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Wireless EV Charging Pathway Based on Electromagnetic Energy

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ABSTRACT: This project presents a dynamic wireless charging system for electric vehicles (EVs) with the Arduino Uno microcontroller as the main controller. The system features a transmitter (TX) coil embedded in roadway infrastructure and a receiver (RX) coil installed in the vehicle unit, enabling continuous charging while in motion. Energy is wirelessly transferred from the TX coil to the RX coil through electromagnetic induction. The Arduino Uno microcontroller serves as the central control unit, managing power transmission, monitoring charging status, and regulating voltage levels. Integrated Internet of Things (IoT) sensors enable real-time data collection on charging parameters and battery health, enhancing efficiency and safety.. The system is achieves 67% efficiency level while providing safety, reliability, low maintenance and longproduct life.

KEYWORDS: Wireless power transfer; electric vehicles; inductive power transfer; battery charging etc.

I. INTRODUCTION

The world suffers from many problems without electricity. In day to day life electric power is important in many applications such as mobile, laptop, camera, sensors, bionic implants, satellites and oil platforms. In 1891, Nikola Tesla has proposed an idea of wireless power transmission and he demonstrated the first wireless power transfer system for illumination [1]. Sometimes connecting too many wires in small power sockets becomes inconvenient and hazardous. The Firstelectric vehicle practically implemented by Thomas Parkerin 1884. Until 1859 rechargeable batteries are not available forstoring electricity, French physicist Gaston Plant invented lead- acid battery and reduced the drawback. Electric vehicles are more popular in many countries, the electric vehicles are small or large in size such as buses, car is large and two wheelers, electric bicycles are small. Electric vehicles are same as like normal vehicles, but electric motor isused in electric vehicle for propulsion purpose, for power supply of that motor battery is used [1]. The new types of rechargeable batteries are available which is used because of small in size, as compared to conventional lead acid battery the energy storage capacity is higher, and weight is also less. The charging process is bulky for users in plug in electric vehicle because for charging battery, charger is required whichis directly connected from vehicle or sometime battery is removing for charging purpose. By utilizing inductive power transfer technology this difficult charging process is simplified [1].Inductive power transfer (IPT) method is design to deliver power wirelessly via magnetic coupling from a static transmitter to one or more movable secondary receiver [1]-[7]. In between primary source and secondary load there is a large air gaps. The power supply is either single phase or three phases depending on the power requirement. WPT system generally consists of power supply, transmitter (primary coil), receiver (secondary coil), micro-controller, battery, sensors, matching circuit [8]. Depending on the magnetic structure of coil IPT system is either distributed or lumped topologies. TheAC current is generated in the transmitter coil by the power supply at a very low frequency. Via magnetic fields single primary coil and multiple secondary coils are coupled. The constant frequency current in the primary coil is creating a strong and controllable magnetic field for WPT.Dirt, ice, water and chemicals are not affected on IPTsystem thus system will be environmentally suitable for all condition and maintenance free [9]. Advancement in power electronics technology have discovered many new application based on IPT system like wireless power supply for professional instrument, wireless battery charging for electric vehicle over large air gaps , material handling these are high power application of IPT system [1]-[7]. Other examples include medical implants, cell phones, lighting theseare low power application of IPT system [1]-[7]. The mutual coupling of IPT system is generally week. The receiver coil is electrically isolated from transmitter coil and move along a long transmitter track. The advantages of IPT system are listedbelow, [1]-[7], [10],

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- The system is Safe.
- Reliable.
- The system has low maintenance.
- It has long product life.
- Energy wastage is overcome.
- Magnetic field radiation problem is overcome.

