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Wireless Charging Station For Electric Vehicles Using Magnetic Induction

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Abstract: Vehicles using petrol and other internal combustion engines now on the road contribute to air, noise, and greenhouse gas pollution. As electric vehicles are a better alternative to curb the ongoing pollution it is vital to make amendments to the battery charging process to attain greater reliability.

In electric vehicles charging batteries through chargers and wire is inconvenient, hazardous, and expensive, therefore we are trying to charge electric vehicle batteries by wireless power transfer at charging stations. The main function of wireless charging is to transmit power by inductive coupling method across a given space. It is possible to use a static or dynamic charging mechanism to perform wireless power transmission.

This paper describes the wireless inductive coupling battery charging technology that has been used for electric car batteries. The driving circuit is used between the transmitter coil & receiver coil where MOSFETs, IR sensors, and Relays are used for switching operation. Whenever the vehicle is present or not, the transmitter coil circuit is switched ON or OFF, correspondingly.

Keywords: Electric Vehicle (EV), Wireless Inductive Coupling, Wireless Power Transfer (WPT).

I. INTRODUCTION

The cost of fuels such as gasoline and diesel are steadily increasing due to an increase in the number of vehicles and proportionately excessive fuel consumption. Depletion of these fuel sources is also a major concern. These ancient vehicle designs are a major contributor to the greenhouse gas problem. The future of automotive technology is moving towards electric vehicles, which are seen as an alternative to oil-powered vehicles with internal combustion engines, with CO2 reduction in mind. Alternative energy plug-in electric vehicles (PEV) have been proposed to enable green transportation. PEV usage is currently increasing, but breakthroughs are needed to overcome battery-related drawbacks. The proposed WPT system is activated when the vehicle enters the loading area. Magnetic flux radiates from the primary coil and is induced in the secondary coil present in the EV. The battery is connected to the electric vehicle's secondary coil and thus charged. Many researchers are working on his WPT technology, but many challenges need to be overcome before it can be commercialized.

II. LITERATURE SURVEY

WPT has become more famous because of its smart usage and all the conveniences. By implementing this scheme, IT enables reduce various troubles which happen due to wired techniques which include electric shocks, trouble because of cords, and cost. It comprises two coils the transmitter coil & receiver coil. In this investigation, the concept utilized is electromagnetic induction type charging which assists with charging the battery of an electric vehicle without wires and this battery power is utilized to operate the electric vehicle. Finally, a new system is introduced for wireless charging which reduces the use of natural fuels, recharges the battery easily, avoids wires, reduces cost as well as capable of convenient installation. We have used 33 turns of copper coils for primary side windings and 22 turns for secondary side windings for efficient transmission of power. Several factors were kept in consideration while designing the number of turns and size of the elementary and secondary coils like flux density, voltage, losses and other variations.

Here we use, $B = \mu N/l*I$ in Tesla.
Where, N= number of turns, l= length of coil,

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I= current in Amps and μ = permeability of free space. So, taking all these parameters into consideration coils are designed. To design primary and secondary coils, the material used is copper. Previously aluminium coils were used which are very cheap but flux radiation is very less. [1]

Wireless Charging can make Electric vehicles more accessible. Wireless charging makes electric vehicle charging more convenient and improves the usability of Electric Vehicles. “The main advantage of wireless power transfer over wired is that it can eliminate cable and power plug compatibility issues” is said by the author. There are many methods of wireless power transmission, but the most effective method is Magnetic Resonant Coupling. It involves the creation of a resonance and transmission of power without radiation problems due to electromagnetic waves. Hence the resonance frequency is a crucial factor in the circuit design. This paper shows the MATLAB simulation of EV charging by magnetic resonance to be 97.1% for a distance of 10cm which is found to be similar to the conventional wired charging system. The isolation transformer is the main lossy component of wired system can be eliminated by using Wireless power transmission method.[2]

In this research paper, the coupling coefficients and quality factors are estimated at the same frequency for both inductive coupling method and magnetic resonance method using the efficiency equation containing both parameters.
Since the magnetic resonant coupling method requires more quality factors and coupling coefficients than inductive coupling method for same efficiency, hence inductive coupling method is better than magnetic resonant coupling method for wireless electric vehicle charging.[3]

