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Electric Vehicle Charging System using Wireless Power Transmission, IoT and Sensors

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Abstract - *As the new era of the automobile, the industry is rapidly transforming from an IC engine vehicle to an electric vehicle. The demand for an electric vehicle is increasing, these lead to an increase in charging station as well. In this project, a wireless charging system is used to charge the vehicle wirelessly via inductive coupling. we just simply need to park the car on the charging spot. The transmission of electrical energy from source to load from a distance without any conducting wire or cables is called Wireless Power Transmission. The concept of wireless power transfer was the greatest invention by Nikola Tesla. Also, an Internet of things based collection system is designed in which a person can use the RFID to pay the charging charges of that vehicle. The system checks if the person has sufficient balance and then deduct the charging charges and update the balance. The Internet of Things describes the network of physical objects that uses sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems. This system doesn't require any human interaction. The result of this project is we can charge our vehicles wirelessly via inductive coupling and pay our charging charges through RFID tags. Wireless power transmission might be one of the technologies that are one step towards the future. This project can open up new possibilities of wireless charging that can use in our daily lives.*

***Keywords*: Wireless power transmission, Static charging, Microcontroller, RFID, Authentication, IR sensor, Liquid Crystal Display, Motor.**

1. INTRODUCTION

We live in a world of technological advancement. New technologies emerge each and every day to make our life simpler. Despite all these, we still rely on the classical and conventional wire system to charge our everyday electronic gadgets. The conventional wire system creates a mess when it comes to charging several electric vehicles simultaneously. It also takes up a lot of electric sockets at the charging port. At this point, a question might arise. —What if a single technology can be used to charge these electric vehicles simultaneously without the use of wires and not creating a mess in the process? We gave it a thought and came up with an idea. The solution to this problem is inductive coupling, a simple and effective way of transferring power wirelessly.

Wireless Power Transmission (WPT) is the efficient transmission of electric power from one point to another point through a vacuum or an atmosphere without the use of wire or any other substance. This can be used for applications where either an instantaneous amount or a continuous delivery of energy is needed, but where conventional wires are unaffordable, inconvenient, expensive, hazardous, unwanted or impossible. The power can be transmitted using Inductive coupling for short-range, Resonant Induction for mid-range and Electromagnetic wave power transfer for high range. WPT is a technology that can transport power to locations, which are otherwise not possible or impractical to reach. Charging the battery of electric vehicles by means of inductive coupling could be the next big thing.

The objective of this paper is to implement an electric vehicle wireless charging station and charging platform to transmit electrical power wirelessly through space and charge the battery of an electric vehicle. The system will work by using inductive coupling to transmit power from a transmitter to a resistive load or battery of an electric vehicle.

Success in doing so would eliminate the use of cables in the charging process thus making it simpler and easier to charge the battery of an electric vehicle. It would also ensure the safety of the battery since it would eliminate the risk of a damaging the battery.

The objective also includes using RFID to make payment easier and safe. And implementing the self-operated gate at entry and exit using of IR sensor and Servo motor.

1.1 Literature review

Supriyadi and Edi Rakhman. [1] demonstrate the effect of wire diameter (AWG) and a number of turns used is directly proportional to the amount of power that can be transferred. When the number of windings increases, more the power will be transferred. When we use the enameled copper wire of 0.5mm diameter and keep the number of turns to 26, and apply the input frequency of 470KHz. The power efficiency obtained at a distance of 1 cm is about 1.51%. This result can turn on 1 Watt LED lamp.

N.UthayaBanu and U.Arunkumar. [2] This study representing the various technologies related to Wireless Power Transfer System, which is used to avoid the flux leakage during the transmission of power and to operate the cars with high efficiency and improve the quality parameters. This project also shows the progress of generating power source through renewable energy.

Govind Yatnalkar and Husnu Narman. [3] present a survey of Duration of Charging of Electric Vehicles is limited. Therefore, wireless charging is important for Electric Vehicles in order to overcome the charging duration problem. This paper also provides a current scenario of the art in electric vehicle wireless charging and the parameters that require for charging section. The most important parameters for electric vehicle wireless charging are the distance between the transmission and reception coils, the position of the coils placed on Electric Vehicle, battery sizes, and the time for charging.

