deg
Frequency (Hz)	50Hz
Sample time	0S
Measurements	None

Table 3.3. AC supply with source

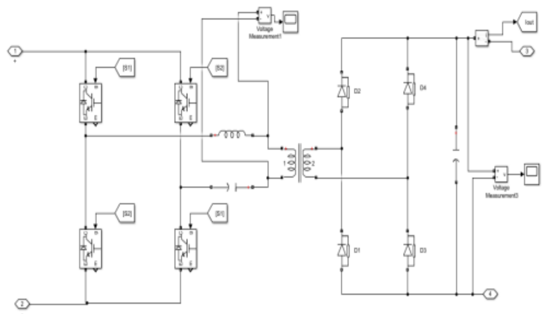

Figure 3.4. Subsystem

Parameter	Value
Nominal power and frequency [Pn (VA) fn (Hz)]	[10w^{3} 100Hz^{3}]
Winding 1 parameters [V1 (Vrms) R1 (ohm) L1 (H)]	[800V 2.592Ω 6.5655H^{-09}]
Winding 2 parameters [V1 (Vrms) R2 (ohm) L2 (H)]	[90V 0.002Ω 5.0661H^{-12}]
Magnetization resistance and inductance [Rm (ohm) Lm (H)]	[6.48Ω+05 4.1035H^{-01}]
Measurements	Winding voltage

Table 3.4. Liner transformer

A working electric car prototype with the charging system depicted in Figure 6 has been created. The wirelessly collected power will be stored in the battery to supply the vehicle's electrical drive over an extended period of time; the car is made up of an inductor and a process converter concept. The coil ends are connected to the rectifier circuit, then a capacitor, which is connected further via the transistor and a 6V relay, in order to operate the load and charge the battery simultaneously. A secondary winding with a diameter of 8 cm and 64 turns is located in the bottom of the vehicle. A lithium-ion battery with a 6 V and 500 mAh capacity was also utilised in this circuit.

The electric vehicle's WPT network prototype's secondary coil has been tested with 64 turns and has an 8 cm diameter. The primary coil's turns were extended in order to raise the input voltage and lower loss. A voltage of 12–14 V was found in the secondary coil when the primary coil and primary coil were isolated by 10 cm, and it was identified that it could charge a 6 V 500 mAh battery in roughly 50 minutes. The testing results obvious that charging the electric automobile at a 10 cm distance is generally in agreement.

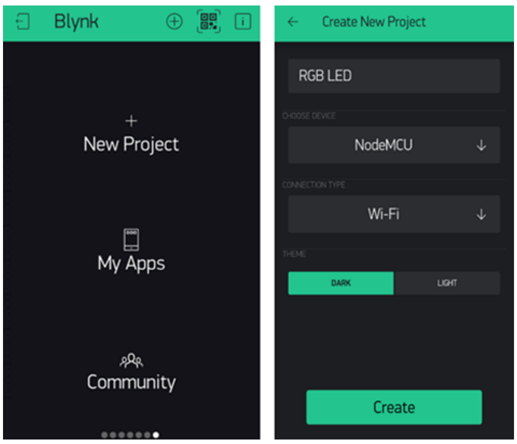

Figure 4.5 Blynk App

Blynk is an app that is compatible with both Android and iOS devices that allows us to use our cell phones to control any IoT device. To develop the GUI of our IoT application, we can develop the customized Graphical User

Interface. You may also view all of the previous Blynk IoT projects that we created. In order to track the sewage situation for this project, we will configure our Blynk application here.

4. CONCLUSION

This work uses analysis to find the nonlinear relationship between transmission efficiency and quality parameter. The presented WPT network design for EV charging was built at the optimal height with the least amount of circuit losses. On an electric car with a secondary coil that has an 8 cm diameter, 64 turns were tested in this study above the main coils that were available in the road. A voltage of 12–14 V was found in the secondary coil when the primary coil and secondary coil were isolated by 10 cm, and it was found that it could charge a 6 V 500mAh battery in about 50 minutes.

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