In this paper, EV wireless charging systems are classified based on the air-gap length between transmitting and receiving ends. Various EV wireless charging techniques reported in the literature are reviewed. The principle of each technique is introduced, various topologies associated with each technique are summarized and compared with a particular focus on power transfer efficiency. For a sustainable electrified transportation system, dynamic wireless charging system should be developed for a greater output power efficiency during misalignments with a reduced installation cost. Enabling the vehicle to grid (V2G) technology and the development of dynamic wireless charging will open a new era of electrified transportation system with reduced battery capacity and increased vehicle driving range.[4]

III. METHODOLOGY

In Electric vehicles, charging of battery through a wired charger can cause inconvenience. Wireless charging is more convenient as it requires fewer physical efforts. Wireless charging is done by transmitting power using the inductive coupling method across the given space. The requirement is to be able to charge the battery quickly and efficiently while the car is parked in the slot. In this method, power transfer takes place between the primary and secondary coil. To ensure accurate results, proper materials must be selected for the coils. Along with the materials, the proper size and number of turns must be determined in order to reduce the loss of power while being transferred.

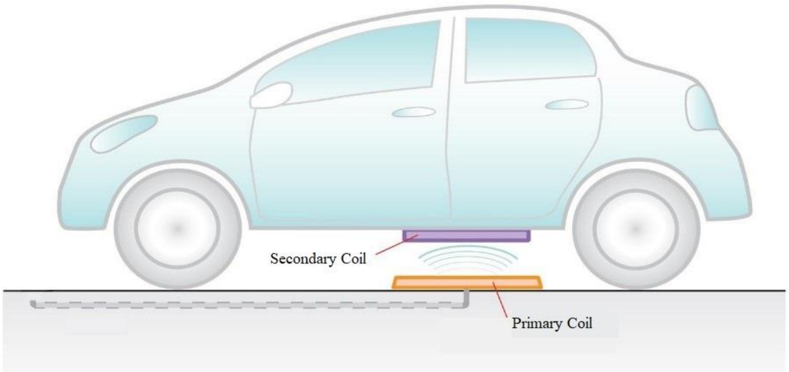

Figure 1: Car charging through power transfer

Given below is the block diagram of our project wireless charging station using magnetic induction.

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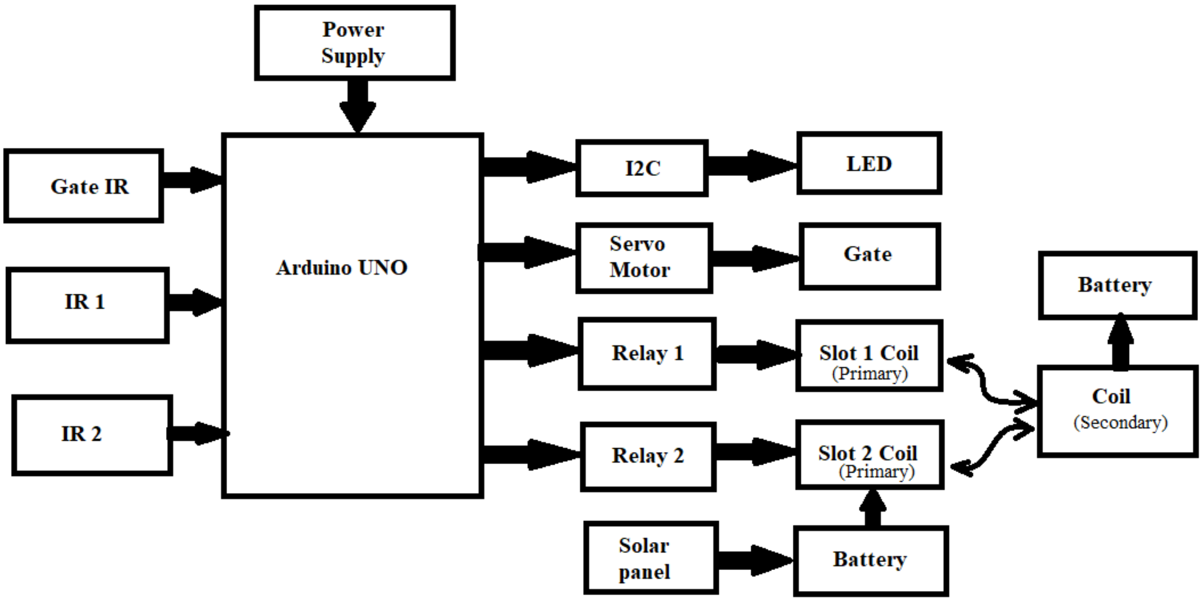

