Design and Development of an Efficient Wireless Charging Station for Electric Vehicles

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Abstract - There is an increasing need to switch to renewable energy sources like solar power as the supply of nonrenewable sources is predicted to decline in the upcoming years. As the world's population grows, so does the number of cars on the road, which raises air pollution levels. Installing "Electric Vehicle Charging Stations" can assist solve this problem by lowering the pollution produced by petrol and diesel automobiles, which are responsible for 75% of pollution each year? Manufacturers will concentrate on creating more electric automobiles as non-renewable resources become more limited. This research investigates the use of solar panels, a renewable energy source, for wireless electric power transmission. Light energy is transformed into electrical energy by the solar panels. It is thereafter kept in a battery. The electrical energy is then transferred to a transmitter coil, or primary coil, through electromagnetic interaction with the receiver coil, or secondary coil.
Flux from the primary and secondary coils creates an electromagnetic field (EMF) that is used to wirelessly transfer electrical power.

Key Words: Electric Vehicle, Wireless Transfer, Arduino, Power.

1. INTRODUCTION

Due to their affordability and environmental friendliness, electric vehicles have grown in popularity in recent years.
However, many EV owners still struggle with the requirement for frequent recharging. Wireless charging stations are relevant in this situation. Electric vehicles may be conveniently and hassle-free charged without the use of cords or plugs thanks to wireless charging stations.
The project's goal is to create an economical and effective wireless charging station for electric cars. The project will entail designing and testing a prototype station in addition to investigating and evaluating various wireless charging technologies.
The vehicle's battery will be charged by the suggested wireless charging station using inductive power transfer technology. This entails wirelessly transferring energy between two coils—one in the charging pad and the other in the EV—using an electromagnetic field. The charging pad will be automatically adjusted by the station's sensors, which will determine the vehicle's position.

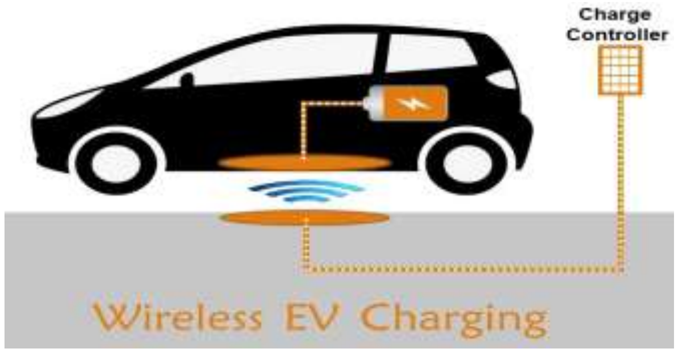

Fig1: Wireless Electric Vehicle Charging System

The initiative will also concentrate on making sure the charging station is dependable and safe. This will entail putting in place a number of safety features, like protection against overvoltage and over current, as well as carrying out extensive testing and certification to guarantee adherence to pertinent standards and laws.

The overall goal of the electric vehicle wireless charging station project is to offer a practical, effective, and environmentally responsible way to address the difficulties associated with EV charging. The station will make EV charging more convenient and accessible by doing away with the need for cables and plugs, which will further encourage the usage of electric cars as a sustainable form of transportation.

2. Body of Paper

Designing, creating, and testing a charging station that employs inductive power transfer technology to wirelessly charge an electric vehicle's battery is the goal of the wireless charging station for electric vehicles project. The project will go through several phases, such as testing, certification, design and development, and research and analysis.

The project's initial phase will entail investigating and evaluating several wireless charging technologies, such as capacitive power transmission, resonant power transfer, and inductive power transfer.

The team will proceed to the design and development phase after the technology has been chosen. This will entail creating the charging station and all of its parts, such as the sensors, coils, and charging pad.

To make sure the station is dependable, safe, and effective, the team will carry out a number of tests. This will entail assessing the station's charging time, energy efficiency, and power transfer efficiency in addition to performing tests to guarantee adherence to pertinent safety standards and laws.

The team will strive to make the wireless charging station affordable and easy to use throughout the project. The station will offer a practical and hassle-free solution to the difficulties associated with charging electric vehicles by doing away with the requirement for cables and plugs. By making charging more convenient and accessible, the project's ultimate objective is to encourage the usage of electric vehicles as a sustainable form of transportation.

3. PROJECT WORKFLOW

This idea will use an electric vehicle battery operation unit to implement a wireless charging system. Additionally, a battery operation unit will be used, which will display the battery percentage and use a relay to cut the force once the battery is fully charged. A wireless power transmitter and an AC to DC motor system are employed for charging stations. On the other hand, wireless power receiver systems are utilized in vehicles. To transfer the most power possible, the transmitter and receiver will be inductively linked.

The power that is wirelessly entered will be controlled and supplied to the battery for charge.

