DESIGN OF EFFICIENT WIRELESS CHARGING PAD DEVELOPMENT AND MAXIMIZING THE POWER TRANSFER SYSTEM FOR AN AUTONOMOUS ELECTRIC VEHICLE CHARGING

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Abstract- Wireless Power Transfer Techniques are gaining popularity in Electric Vehicle charging applications due to its safety and convenience. Wireless Electric Vehicle charging system can be a potential alternative technology to charge EVs without any plug-in problems. The fundamental challenge for implementing Wireless Power Transfer for Vehicle application is the coupling variation between the primary and secondary coils due to misalignment and air-gap between coils. Compensation circuits are necessary for the Wireless Inductive Power Transfer system, to have maximum power transfer from the primary coil to secondary coils. This paper describes the design and simulation of the Inductive Wireless Power Transfer System using PLECS software. FEM simulation is carried out to verify the effect of coupling variation between primary charging pads and secondary coil mounted on the vehicle due to air gap distance between them.

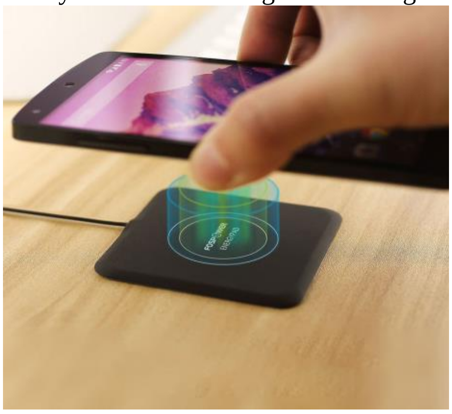
Keywords—Wireless Power Transfer ; Renewable Energy Systems ; Power ; Transmitter ; coil

I.INTRODUCTION

Wireless power transfer involves the transmission of power from a power source to an electrical load without connectors, across an air gap. The basis of a wireless power system involves essentially two coils – a transmitter and receiver coil. The transmitter coil is energized by alternating current to generate a magnetic field, which in turn induces a current in the receiver coil. The basics of wireless power transfer involves the inductive transmission of energy from a transmitter to a receiver via an oscillating magnetic field. To achieve this Direct Current (DC), supplied by a power source, is converted into high frequency Alternating Current (AC) by specially designed electronics built into the transmitter. The alternating current energizes a copper wire coil in the transmitter, which generates a magnetic field. Once a second (receiver) coil is placed within proximity of the magnetic field, the field can induce an alternating current in the receiving coil. Electronics in the receiving device then converts the alternating current back into direct current, which becomes usable power. One of the key advantages of wireless power transfer lies in its potential applications across various industries. From consumer electronics to automotive, medical devices to industrial machinery, the ability to transmit power wirelessly offers a range of benefits. In consumer electronics, for instance, it enables sleeker and more convenient designs by eliminating the need for bulky power cords and connectors. In the automotive sector, it paves the way for electric vehicle charging without physical contact, simplifying the charging process and reducing wear and tear on charging infrastructure. Moreover, in medical devices, wireless power transfer can facilitate implantable medical devices by eliminating the need for invasive procedures to replace batteries. As technology continues to advance, the possibilities for wireless power transfer are expanding, promising increased efficiency, convenience, and innovation across various fields. Furthermore, the evolution of wireless power transfer technology is driving research and development in renewable energy systems. By enabling efficient wireless transmission of power, renewable energy sources such as solar and wind can be harnessed more effectively. For instance, in remote areas or during disaster relief efforts, where traditional power infrastructure may be lacking, wireless power transfer offers a viable solution for delivering electricity to critical locations without the need for extensive wiring or grid connections. Moreover, the integration of wireless power transfer with smart grid systems holds promise for enhancing energy distribution efficiency and resilience. By enabling dynamic and adaptive power routing, wireless power transfer technology can help balance supply and demand in real-time, optimizing energy usage and minimizing wastage. In addition to these practical applications, the continued advancement of wireless power transfer technology is also sparking innovation in new fields such as robotics, space exploration, and Internet of Things (IoT) devices. For example, in robotics, wireless power transfer enables continuous operation of autonomous robots without the need for frequent battery replacements or recharging. Similarly, in space exploration missions, wireless power transfer can provide a means of recharging spacecraft or powering remote sensors and instruments. Overall, the ongoing development and adoption of wireless power transfer technology are poised to revolutionize multiple industries while paving the way for a more sustainable and interconnected future. As research and innovation in this field progress, we can expect to see even greater efficiency, reliability, and versatility in wireless power transmission systems, unlocking new possibilities for energy access, automation, and connectivity on a global scale.