II. LITERATURE SURVEY

The concept of wireless power transfer by IPT method is discovered from many years and is now gaining more. Literature survey is prime component during this dissertation; an exhaustive review on the subject area has been done as given below
Hui Zhi (Zak) Beh [1] proposed a DCS (double-coupled system) which is used for charging of a battery of electric vehicle. In between primary coil and secondary pickup intermediary coupler is placed where it operates as a switch. The system efficiency is increase by sharing all losses betweenthe branches.Jesus sallan [4] explain a new design process in which design factor is considered to choose the parameter of a coreless IPT such as optimum number of coil, compensation capacitors and frequency. If a appropriate design is selected then there is possibility to deliver high power with high efficiency.Akshya K. Swain [5] explain bidirectional IPT system in which wireless power transfer is possible easily between the two sides which are separated by air gap, through weak magnetic coupling. Without an accurate mathematical model system is difficult to design and control. A dynamic model has been developed by state variables. This model is a standard tool for steady state and transient analysis of IPT systems as well as for the design of controllers.Dukju Ahn and Songcheol Hong [12] says that for IPT system the concept of repeaters can be applied, in which enhance the power transfer distance between transmitter and receiver coil by placing intermediate repeaters. The position of the repeater between transmitter and receiver is carefully obtained. The efficiency is significantly different from each other for two different configurations while delivering the same amount of power. Better efficiency is obtained if the repeater is inserted nearest to the transmitter than receiver.The 10-15 cm gap is in between road surface and bottom of electric vehicle, this gap is large for vehicles like trucks or buses therefore to extend the charging distance depending on the gaps certain methods are needed. By inserting repeaters this goal is achieved.

III. NEED OF WIRELESS POWER TRANSFER SYSTEM

In future the fuel like coal, petrol, diesel are vanishesbecause these are non renewable source of energy. The transportation system will have limitations in future. Therefore we go for the electric vehicle for transportation purpose. Because of existing gasoline and petrol engine technologyvehicles greenhouse gases are increases [11]. Plug-in Electric Vehicles are implemented to achieve environmental friendly transportation and reduced some extent of greenhouse gas. The usage of PEV is currently increased but there are some battery related problems such as slower charging rate, low energy storage capacity, size, and weight [1]. A new technology is required to reduced battery related problems and for development of EVs. Due to charging related issues many consumers do not have accepted PEVs as priority basis [11]. To reduce battery related problems, greenhouse gases and to resolving the magnetic field radiation problem the concept of Wireless Power Transfer (WPT) system is developed [10]. Many charging stations are built up on the side of road, since the users travel further distance by recharging their electricvehicle. Therefore high capacity battery is not required and it is replaced by small battery, since reduced the weight of battery [1].

Stationary IPT charging system is simple in that EVs are charged wirelessly when vehicle are park at home or stopped at parking of office [11]. These IPT systems are not required charger to charge EV. Such systems offer reliability and convenience. Including existing conventional transportation system IPT system has lowest cost. The most expensive components are power supply and track, installation cost of system is also high. Some difficulties related to designing of system must be overcome to achieve these features and advantages of the system. There is a tremendous development from past two decades in the IPT method, which start from industrial applications and currently shifted to designs of both stationary and dynamic charging system, which can achieve the challenge of powering electric vehicles (EVs). Implementation of EVs by using IPT method is more advantageous from consumer point of view as well as from sustainable energy point of view. To achieve distributed energy generation and energy storage model the concept of Vehicle to-Grid can be brought into next stage with WPT facilitated EVs [11].

IV. PROPOSED METHOD

Fig.1 represents the block diagram of proposed wireless power supply system for charging battery of electric vehicle. It consists of three parts a transmitter to generate AC signalwhich is to be transferred, transmitting and receiving coil to transfer power wirelessly and receiver to convert received AC signal into DC voltage for charging the battery of electric vehicle [10]. The aim of implemented system is to design a prototype of wireless power supply system to recharge the battery of an electric vehicle and avoid wastage of power.

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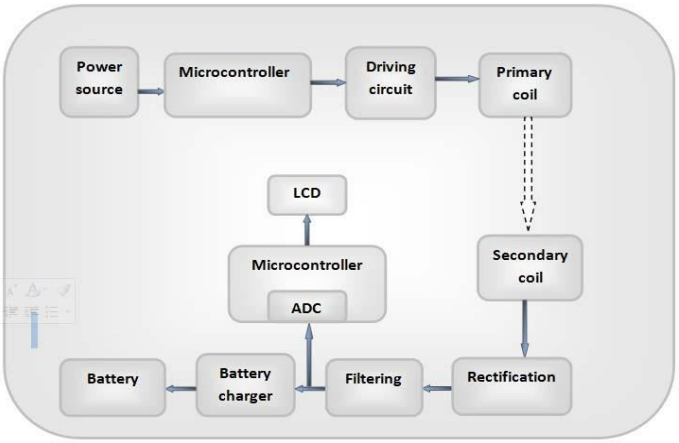

Fig. 1. Block diagram of WPT system.