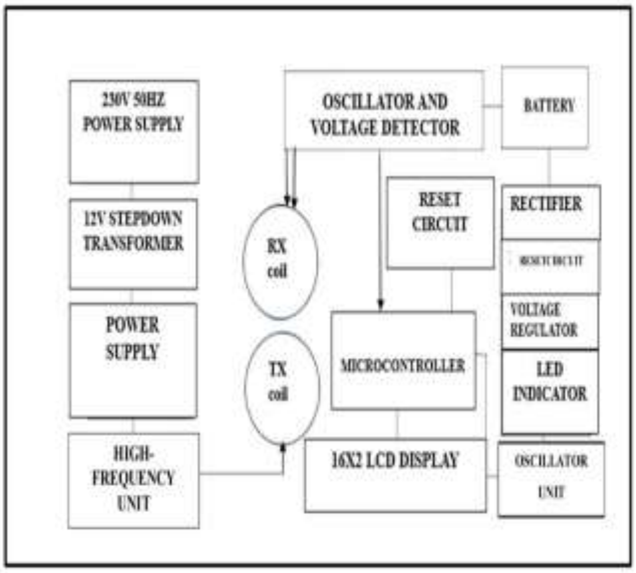

Fig2: Project Workflow

A voltage sensor is used to measure battery voltage. A microcontroller will measure the battery voltage and show it on a 16x2 LCD. When the battery voltage drops below a specific %, it will also indicate that the battery is low. When the battery is full, the microcontroller will cut off the charging trough relay to prevent overcharging.

4. PROPOSED SYSTEM

The expense of meeting the fuel requirements for petroleum-powered automobiles is rising daily. The easiest way to address this issue is to employ electric vehicles. This project will have a battery management unit and wireless charging technology. The following are the project's main goals: 1.To wirelessly charges the electric vehicle. 2. Show the percentage of battery charging on the LCD

3.When the battery percentage drops, indicate or send out a warning.
4. When the battery is fully charged, the supply is immediately cut to prevent overcharging.

5. METHODOLOGY

A step-down transformer receives 230V and transforms it into 12V in order for the circuit to function. After that, this voltage is passed into a little circuit that includes a VR2 7812 voltage regulator and a bridge rectifier. Four 1N4007 diodes in the bridge rectifier transform 12V AC into 12V DC. The transmitter module receives a steady 12V DC from the voltage regulator, transforms it into 12V AC, and then feeds it into the transmitter coil at the resonant frequency for optimal power transfer. After receiving the power supply from the transmitter coil, the receiver coil transfers it to the receiver module.

A relay that is linked to the receiver module's positive terminal receives the power supply after it has been converted to 5V DC by the receiver module. The relay's common terminal is attached to a 4V, 1 amp sealed lead-acid rechargeable battery, which begins to charge when its voltage falls below 97%. The ATMEGA328 microcontroller receives voltage level data from a voltage sensor module that is coupled to the battery through a voltage divider circuit made up of two 33Kohm resistors. A boost converter module is used to convert 4V, 1A to 5V, 500mA, which is then supplied to the entire circuit because all other components need 5V to function.

The voltage level of the battery is read by the microcontroller and shown on a 16*2 LCD display. The microcontroller signals a buzzer and displays a message on the display when the battery is fully charged. Additionally, it sends a signal to the relay via a tiny circuit made up of a diode, resistor, and BC547 transistor. After receiving the signal via this circuit, the relay disconnects the receiving module from the other circuit.

6. RESULTS AND DISCUSSIONS

Any nation's development is largely dependent on its transportation system, and electric vehicles are fast emerging as the transportation sector's future. There is still a great deal of uncharted terrain in this topic despite earlier study attempts. A wireless charging system will be used for this specific project, and a battery management device will be built to show the battery's percentage and turn off the power when it is full. The battery voltage will be measured by the microcontroller and shown on a 16x2 LCD. After a thorough analysis of numerous wireless charging techniques, affordable parts were chosen to effectively design the prototype.

Fig3: Transmitter Side of Project

Both the transmitting and receiving portions were examined under controlled circumstances during testing. Accurate coil alignment, air gap variation, and load behavior were all noted. Understanding how mismatch between the systems's output power and efficiency are affected by the transmitting (Tx) and receiving (Rx) coils. The system reached efficiencies as high as in optimal alignment, but as misalignment or air gap increased, there was a discernible decline in performance.