Figure 2: Block Diagram

Description of the Block Diagram:

1. Vehicle will be parked on charging spot 1 or spot 2, this will be sensed by the IR sensor and the status will be forwarded to Arduino UNO.
2. Based on the status received by the IR sensor, the Arduino UNO sends the signal to the relay which turns on the supply to the respective primary coil.
3. Primary coil is present under the spot will produce variable magnetic flux.
4. Secondary coil is present at the base of the vehicle when it comes in the vicinity of the flux will get linked and by the principle of mutual induction emf is induced in the secondary coil.
5. This voltage is then given to the battery which will initiate charging. The charging status is displayed on Lcd.
6. In this process, power is transferred from the primary coil to the secondary coil through inductive coupling.

IV. SPECIFICATIONS

We will put together a list of the precise components in order to carry out the desired project. The components used and their specs are mentioned below:

A. Arduino UNO

A microcontroller board called Uno is built on the 8-bit ATmega328P microprocessor. It also includes additional parts to support the Atmega328P microprocessor, including a voltage regulator, serial connectivity, and crystal oscillator.

Figure 3: Arduino UNO

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The Arduino Uno has 14 I/O digital ports, a USB interface, and 6 analogue input pins for connecting to other electrical circuits. Six pins of the 14 I/O ports can be utilised for PWM output. The designers can use it to interact with and perceive actual external electronic equipment. Because it is an open-source platform, anybody may change and improve the boards' capabilities. The boards and software are widely available. IDE (Integrated Development Environment) is the name of the free to use, basic-skills-required software that is utilised for Arduino devices. It may be written in the programming languages C and C++.

B. Two – Channel relay module

Figure 4: Two- Channel relay module

Controlling high voltage, high current loads including motors, solenoid valves, lights, and AC loads is easy with the 2 Channels Relay Module, a handy board. It is made to connect to microcontrollers like the Arduino, PIC, and others. With the fewest feasible parts and connections, a microcontroller or sensor may be readily interfaced utilising the two-channel relay module's four 5V relays and the associated switching and isolating components. Another use for it is the connection between two or more locations in response to the input signal.

C. IR Sensors

Figure 5: IR Sensor

A sensor is an electronic device that emits infrared light to detect specific aspects of its surroundings. An IR sensor may detect movement in addition to tracking the heat of an item. Since they only monitor infrared light, these sensors are referred to as passive IR sensors. These radiations, which are invisible to the human eye, may be detected by an infrared sensor. The emitter is an infrared light emitting diode, and the detector is an infrared photodiode, which is sensitive to infrared light of the same wavelength as that generated by the IR LED. When IR light reaches a photodiode, the resistances and output voltages change depending on how intense the IR light is.

D. Liquid Crystal Display 16x2

A type of flat panel display known as an LCD (Liquid Crystal Display) operates primarily on liquid crystals. Electrical display modules called LCD (Liquid Crystal Display) displays have a variety of applications.

Figure 6: Liquid Crystal Display 16x2

Electrical display modules called LCD (Liquid Crystal Display) displays have a variety of applications. A relatively basic component that is widely used in many different devices and circuits is a 16x2 LCD display. A 16x2 LCD has 2 lines, each of which can show 16 characters. On this LCD, each character is shown using a 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix display's 224 different letter and symbol combinations. This LCD's two registers are the Command and Data registers.

E. I2C Module for LCD

Figure 7: I2C Module for LCD

I2C is a synchronous, multi-slave, multi-master, single-ended serial bus with packet switching. I2C only employs the Serial Data Line (SDA) and Serial Clock Line (SCL), which are both bidirectional open collector or open drain lines that are pushed up using resistors. Although systems with various voltages are allowed, the commonly utilized voltages are +5 V or +3.3 V. The PCF8574 I2C chip integrated within the I2C Module transforms I2C serial data into parallel data for the LCD display.

F. Solar Panel

Figure 8: Solar Panel

A collection of photovoltaic cells is known as a solar panel or photovoltaic (PV) module. Solar panels produce direct current electricity using sunlight as its energy source. PV panels are systems of PV modules, while arrays are collections of PV panels. Electrical equipment's is also can be powered by solar energy from photovoltaic arrays. Designed with high-efficiency polycrystalline silicon solar cells, this 6V 500 mA solar panel.