Balamurugan A and Aman Bhattad. [4] propose a method to design an RFID based transaction system. This paper shows how PIC Microcontroller board is interfaced with the RFID controller shield using the libraries developed for SPI protocol. An RFID integrated campus ID card is scanned to the RFID reader in order to do the transaction and will not be interrupted until the previous payment is complete and the card is swiped again for a new transaction. So, a smart campus payment system is developed using the RFID controller shield.

Norsuzila Ya'acob and AzitaLaily Yusoff. [5] propose a method of a cashless system that help the students at school level so they can use LF RFID technology and database system. Generally, this Cashless Payment Transaction is designed to replace the use of actual cash with virtual cash and parents can monitor their spending through the transaction data that has been uploaded to the database every time whenever a transaction took place. The system also calculates the remaining credit left inside the card and sent a notification to their parents. Once a credit has been transferred by parents, students can continue to do other transaction.

Vaishali Pande and Nivedita Hasti. [6] provide a method to implement this system. So, we can detect the vehicle identity at the toll plaza. By developing this system in toll plaza it will reduce the processing time by few second as well as vehicle congestion at the toll plaza.

This paper will demonstrate the idea of the charging station just like our petrol pump. We will use the wireless charging platform where the car can charge their battery while parking the car at that platform. The station covers all the technologies that can help the customer to save their valuable time. This includes the smart payment method done by the RFID system, which deducts the money according to the charging time by just reading RFID tags placed on the windshield of the car. This station also covers the smart entry and exit gate which uses the infrared technology, when the car is detected at the entry gate the gate will open and allow the car to enter the station and vice versa for exit gate as well.

2. PROPOSED METHODOLOGY

Based on operating Techniques electric vehicle wireless charging station can be classified into four types

1. Capacitive Wireless Charging System
2. Permanent Magnetic Gear Wireless Charging System
3. Inductive Wireless Charging System
4. Resonant Inductive Wireless Charging System

Inductive wireless charging station

The basic principle of Inductive wireless charging is Faraday's law of induction. Wireless transmission of power is achieved by mutual induction of magnetic field or flux between transmission and reception coil. When the main AC supply applied to the transmitter coil, it creates an AC magnetic field that passes through receiver coil and this magnetic field moves electrons in receiver coil causes AC power output. This AC output is rectified and filtered to Charge the battery of an electric vehicle. The amount of power transferred relies on frequency, mutual inductance and distance between the transmission and reception coil.

Operating frequency of Inductive wireless charging is between 19 to 50 kHz.

The harmonic current can cause heating in a conductor which lead increase in current value than expected. This mechanism leads to losses in the distribution of current in the conductor. These losses are skin effect and proximity effect.

Skin effect is caused due to surface current, which does not penetrate far into the body of a conductor but travels along its surface. Therefore, in a large diameter conducting wire, most of the cross-sectional area of the wire is not used to conduct the current. This effect increases the resistance of the wire in the coil, which may already have a relatively high resistance due to its length and small diameter.

While the proximity effect is caused due to the conductor magnetic field, which disrupts the current distribution in adjacent carriers.

Inductor value for Multi-layer, Multi-row coil is calculated by using below formula and 2D image of Inductor is shown in fig 1.

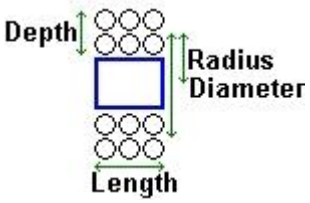


Fig -1: 2D image of Inductor

$$L = \frac{\left(0.8*\left(Radius^2 * Turns^2\right)\right)}{(6*Radius+9*Length+10*Depth)}$$

Where,

L = inductance of coil (Henry)

Turns = Number of turns in the wire coil

Radius = Mean radius of the coil (centimeters)

Length = length of coil (centimeters)

Depth = thickness of coil (centimeters)

Or we can use inductance meter to find the value of inductor.