A basic block diagram of wireless power transfer system consists of two sections. One is a transmitter section or primary coil and another is receiver or secondary coil section. AC source provides 230V, 50Hz AC signal. Micro controller is used to control the AC current in transmitter coil through MOSFET switch. By Amperes law an alternating current(AC) passes through the transmitting coil which creates a magnetic field then it is passes through the receiving coil. By Faradays law of electromagnetic induction an alternating EMF (voltage) is induced in receiver coil which creates an AC current in secondary. This AC signal is converted into DC signal using rectifier. Voltage regulator gives regulated DC signal so that it can be used for electric vehicle.

In proposed system 12V DC source is applied to AC converter. AC converter converts this DC signal into AC. AC current is applied to transmitting coil and it creates a magnetic field. Power is transferred through this magnetic field to the receiving coil. At receiving coil received AC signal is converted into DC using rectifier. Rectified voltage is stored in battery, Hence rechargeable battery is used in a proposed system. Now as per conventional system, once the supply is given, the whole equipment starts working and magnetic field is produced which induces voltage and the wireless transmission occurs. When vehicle is present IR sensor sense the active low signal and send this signal to MOSFET switch then turn ON the supply and transmitter transfer power to receiver circuit. When vehicle is absent, IR sensor send the active high signal to MOSFET switch then turn OFF power supply. The magnetic field radiation problem is prevent also energy wastage is overcome by using micro-controller for controlling purpose [1].The prototype WPT system, including arrangement of transmitter track coil and in vehicle placement of receiver coil and LCD display. Description of various components of system is given next.

A. Coil Design -
The transmitter coil and receiver coil is the key part of the whole system. The coils are tightly coupled if they have the same size and same configuration. In a proposed system tight coupling configuration with small distance power transfer system is used to achieve high efficiency for electric vehicle application. System consists of two coils tuned at the same frequency. Transmitter and receiver coils have been constructed using electrically conducting copper tube with a diameter of 16cm. Each coil has 48 numbers of turns and an inductance of 56uH. The air gap between these two coils is 6cm.

B. Microcontroller PIC16F877 -
PIC16F877 is 40 pin IC and 8 bit microcontroller which are one of the most advanced microcontrollers from Microchip. Because of its high quality, low price, and ease of availability it is mostly used in experimental and modern applications.

PIC16F877 microcontroller provides the following features [8]:

- 14K bytes of flash memory
- 368 bytes of RAM
- 256 bytes of EEPROM data memory
- Two 8 bit and one 16 bit timer

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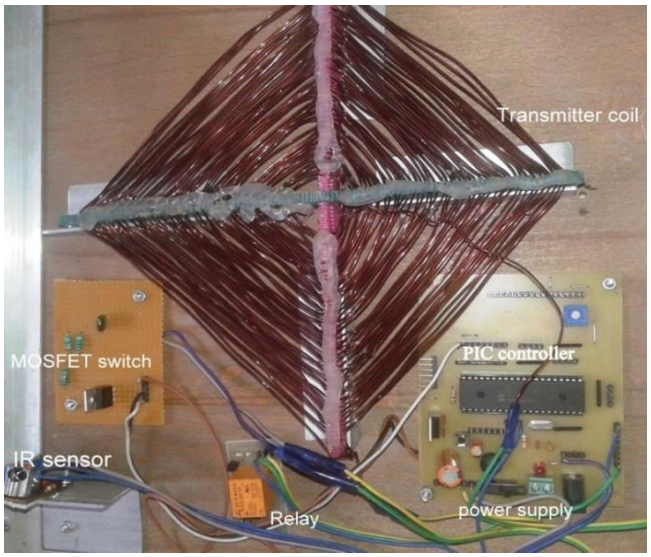
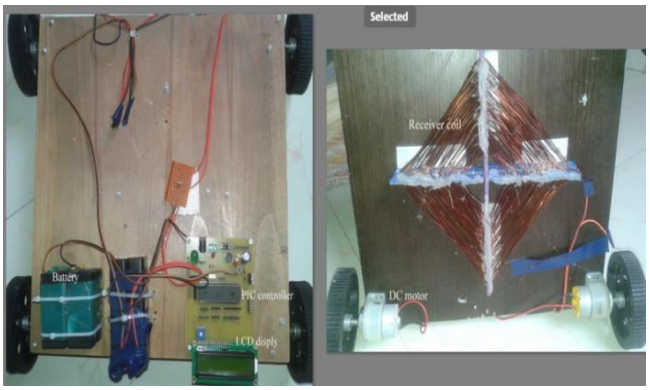
- Five input output ports
- Two serial communication ports (MSSP,USART)
- 8 channel 10 bit ADC
- 2 CCP modules.