G. 3.7V Li-ion Battery

Figure 9: 3.7V Li-ion Battery

V. SIMULATION

We have used the Proteus Design Suite software to simulate our model.

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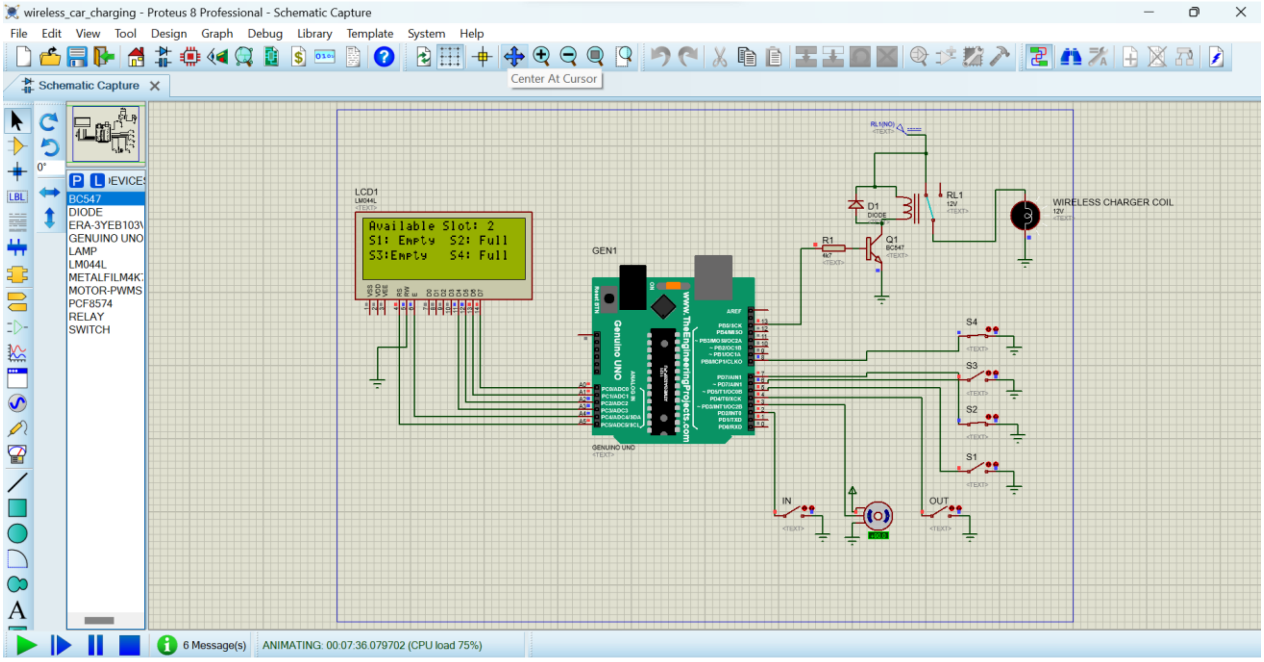

Figure 8: Simulation

Above shown is the screenshot of a working simulation of the model. The model contains an LCD Display showing us the available parking slots. We used switches instead of IR sensors as we are unable to show objects on the simulation platform. The In and Out switches are the entry and exit of parking. A servo motor will be present to open the parking gate but here we will manually turn on the switches for every car entry and exit. S1, S2, S3 and S4 are the switches used in parking to detect the car. Also, to show the working of the primary coil, we used a lamp as magnetic induction couldn't be displayed in the simulation. As the primary coil works, the lamp will light up. It indicates that power is generated in the primary coil and can be transferred to the secondary coil.

VI. RESULT

We have built and assembled a hardware model as shown below.