2.1 Block diagram

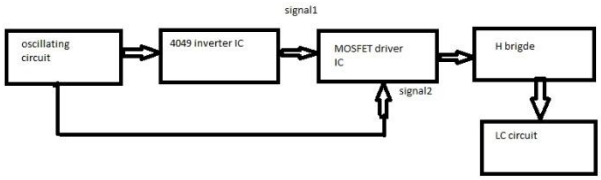
In this paper, the block diagram consists of three types namely,

- Primary side
- Secondary side
- And Embedded system

Primary side

As 555 timer ic is present to generate an oscillating signal of required frequency for LC resonance. The output produced by timer ic is applied to inverter circuit to invert the oscillating signal and refer as signal 2 while signal 1 for a non inverted oscillating signal. This both original and inverted oscillating signal is applied to MOSFET driver ic to generate a high and low pulses to trigger the gate of the MOSFET terminal. This forms as a driver circuit. This driver circuit sent the Alternating current to the LC circuit. This current across the inductor and the capacitor produces the magnetic field as shown in fig 2.

Fig -2: Block diagram of Primary side



Secondary side

The coil from the primary side gets energy and it creates the magnetic field around the coil. Due to the using of high-frequency output, the creation of magnetic flux will be very strong. When the flux from the primary coil links with the secondary coil or Receiver coil, this will induce the current in inductor and capacitor connected in parallel. The voltage generator across the LC circuit is Alternating current and this A.C. signal is applied to Bridge rectifier circuit. This circuit converts the Alternating current into Direct current and the capacitor is connected to the output to generate a smooth DC signal. The Voltage regulator is used to limit the voltage to prevent the damage to the load as shown in fig 3.

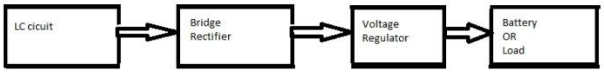


Fig -3: Block diagram of Secondary side

Embedded system

Arduino Mega 2560 is present to interface with RFID, IR sensor, Servo motor and Led as shown in fig 4. The RFID is used to make payment convenient by using virtual money. That can be easily paid for the charging time at the Electric vehicle wireless charging station. IR sensor is used to take data as if an electric vehicle is present on an entry gate and if, yes. Then servo motor open the gate and allow the electric vehicle to park at the platform for charging. And all the data like payment status and insufficient balance is displayed on Liquid crystal display.

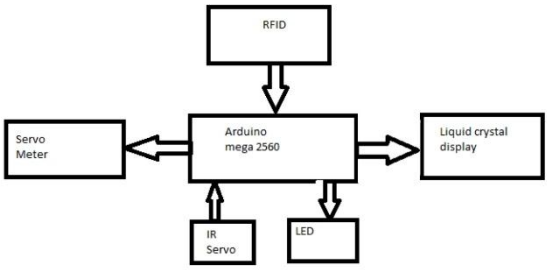


Fig -4: Block diagram of Embedded system

2.2 Flowchart

In this paper, Functioning of the Arduino Mega 2560 is shown by Flowchart in fig 5. This Flowchart starts with the Entry gate and if it sensor reads '0' then, the servo motor will allow the electric vehicle to enter to charging station. The IR sensor at the charging platform reads '0' then the relay connects the wire and vehicle starts charging the battery. After, charging has done. The RFID tags are read by the reader and the amount is deducted depending upon charging time. The IR sensor at the exit gate reads '0' then, the exit gate is opened and the Servo motor allows the customer to exit.