In developed system PIC16F877 microcontroller is usedbecause of following reasons.

- It has inbuilt ADC which is required to sensebattery voltage and convert it in digital format.
- It requires low power supply.



- It is less expensive than other microcontrollers.



Photograph of the prototype WPT system, including transmitter and receiver coil

A. Rectifier -

Rectifier is used to converts AC signal into DC signal for charging battery but the DC output is varying. In many power supply circuits, the bridge rectifier is used. In proposed systemsingle phase full wave bridge rectifier is used to convert received AC voltage into DC. A full wave bridge rectifier is used because it has a high efficiency of 81.2%.

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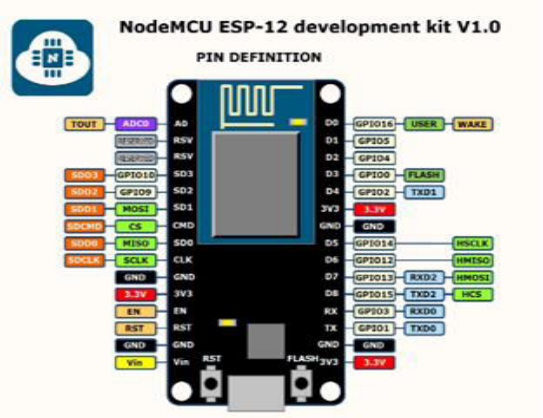

B. Voltage Regulator 7805 -

It eliminates ripple and provides a stable voltage. By using7805 voltage regulator high DC voltage is stepped down into 5V DC voltage. In general, an IC7805 regulator can withstand voltage ranging from 7.2V to 35V and gives maximum efficiency of 7.2V voltage. There is an energy loss in the form of heat if the voltage exceeds above 7.2V. In this system voltage regulator 7805 is used to give 5V DC voltage to regulate the supply [9].

IV. RESULT

By initializing wireless power transfer system, transmitter section transfers power wirelessly to receiver section. In transmitter section 240 KHZ frequency is applied to AC converter. In receiver section received power recharges the battery and runs an electric vehicle.In After initializing wireless power transfer transmitting coil transfers 10.1 V at 191.5 KHz frequency. Because of some losses receiving coil receives6.72 V at 194.8 KHz frequency. Results in calculated and implemented electric vehicle show good correlation.Table I. shows result of prototype system. As distance increases received voltage decreases. It means as distance increase efficiency decreases. The total system efficiency 67 % is achieved by considering all lasses and power supply. Received voltage which is displayed on LCD.

TABLE I

Description	Range
Transmitter coil voltage	10 V
Receiver coil voltage	6.72V
Distance between coil	6cm

Output Voltage on LCD

V. CONCLUSION

The IPT concept is implemented for wireless chargingsystem which is used to recharge an electric vehicle battery. The driving circuit is used between the transmitter coil &receiver coil where MOSFET and micro-controller is operates as a switch. Power transferred is allowed by turn ON the transmitter circuit when the vehicle is present, and turn 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 which control the system power transferred. The implementation of

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an inductive power transfer system is verifies by using battery charger application of electric vehicle. A prototype practical system is developed with efficiency level of 67 % and results are verified. The system provides reliability, long life and safety.