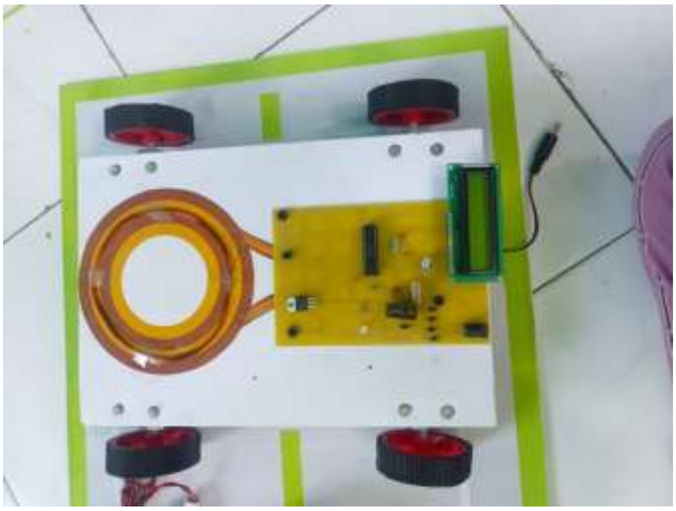

Fig4: Receiver Side of Project

The output power was calculated using the formula:

$$P = V \times I = 11.5\ V \times 1.4\ A = 16.1\ \square$$

Assuming DC input power is:

Pin=Vin×Iin=16.8 V×1.5 A=25.2 W

Then the efficiency is:

$$\eta = \left(\frac{P_{out}}{P_{in}}\right) \times 100 = \left(\frac{13.8}{25.2}\right) \times 100 = 94.3\%$$

One of the critical goals was to determine the time required to fully charge the battery system. Using the basic formula:

$T = C / I \times \eta$

Where:

C= 1.5 Ah (battery capacity)

I = 1.18 A (measured output current)

η= 94.3% = 0.943 (measured system efficiency)

Substituting the values:

$T = \frac{1.5}{1.4 \times 0.943} \approx 1.01$hrs(64min)

Therefore, under optimal alignment and stable current flow, the batteries were expected to reach full charge within 1.01 hours. This charging duration was consistent with observed experimental behavior and confirms that the wireless system is capable of practical charging within acceptable time frames for low-voltage batteries.

6.1 Real-World Implementation Strategy and EV Case Study: Tata Tiago EV:

The Tata Tiago EV, a commercially available electric hatchback in India, was used in a case study to illustrate the scalability and practicality of the suggested wireless EV charging system. The two versions of the Tiago EV, Medium Range (MR) with a 19.2 kWh battery and Long Range (LR) with a 24 kWh battery, have respective driving ranges of 250 km and 315 km. The 24 kWh edition of this EV can be fully charged from 10% to 100% in 6.9 hours using AC slow charging @ 3.3 kW. Additionally, it provides DC fast charging; under high-voltage input, it can reach 10–80% charge in just 58 minutes.

It is clear from comparing the prototype wireless charging system created for this research with the specifications of the Tiago EV that the system can be scaled up to meet actual EV requirements. The theoretical charging time for the 24 kWh battery would be as follows if a wireless power transfer system, akin to the Tiago's onboard AC charger, were built to deliver 3.3 kW of electricity:

$$\boldsymbol{T} = \mathbf{24}\ \boldsymbol{kWh}\ /\mathbf{3.3}\boldsymbol{kW} \approx \mathbf{7.27}\boldsymbol{HOUR}$$

Higher-rated coils, notably Double-D coil designs with ferrite cores for stronger magnetic coupling and lower leakage, must be added to the system in order to attain this power wirelessly. As advised by the SAE J2954 standard, these are already utilized in commercial wireless EV charging systems. Additionally, the system must maintain resonant operation at 85–150 kHz, which calls for compensation capacitors on both the Tx and Rx sides as well as precisely calculated coil inductance.

7. CONCLUSIONS

Due to environmental and energy-related concerns, it is obvious that vehicle electrification is inevitable. When opposed to wire charging, wireless charging offers numerous advantages. Regardless of battery technology, the broad market penetration of EVs will be facilitated by the electrification of highways with wireless charging capabilities. Wireless EV charging may become a reality as technology advances. In the near future, more research is still required in the areas of topology, control, inverter design, and human safety. Wireless charging systems use a variety of techniques, including laser power beaming, microwave radiation, magnetic resonance coupling, inductive coupling, and radio frequency energy harvesting. The inductive coupling method is the one that this study will employ.

Compared to other wireless power transmission techniques, the inductive coupling wireless charging system is safer and more effective. By altering the coil and circuit designs, the wireless charging method can improve efficiency. Additionally, we can use photovoltaic (PV) panels to increase the amount of solar energy used in this project. One of the best renewable energy sources that don't hurt the environment is solar energy. Additionally, since the battery car needs to be charged while driving, we can use dynamic wireless charging, which a more sophisticated technique than static wireless is charging. Nevertheless, it is more difficult to build, the infrastructure required is too costly, and the cost-benefit ratios are unfair.

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