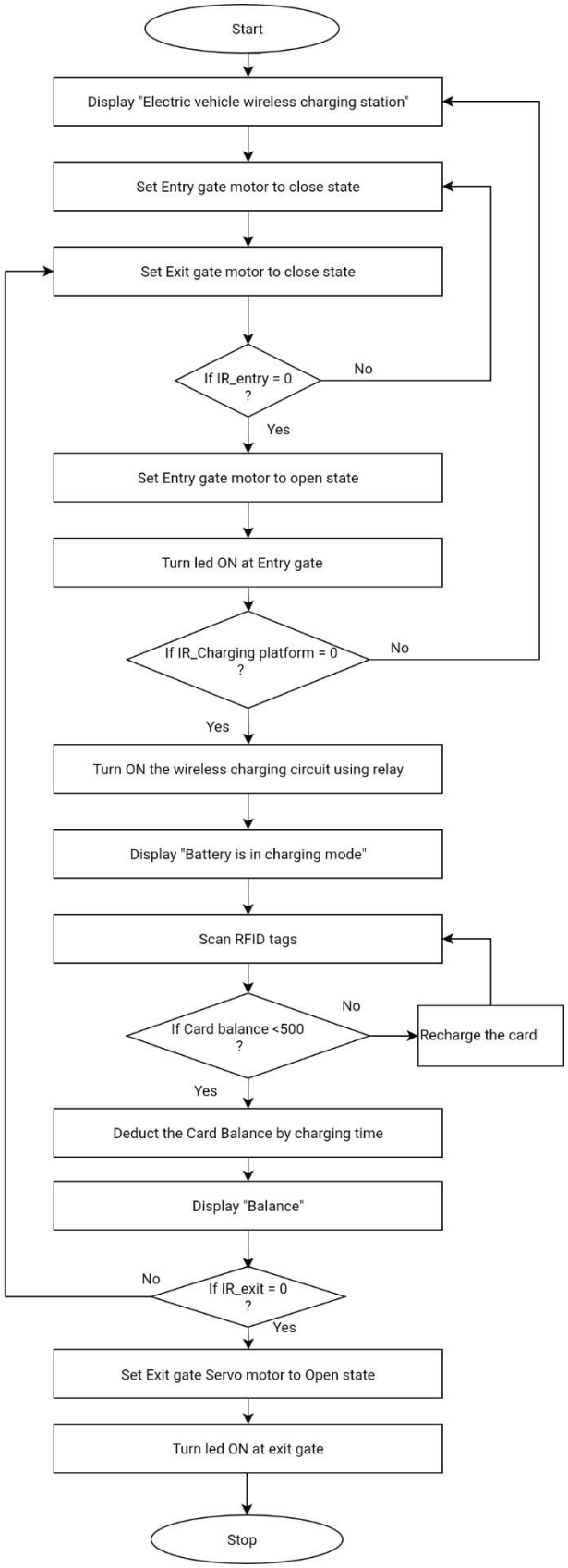


Fig -5: Flowchart

2.3 Working

Oscillating circuit

An Astable Multivibrator is used as an oscillator circuit that will generate a continuous rectangular wave without the support of external triggering. Astable Multivibrator can be easily implemented by using 555 Timer ic, it generates stable output and cost is low. It can be used for timing from microseconds to hours. Due to these reasons, 555 ic has a large number of applications. Fig-6 shows the circuit diagram of a 555 Timer ic in Astable Mode. 8th pin and 1st pin of the IC are used as Vcc and GND. The 4th pin is RESET pin which is connected to Vcc to avoid resets. 5th pin is the Control Voltage pin which is connected to a capacitor C' whose other end is connected to ground. Usually C' = 0.01µF. The 2nd pin and 6th pin inputs are connected to the capacitor which determines the output of the timer. 7th pin is discharge pin connected to the resistor Rb such that the capacitor can discharge through Rb.

