Solar Wireless EV Charging System

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ABSTRACT

A lot of power plants are needed to electrically charge the increasing number of electric vehicles that are hitting the road today. Electric vehicles are powered entirely or partially by electricity to reduce pollution. Nevertheless, there are very few charging stations in and around cities since they require sophisticated infrastructure that is expensive to maintain. These restrictions have been heightened the need for energy generation that is cost-effective and sustainable. One of the most popular ways to recharge pure EV is by wireless charging. Wireless charging systems, however, have a convoluted operating philosophy and several criteria, including the notion of the vehicle, the distance between the receiver and the transmitter coils, the size, and dimensions of the coils and more. The research outlines a cutting-edge technique for creating a solar-powered wireless EV charging system that used coupled induction theory for wireless charging od the vehicle. Under this concept, several mathematical equations are put forward to analyse and characterise the system's efficiency while in motion. Using a Light Emitting Diode and a liquid crystal display, a microcontroller is used to show the electric vehicle's input voltage and charging status, respectively. The installation of this wireless charging system will do away with the expensive maintenance needs, and the solar-powered charging system will guarantee continuous charging.

Introduction

Electric automobiles are a novel idea in the worldwide transportation industry. By the end of 2025, it is anticipated that the market share of EV might increase to 30% globally. (Prasad, 2022). Over the past five years, electric vehicles have gained tremendous popularity. Electric vehicles are powered entirely or partially by electricity. This not only reduce pollution in the environment but also help reduce cost by eliminating the need of fuel. EVs have risen to the status of a more competitive option than conventional cars. However, because of several restrictions, such as high price, extended charging times, and a lack of adequate charging infrastructure outside of cities and rural towns, electric vehicles are still not commonly used. In this instance, because of how simple and effective it is to use, wireless charging has emerged as the most popular type of charging. Power can be moved from one location to another wirelessly by using no cables or other transmission lines.

The Tesla coil was created because of Nikola Tesla's innovations for wireless power transfer in 1891. Tesla then began construction of the Warden Cliffe Tower, a high-voltage wireless energy transmission station. On July 4th, 1917, the tower was ultimately destroyed. (Prasad, 2022) Radio frequency (RF) based charging, inductive charging, radiative wireless charging, or coupling based wireless charging are currently the four main types of wireless charging technologies that are progressively becoming more common. The most popular method of powering electric devices in the current world is wireless charging. Given its abundance in the natural world, solar energy is a fantastic source of electricity. Using the idea of the photoelectric effect, solar panels convert solar energy into electric energy and are constructed of silicon cells. The batteries that eventually serve as wireless chargers for electric vehicles are stocked with the solar energy that the solar panels collected. (Nidmar et al., 2019). To maximize the use of renewable energy and reduce pollution, solar wireless EV charging systems are now being developed. A wireless electric car charging system transmits power wirelessly from a roadside transmitter to the receiver coil of the moving electric vehicle. The battery of this technology stores less big amounts of energy thereby minimising the size and mass of the vehicle. Systems for wireless charging allow for charging without a plug. An electric vehicle is wirelessly charged by an EV wireless charging station. There are now two types of wireless EV charging systems, namely:

1. Wireless static charging
2. Wireless dynamic charging

Static wireless charging charges the vehicle while it is stationary, and dynamic wireless charging charges the vehicle while it is moving. To create a standard for wireless charging systems that are user-friendly and suitable for the majority of electric vehicles, the Society of Automotive Engineers (SAE), Underwriters Laboratories (UL), and Institute of Electrical and Electronics Engineers (IEEE) are continuously working together. One of the standards: Light-Duty Plug-In Electric Vehicles employ SAE J2954. There are 4 levels of maximum input powers in this standard. (Prasad, 2022). When the EV is aligned, it gives up to 85% minimum efficiency. The magnetic triangulation is the ideal alignment. Additionally, it helps the autonomous vehicles locate charging stations so they can maintain the desired charging range. The SAE J1772, SAE J2847/6, SAE J1773, SAE 63027, and other emerging standards are examples. This project is comparable to the SAE J1773 standard for wireless inductive coupling EV charging. Pradosh, 2022. For EVs like the BMW i3, Chevrolet Volt, Tesla, and Nissan Leaf, the Evatran Group is creating plug-free charging. WCS is being developed by Qualcomm Halo for race and sports cars. Among the other businesses creating and developing WCS for vehicles and SUVs are WiTricy Corporation and Hevo Power. (Prasad, 2022).