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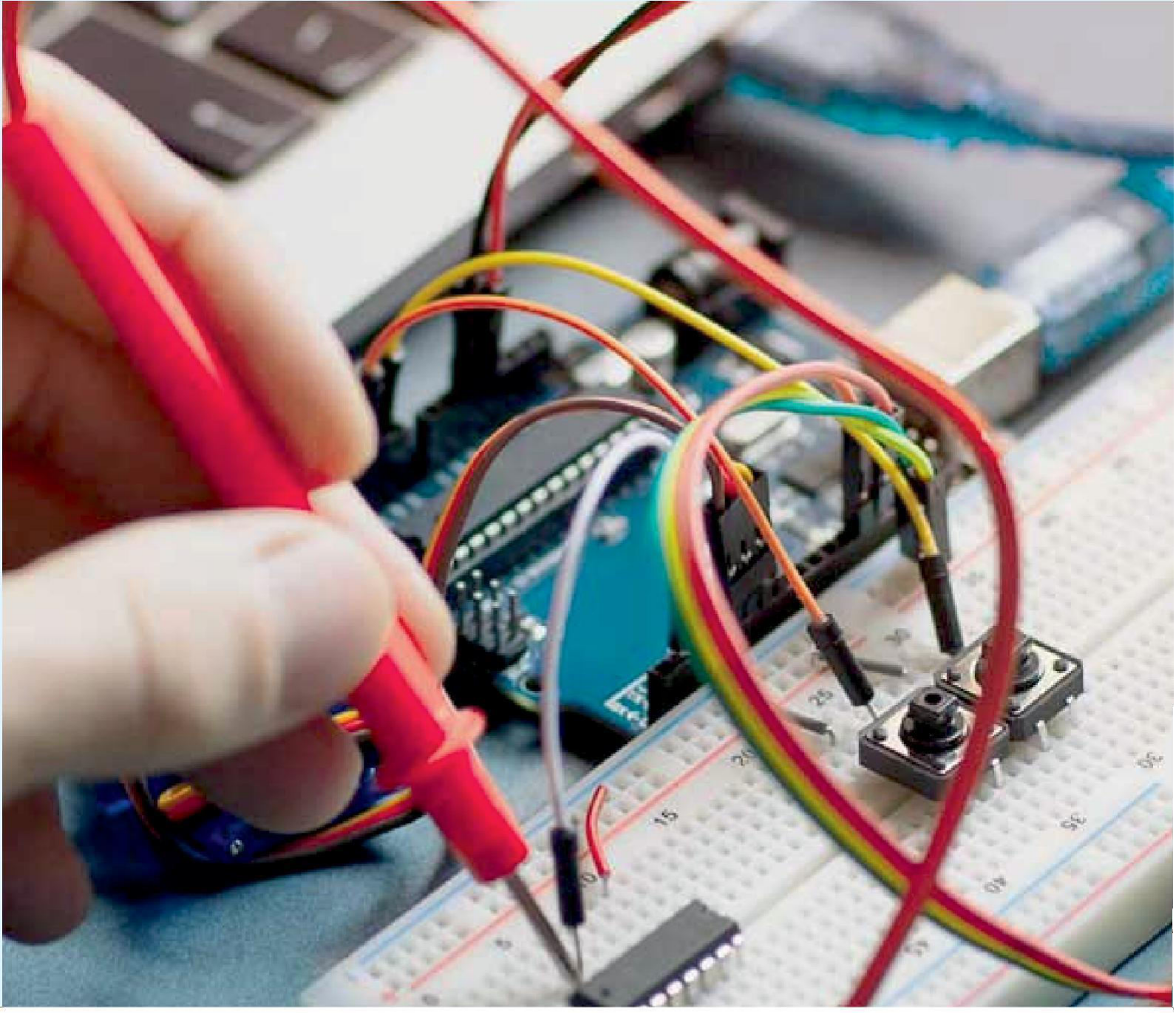

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