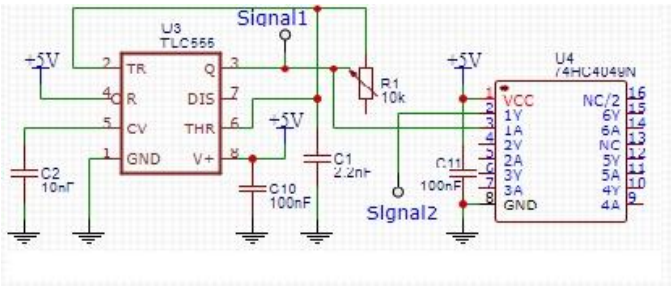


Fig -6: Circuit diagram of oscillating circuit

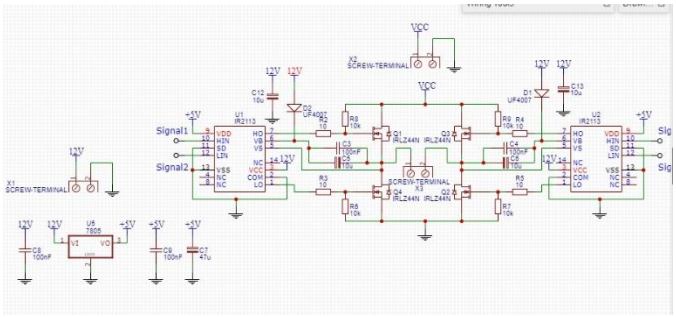
So, by using 555 timer ic we can generate a rectangular waveform. We can connect the potential meter of 10k ohm between the Threshold (pin 6) and the discharge (pin 7) so we get the variable rectangular waveform. Now, we can adjust the oscillating signal output that is the frequency of 555 timer ic depending upon the frequency required to drive the MOSFET ic in the power transmission circuit.

Power transmission Circuit

In this paper, we have used Astable multivibrator to generate an oscillating signal of required frequency to so that the LC circuit starts resonating. Now, we take the two signal as an input signal for the transmission circuit. Signal 1 is non inverted output signal and signal 2 is the inverted signal generated by 4049 inverter ic. This both signals are applied to IR2110 ic which is a MOSFET driver ic. We have used 2 IR2110 ic for forming a H bridge circuit or it can be called as the driver circuit. Signal 1 is applied to the input pin of one IR2110 ic and inverted signal 2 is applied to an input pin of another IR2110 ic. The SD pin of both the IR 2110 ic set to High. Now, we will use the 4 MOSFET specifically, IRFZ44N n channel MOSFET as a driver circuit. An output signal from Ho pin of one IR 2110 and output signal from Lo pin of another IR2110 will turn ON the MOSFET Q1 and Q4. This produces the A.C. signal of Resonant frequency to oscillate the LC circuit as shown in fig 7.

An output signal from Lo pin of one IR 2110 and output signal from Ho pin of another IR2110 will turn ON the MOSFET Q2 and Q3. This will again produce the A.C. signal of Resonant frequency to oscillate the LC circuit. The triggering pulses from IR2110 are connected to the gate terminal of the MOSFET switches. As the resonant frequency is generated. Now, it will be transferred to the coil through the compensation Network.

Fig -7: Circuit diagram of Power Transmission circuit



For this project, the transmitter coil was constructed with 0.67mm diameter, 20 SWG copper wire and 20 turns. From the equation of inductance of a multi-layer, multi-row coil, we get inductance L = 216uH.

Power reception circuit

Power reception circuit consists of a receiver coil, a rectifier circuit and a voltage regulator IC. And additional buck converter so that current at the output will be more, by decreasing output voltage to 5 volts. An A.C. voltage is induced in the receiver coil. The rectifier circuit converts it to D.C. and the voltage regulator IC helps to maintain a constant voltage at the load as shown in fig-8