Literature Review

The fundamental idea behind using wireless power transmission for electric vehicles are examined in this essay. Traditional automobiles consume up to half of the world's fuel supply, placing a significant burden on non-renewable resources and producing significant pollution. The creation of electric vehicles is now a crucial component of the automotive sectors. But one significant disadvantage of electronic vehicles is the high cost of manufacturing storage technologies. Moving electronic vehicles can be charged using a technique called dynamic wireless power. This approach minimizes the size and expense of the batteries used in electric vehicles while resolving issues with range. To maximize charging, receiver coils are used in this study to demonstrate improvements in wireless charging performance for electric automobiles. For the method, dynamic mathematical models are used for each physical parameter. The study assesses the dynamic wireless charging system, which consists of two coils, one of which is on the vehicle's body and the other of which is implanted in the road. (Mohamed et al., 2022). The coil on the road serves as the permanent transmitter, while the coil on the car's body serves as the moving receiver. As previously indicated, the design of the coils used for transmission and reception, as well as the compensatory topologies employed in wireless power transfer, are important aspects that have a substantial impact on the overall system performance. For both static and dynamic models, mathematical expressions are presented in the work. The main output of this research was the creation of a novel model that guarantees very efficient battery charging. The results also indicate that by adopting a wireless charging system with two receiver coils, it may be possible to boost efficiency to 100%. Global efficiency, which accounts for 90% of the efficiency, lengthens battery life.

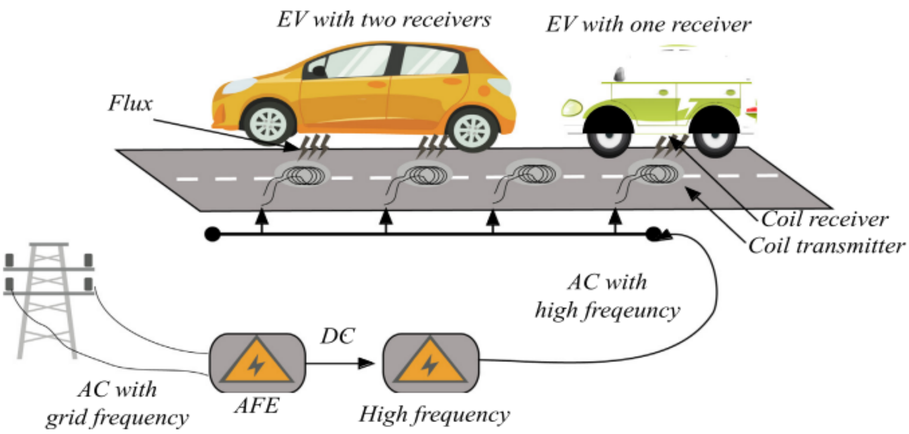


Figure. 1. Two different compositions of the receiver coil in the electric vehicle. (Mohamed et al., 2022).

The distance and amount of time required to fully charge an electric car utilizing one receiver coil as opposed to two receiver coils are displayed in Table 1 below. The project's limitations include the inability to suggest a method that maintains the vehicle's charging efficiency when the distance from the transmission coil grows and the fact that the charging time is longer for faster cars. Making sure the receiver coil has the most fluxes possible to be generated is one possible recommendation to improve the system. Depending on the shape of the coil and the segment dimensions, using huge coils in the system can cause certain problems. (Mohamed et al., 2022).