II.PRINCIPLE OF WIRELESS TRANSMISSION

The principle of wireless power transmission is based on the concept of electromagnetic induction. Electromagnetic induction is the process of generating an electric current in a conductor by exposing it to a changing magnetic field. In the case of wireless power transmission, a magnetic field is generated by the primary coil, and this field induces a current in the secondary coil, which is used to power a load. The primary coil is connected to an AC power source, which generates a varying current that produces a magnetic field. The secondary coil is placed near the primary coil, and when the magnetic field generated by the primary coil changes, it induces a current in the secondary coil. The magnitude of the induced current depends on the number of turns in the secondary coil and the strength of the magnetic field.



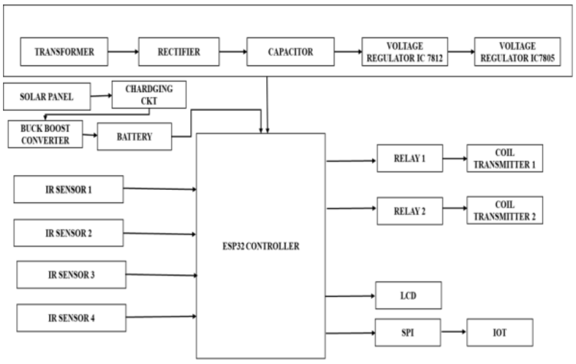


FIGURE 1. Block Diagram

1. Power Supply

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others. Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.

2. Rectifier

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full- wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC.

3. EMP32 Controller

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Ten silica Xtensa LX6 microprocessor in both dual-core and single-core variations, XtensaLX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Es press if Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process. It is as success or to the ESP8266 microcontroller.

FIGURE 2. EMP32 Controller

4. IR Sensor

IR sensor is an electronic device, that emits light to sense some object in the surroundings. An IR sensor can measure the heat of an object as well as detect the motion. Usually, in the infrared spectrum, all the objects adiate some form of thermal radiation. The set types of radiations are in visible to our eyes, but infrared sensor can detect these radiations. The emitter is simply an IRLED (Light Emitting Diode) and the detector is simply an IR photodiode. Photodiode is sensitive to IR light of the same wave length which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received. Five basic elements used in a typical infrared detection system: an infrared source, a transmission medium, optical component, infrared detectors or receivers and signal processing. Infrared lasers and Infrared LED’s of specific wavelength used as infrared sources. The three main types of media used for infrared transmission are vacuum, atmosphere and optical fibers. Optical components are used to focus the infrared radiation or to limit the spectral response. Infra-red sensors are the most often used sensor by amateur roboteers. Understanding how they behave can help address many of your requirements and would suffice to address most of the problem statements for various robotics events in India. Be it a typical white/black line follower, a wall follower, obstacle avoidance, micro mouse, an advanced flavour of line follower like red line follower, etc, all of these problem statements can be easily addressed and granular control can be exercised upon your robot's performance if you have a good operational understanding of Infrared sensors.

FIGURE 3. IR Sensor

III. SOFTWARE DEVELOPMENT

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

1.Written Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension **.ino**. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension .pde. It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .ino extension on save.

2.File

New Creates a new instance of the editor, with the bare minimum structure of a sketch already in place. Open Allows to load a sketch file browsing through the computer drives and folders. Open Recent Provides a short list of the most recent sketches, ready to be opened. Sketchbook Shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance. Examples Any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that allows easy access by topic or library. Close Closes the instance of the Arduino Software from which it is clicked. Save Saves the sketch with the current

name. If the file hasn't been named before, a name will be provided in a "Save as.." window. Save as... Allows saving the current sketch with a different name.
Page Setup It shows the Page Setup window for printing. Print Sends the current sketch to the printer according to the settings defined in Page Setup. Preferences Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.