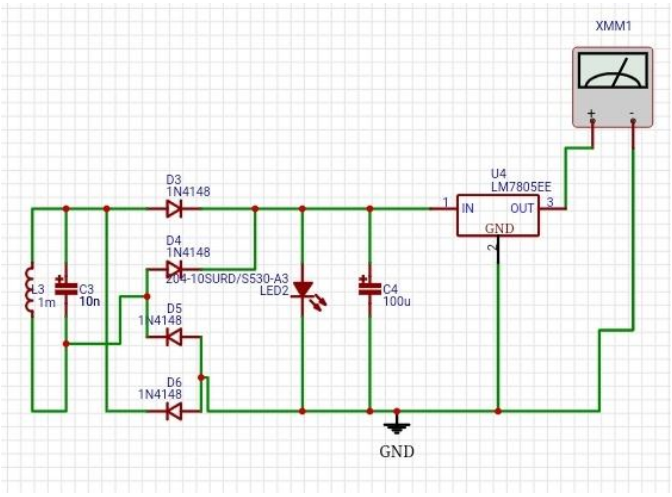


Fig -8: Circuit diagram of Power reception circuit

The coil from the primary side gets energy and it creates the magnetic field around the coil. Due to the using of high-frequency output, the creation of magnetic flux will be very strong. When the flux from the primary coil links with the secondary coil or Receiver coil, an EMF is induced at the receiver coil which in turn induce the A.C. voltage at the Receiver coil through the magnetic field. The receiver coil is formed by connecting air core inductor parallel with the capacitor. Then, a bridge rectifier circuit can be formed by arranging four diodes in such a configuration such that it provides the same polarity of output for either polarity of input. It is basically used in the most common application, for conversion of an alternating current (AC) input into direct current a (DC) output. Next, we can use the capacitor filter to remove ripples present in the output of bridge rectifier. After the capacitor filter, smooth DC voltage is applied at the input of the voltage regulator. A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level. In this project, the LM 7805 voltage regulator IC is used since it allowed no more than 5v to the output.

Arduino Mega

It is an important component in the system. In this paper, Arduino Mega is used as a development board for this controller by using, we can easily dump a program in Microcontroller. Arduino Mega is interfaced with RFID, Servo motor, IR sensor and few Led for indications. RFID is used for payment method after charging the electric vehicle at the charging platform. IR sensor and Servo motor is used for opening and closing the gate at the entry and exit gate. Led is used to indicate if the payment is unsuccessful or reading data from RFID.

RFID technology

RFID uses radio frequency. Radio frequency identification (RFID) tags basically use two kinds of data transmission, depending on the behavior of electromagnetic fields at the frequency used. RFID tags classified as active, passive and semi-passive. Here, we have used passive RFID which operates using a small electric current created in the antenna instead of internal power supply. In this paper, the RFID reader is interfaced with Arduino Mega. This is used to pay at the charging platform just by scanning the RFID tag which is attached at the windshield of the car. The payment is deducted depending upon the charging time of an electric vehicle.

Infrared technology

As mentioned earlier in this paper, Electric vehicle wireless charging station is automated that means it uses IR sensor, Servo motor and Led. The IR sensor module consists of the IR Transmitter and IR Receiver. As the car enters through the entry gate of electric vehicle wireless charging station, IR sensor reads '0' and transmit the data to Arduino, the servo motor will open the gate by receiving the data from Arduino based on an algorithm and turn ON the Led which indicate that Costumer can now enter through the gate.

3. RESULT

This paper shows the whole study which includes the Transmitter and receiver coil, MOSFET driver circuit, oscillating circuit, Arduino and other hardware parameters. First, the testing was done by calculating the inductance of the self-made multi-layer, a multi-row coil which gives values of Resonant frequency to drive the circuit. This resonant frequency is generated from the Astable multivibrator circuit. This frequency is transferred to the MOSFET driver ic. The driver ic generates the high and low pulse that triggers the MOSFET through the gate terminal. The H bridge formation is used to generate an Alternating current of high frequency. This high-frequency signal is then applied to the LC circuit. This creates the magnetic field or flux at the primary side. The flux generated at the primary side links to the secondary side and alternating current is induced at the secondary side. This alternating current is converted into Direct current by using a bridge rectifier. And Direct current is obtained at the output of the secondary side which is applied to the load or battery of an electric vehicle. The operation of entry and exit gate of the charging station is performed by

Microcontroller. RFID is used to make payment which depends upon the charging time of the electric vehicle.

4. CONCLUSIONS

In this system, we are presenting the Wireless Power Transmission. As the electric vehicle in the market is increasing. We can use the wireless charging system to charge our vehicles. This system shows the efficiency and implementation of the charging station in future technology. This paper also covers future technology like payment through RFID tags and self-serviced entry and exit gate to maintain congestion at the station. This will be helpful for those who are doing research in the field of wireless power transmission. And many had came up with the greatest invention like charging mobile wirelessly, and other electronic gadgets too. This could be the future scope for developing the charging station, As electric vehicle are increasing in demand.

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