Table 1. Distance and time needed to completely charge an electric car. (Mohamed et al., 2022).

Speed (Km/h)	Receiver (one coil)		Receiver (two coils)	
	Distance (km)	Time (h)	Distance (km)	Time (h)
10	1666	40	833	20
100	4000	83	2000	41

Another study has been done to show the comparison between different wireless charging techniques. The below table is a comparison of some of them.

Table 2. Comparison table of different methods of wireless charging (Sulaiman et al., 2016)

Technique	**Advantage**	**Disadvantage**	**Charging distance**	**Application**
Inductive coupling	Safe for people, straightforward to use	Short charging distance and warming impact.	Measurements between millimetres and centimetres	Smart phones, small cameras, RFID tags, etc.
Magnetic resonance coupling	multiple device charging, high charging efficiency, and non-viewable charging paths	Limited charging range, difficult implementation, and inapplicable to portable devices.	range from a centimetre to a meter.	Smart phones, TV, PC, laptops, electric vehicles, etc.
Microwave radiation	A long charging distance that is practical and suitable for portable electronics.	Not safe when the RF radiation density to exposure is high, viewable pathways.	range from a few centimetres to a few kilometres.	Implanted body devices, RFID tags, LEDs, and wireless sensors.

The various wireless charging methods are listed in Table 2 along with their associated benefits and drawbacks. The study's findings demonstrate that solar-powered wireless charging devices that use the inductive charging technique only perform well in terms of standby time. The main disadvantage of this kind of charging mechanism is that it requires much longer to charge than wired charging. (Sulaiman et al., 2016)

Methodology

Block Diagram

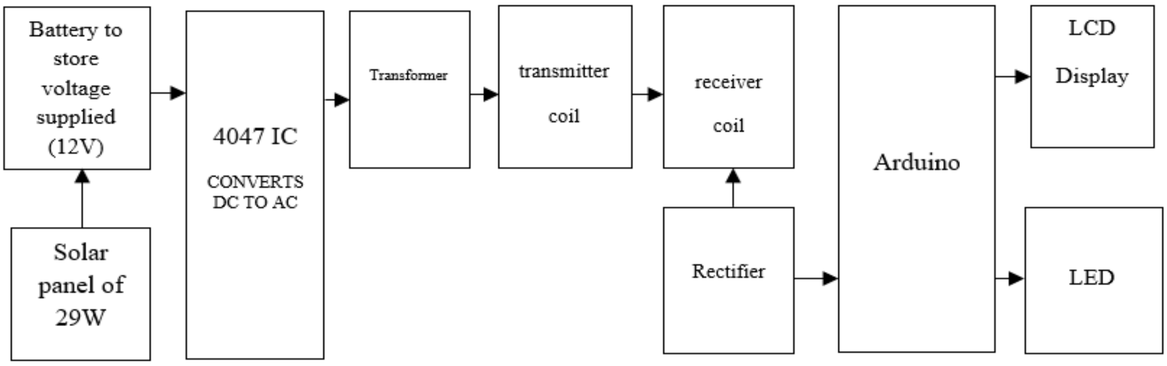
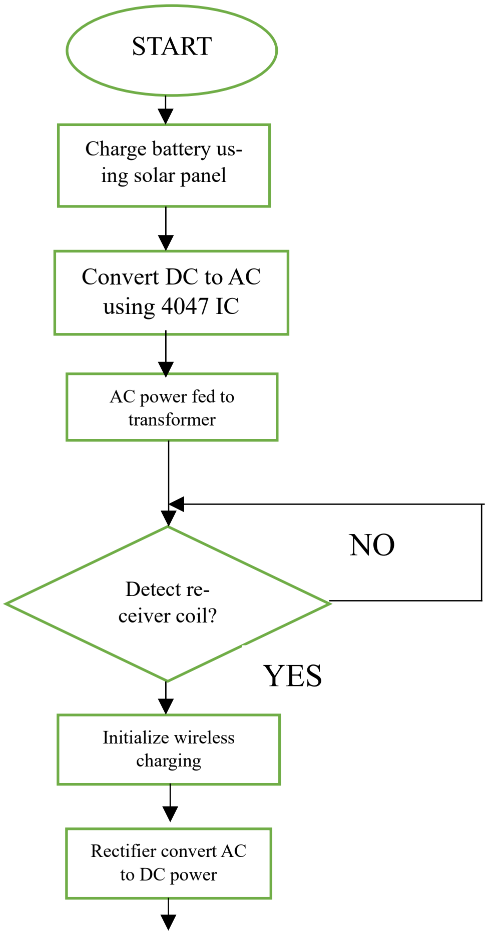
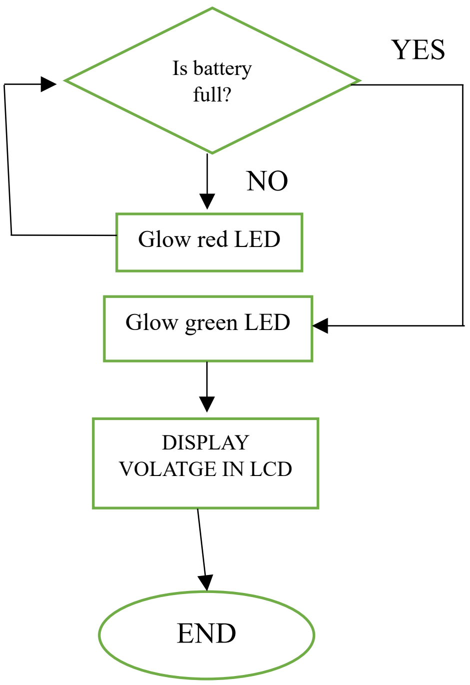