3.Tools

Auto Format This formats your code nicely: i.e. indents it so that opening and closing curly braces line up, and that the statements inside curly braces are indented more.Archive Sketch Archives a copy of the current sketch in .zip format. The archive is placed in the same directory as the sketch. Fix Encoding & Reload Fixes possible discrepancies between the editor char map encoding and other operating systems char maps. Serial Monitor Opens the serial monitor window and initiates the exchange of data with any connected board on the currently selected Port. This usually resets the board, if the board supports Reset over serial port opening. Board Select the board that you're using. See below for descriptions of the various boards. Port This menu contains all the serial devices (real or virtual) on your machine. It should automatically refresh every time you open the top-level tools menu. Programmer For selecting a hardware programmer when programming a board or chip and not using the onboard USB-serial connection. Normally you won't need this, but if you're burning a boot loader to a new microcontroller, you will use this.Burn Bootloader The items in this menu allow you to burn a bootloader onto the microcontroller on an Arduino board. This is not required for normal use of an Arduino or Genuino board but is useful if you purchase a new ATmega microcontroller (which normally come without a bootloader). Ensure that you've selected the correct board from the Boards menu before burning the bootloader on the target board. This command also set the right fuses.

4.Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #includestatements from the top of your code. There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

IV. WORKING PRICIPLE

When the electric car is parked on a charging slot where wireless charging technology is installed, the vehicle battery starts charging. Beneath the parking area, coils are installed to generate an alternating magnetic field to enable wireless charging. An electric car with wireless charging would also be installed with coils to generate electricity from the alternating magnetic field. The car parks above the wireless charger's installation, which is the charging station. The wireless charging station is then exposed to high-frequency electricity. As a result, the nearby coils in the automobile experience electrical induction and produce alternating magnetic fields. A rectifier (AC-DC converter) transforms the generated electricity into DC and charges the battery. As is widely understood, the primary coil transmits electromagnetic radiation to the secondary coil during charging. The health of passengers, beverage items, etc., may be impacted by electromagnetic radiation if the secondary coil is left below or inside the car. Therefore, we developed a novel idea of removing the secondary coil from the passenger zone. To do this, we developed a drawer-style platform on which the coil is bound, removed from the vehicle zone during charging, and transferred outside of the hazardous area. We utilised a double-pinion rake gear arrangement, driven by a DC motor rotating at 30 rpm, to move the plate form. The driver turns on the secondary circuit, which includes an IR
sensor, when a car approaches the transmitter platform.

1.Solar Panel

Solar panel refers either to a photovoltaic module, a solar hot water panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure. A PV module is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency.

2..ESP32 Controller

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth.

3.IR Sensor

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. An IR sensor can measure the heat of an object as well as detects the motion.

4.Bidirectional Conveter

The Bidirectional DC-DC Converter block represents a converter that steps up or steps down DC voltage from either side of the converter to the other as driven by an attached controller and gate-signal generator. A bidirectional bus buffer (transceiver) is a type of logic circuit whose I/O pins can be configured as input and output to receive and transmit data. Since a transceiver allows the signal direction to be changed via a control signal (DIR), it is used along a bus line through which data are transferred bidirectionally.

5.Coil

Coil, in an electric circuit, one or more turns, usually roughly circular or cylindrical, of current-carrying wire designed to produce a magnetic field or to provide electrical resistance or inductance; in the latter case, a coil is also called a choke coil (see also inductance).

V.RESULTS

The wireless charging power stations for lectric vehicles represents an important step forward in the field of electric vehicle charging infrastructure. Wireless charging technology offers several advantages over traditional wired charging, including convenience, safety, and reduced wear and tear on the vehicle's charging port. There are still several challenges that need to be addressed in the development of wireless charging power stations,
including issues related to efficiency, cost, and compatibility with different vehicle models. Researchers and industry stakeholders must work together to address these challenges and develop solutions that can help to bring wireless charging technology to the mainstream.