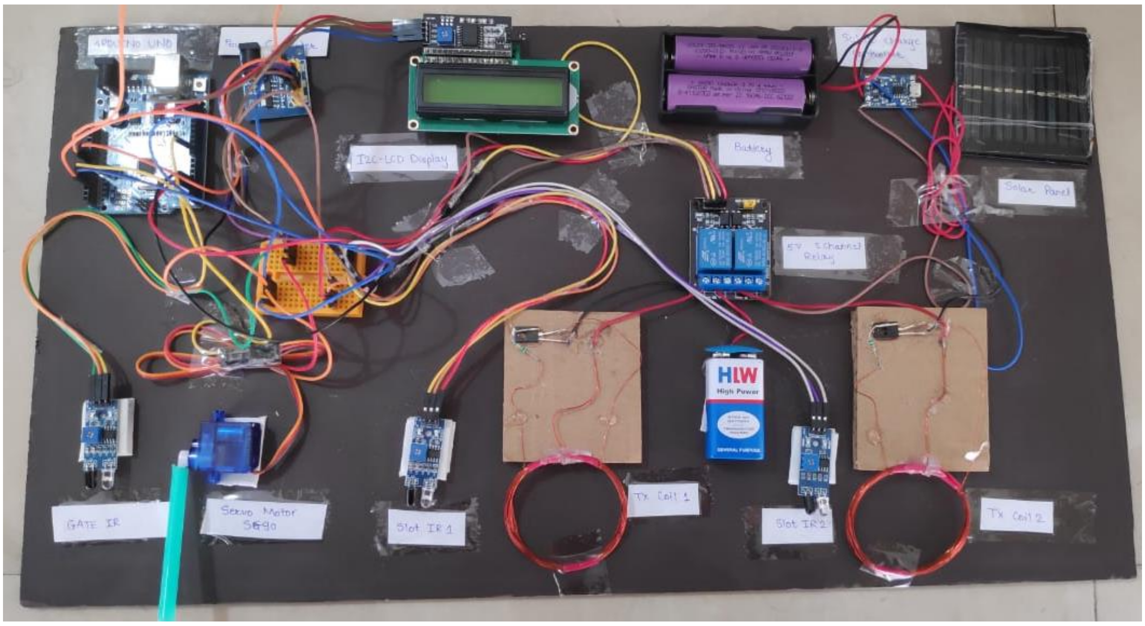

Figure 9: Assembled Hardware

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First, the gate IR sensor will sense the car and the servo motor will open the gate. Then, when the electric car will stand in front of the respective coil, the IR sensor will signal the relay to turn on the circuit and it will turn on the power supply to the primary coil. As the secondary coil will be present in the magnetic field region, a change in flux will occur which will induce the emf in the receiver coil. As the Led bulb glows, it shows that voltage is being induced in the secondary coil.

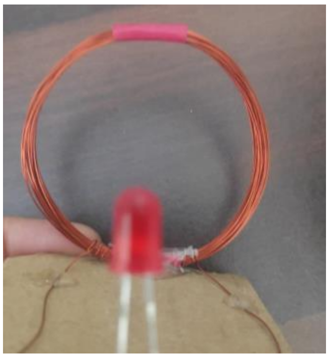

Figure 10: Secondary Coil

This is a secondary coil that will be attached to the bottom of the car. So, when this coil comes in the magnetic field of the primary coil, voltage will be induced in this coil which will help to charge the battery. The secondary coil is important as its size, number of turns and the thickness of the wire determines the amount of power transfer. These differences in the primary and secondary coils can result in less power transfer and can cause power loss. Therefore, it is important to select secondary coils which are eligible for power transfer with respect to the primary coil. Also, the distance between these two coils matters for the perfect result. If the coils are far away the power transferred will be less compared to when it is near.

We have made 3 sets of coils for this experiment. The first coil has a diameter of 5.2 cm, the second coil has a diameter of 5.2 cm and the third coil has a diameter of 5.9cm.

On testing these coils for an input voltage of 9v DC, 7.63 V lithium-ion battery, the readings were observed and tabulated as follows

24 AWG Wires primary and secondary coils (30 turns each, coil diameter of 5.2 cm)		
Input voltage (DC)	Output Voltage	Current
7.63 V	7.2 V	53 mA

24 AWG Wires primary and secondary coils (33 turns each, the coil diameter of 5.2 cm)		
Input Voltage (DC)	Output Voltage	Current
9 V	8.7 V	80 mA

24 AWG Wires primary and secondary coils (33 turns each , coil diameter of 5.9 cm)		
Input Voltage (DC)	Output Voltage	Current
9.0 V	8.3 V	72mA

VII. CONCLUSION

The IPT concept is implemented for a wireless charging system that is used to recharge an electric vehicle battery. The driving circuit is used between the transmitter coil & receiver coil where MOSFET and micro-controller operate as a switch. Power transfer is allowed by turning ON the transmitter circuit when the vehicle is present, and turning OFF power transfer when the vehicle is absent to overcome the energy waste and to avoid the magnetic field radiation problem. The proposed driving circuit utilizes an ac switch that controls the system power transferred. The implementation of an inductive power transfer system is verified by using the battery charger application of the electric vehicle.

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