Figure 2. Block diagram of solar wireless EV charging system

A solar panel, battery, 4047 integrated circuit, transformer, copper coils for wireless signal transmission and reception, rectifier, ATmega320P controller, LCD display, and LED are all components of the solar wireless EV charging system. (Refer Fig 2). The battery is charged by a charge controller while the solar panel stores solar energy. For wireless communication, DC power is changed to AC power using the 4047 IC. Transformer use is regulated by a regulator circuit. The transmitter copper coils are now powered to enable wireless transmission. While driving down the road, the car's receiver coil, which is mounted underneath, wirelessly picks up the signals. The AC power that was received needs to be converted back to DC power. For this, a rectifier is employed. An AT mega microprocessor measures the input voltage. The microcontroller-interfaced LED will light to show that the EV is charging. The microcontroller is also attached to an LCD display, which shows the input voltage.

Flow Chart





Prototype

Solar panels, batteries, transformers, regulator circuits, copper coils, AC to DC converters, Atmega controllers, and LCD displays are all used in the system's construction. The technology shows how electric cars may be charged while driving, doing away with the requirement to pull over for charging. Using a charge controller, the battery is powered by the solar panel. DC electricity is fed into and stored by the battery. A transformer is used to convert the power to AC, and regulator circuitry is used to regulate it. The copper coils that are utilized for wireless energy transmission are now powered by this energy. The receiver coil receives the power and stores it in the vehicle battery. An ATmega microprocessor measures the input voltage. The microcontroller-interfaced LED will light to show that the EV is charging. The microcontroller is also attached to an LCD display, which shows the input voltage.