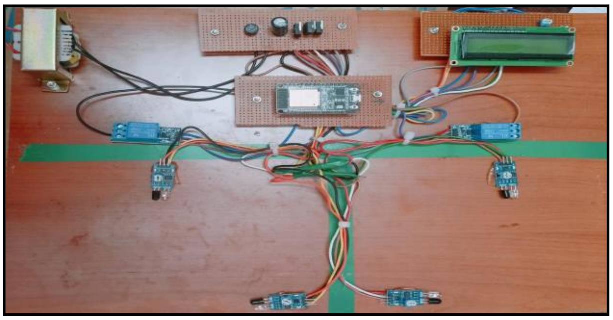


FIGURE 4. Pad Connection

The solar panels capture sunlight and convert it into electricity. This electricity is then fed into the transformer.The transformer steps up or steps down the voltage of the electricity as required for charging the EV battery. The transformed electricity is sent to the primary coil installed in the ground. When the vehicle parks over the primary coil, the secondary coil on the vehicle picks up the magnetic field generated by the primary coil. This induces an electric current in the secondary coil, charging the vehicle's battery. The ESP32 microcontroller controls the charging process, ensuring optimal charging conditions and safety. It manages the flow of electricity, monitors battery temperature and voltage, and communicates with the vehicle.

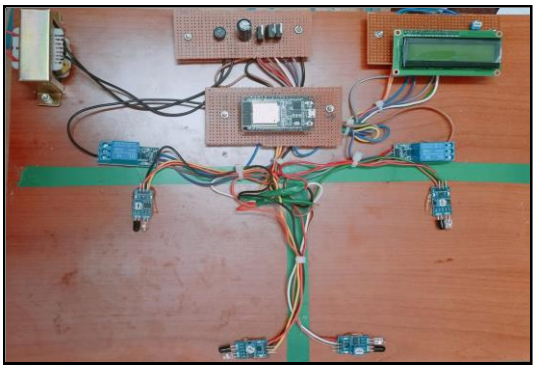


FIGURE 5 : Output Circuit

The bidirectional connector enables communication between the EV and the charging system. This communication allows the EV to provide feedback on its charging status and requirements, enabling the charging system to adjust the charging process accordingly. Overall, this system provides a convenient and environmentally friendly way to charge electric vehicles using solar power and wireless technology.

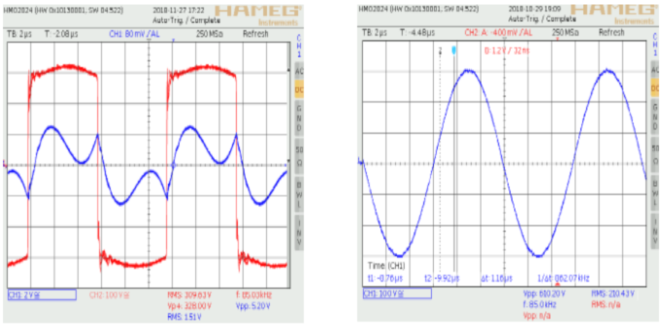


FIGURE 6. Experimental Waveforms

IV. CONCLUSION

To sum up, this article has put forth a unique strategy to improve wireless power transfer (WPT) system efficiency and power density, especially for MHz applications. We have shown notable gains in power harvesting capabilities over traditional single-coil based receivers by inventing a high power density stacked-coil based power receiver. A thorough foundation for optimising WPT systems is provided by the thorough circuit model and compensation technique described in this paper, which guarantees reliable performance even in the face of fluctuations in coil coupling and final loads. We have verified the higher energy harvesting and efficiency of the stacked-coil based receiver through experimental validation. These results have important ramifications for the development of wireless charging systems, especially when it comes to charging electric vehicles on their own. Our method promises to improve the viability and competitiveness of wireless charging systems in practical applications by optimising power transfer efficiency and density.

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