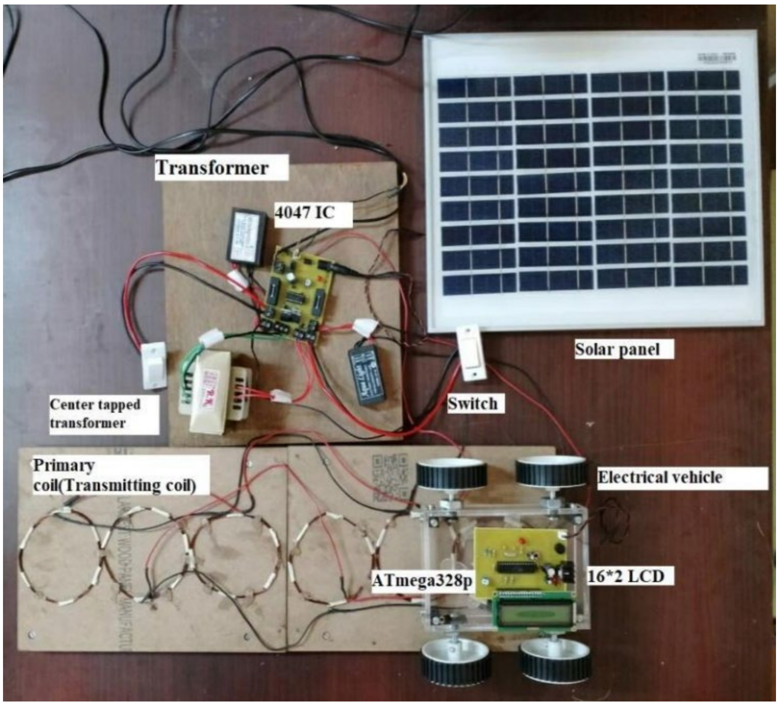


Figure 3. Prototype of the project

Results and Discussion

The solar panel to be used is a 1W solar panel supplying 12V of voltage. The battery to be used to store the voltage from the solar panel is a DC rechargeable battery with maximum voltage capacity of 12V (1400mAh)

The current supplied is given by the equation:

Equation 1 $I = \frac{P}{V} = \frac{1W}{12V} = 88.333mA$

The estimated time taken for completely charging the battery using the solar panel during maximum sunlight hours will be 15hours 8mins approximately.

Equation 2 $charging\ time = \frac{battery\ capacity}{current\ supplied}$

$$charging\ time = \frac{1400}{88.333} = 15hours\ 8mins\ (approx)$$

The working frequency for transmitter and receiver

Equation 3 $F = \frac{1}{2\pi\sqrt{LC}}$

The main aim of the paper is to observe the distance and voltage relation for dynamic wireless charging.

Table 3. The relation between the distance between the two coils and induced voltage in receiver coil.

Distance (mm)	Voltage (V)
10	4.62
20	3.33
30	1.65
40	0.44
50	0

To conclude he separation between the primary and secondary coils is shrinking. As the distance between two coils grows, the induced voltage for voltage generated on the secondary side decreases. To maintain smooth voltage characteristics for wireless charging, the trade-off is maintaining the distance between the primary and secondary coils. To establish a fixed voltage at the receiver side, a voltage regulator is helpful. For the sizes and configurations of the identical coils, the maximum value of the mutual inductance is conserved. However, the mutual inductance value will be increased by two, which aids in drawing more power from the transmitter.

Conclusion

There are two types of wireless transmission technology. By utilizing inductive coupling between two coils, near field technology, also known as non-radiative near field technology, is helpful over short distances. Devices like phones, electric brushes, and inductive cooking may all be charged with it. Radiative or far-field techniques are helpful for long-distance transmission. Wireless power transmission methods can be used with electromagnetic radiation or laser beams. Solar-powered satellites can use this radiative far field approach. The separation between the primary and secondary coils is reducing. As the distance between two coils grows, the induced voltage for voltage generated on the secondary side decreases. In order to maintain smooth voltage characteristics for wireless charging, the trade-off is maintaining the distance between the primary and secondary coils. To establish a fixed voltage at the receiver side, a voltage regulator is helpful.

Acknowledgment

My sincere gratitude to Middle East College for giving me the opportunity to conduct the research. I appreciate the assistance, questions, offering the information source, and insightful comments from the head and faculty of the Department of Computing and Electronic Engineering that helped me optimize my research.

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