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Wireless Charging System For Electrical Vehicles On Road

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ABSTRACT:

The increasing adoption of electric vehicles (EVs) presents a critical challenge in ensuring convenient and widespread access to charging infrastructure. Traditional charging stations, while effective, create logistical limitations and contribute to range anxiety among EV users. To address this, a wireless charging system embedded within roadways has been proposed, which would enable vehicles to charge dynamically as they drive over specially equipped roads. This project aims to design, implement, and test a system based on inductive charging technology, where electromagnetic fields are used to transfer energy from the road to the vehicle's battery, eliminating the need for physical charging stations.

1.INTRODUCTION

The fundamental working principle of wireless charging is similar to that of a transformer. In this system, a transmitter and a receiver work together to enable power transfer without physical connections. The process begins with a 220V, 50Hz AC supply, which is first converted into a low-voltage, high-frequency alternating current (AC). This high-frequency AC is then supplied to the transmitter coil, generating an alternating magnetic field. As this field interacts with the receiver coil, it induces an AC voltage through electromagnetic induction. The induced AC power is then rectified into direct current (DC) at the receiver end and subsequently used to charge the battery efficiently.

This project focuses on the implementation of static wireless charging stations, where electric vehicles (EVs) can be charged while parked. The power transfer occurs over the air from a stationary transmitter to a receiver coil embedded within the stationary vehicle. One of the key advantages of this system is that it reduces the need for large onboard energy storage, thereby decreasing the weight and space requirements of the vehicle magnetic field, which then interacts with the receiver coil. This changing magnetic field induces a current in the receiver coil, producing an AC power output. The induced AC power is then rectified and filtered to provide a stable DC output, which is used to charge the EV's energy storage system. The efficiency of power transfer in an inductive wireless charging system depends on several factors, including the operating frequency, mutual inductance between the coils, and the distance between the transmitter and receiver. Optimizing these parameters can enhance charging efficiency and improve the overall practicality of wireless charging technology for EV applications. (Migliore, P., & Lanza, G)

The Inductive Wireless Charging System (IWC) operates based on Faraday's Law of Electromagnetic Induction. Wireless power transmission is achieved through mutual induction between the transmitter and receiver coils. When the primary AC supply is applied to the transmitter coil, it generates an alternating

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1.1ARDUINO UNO:

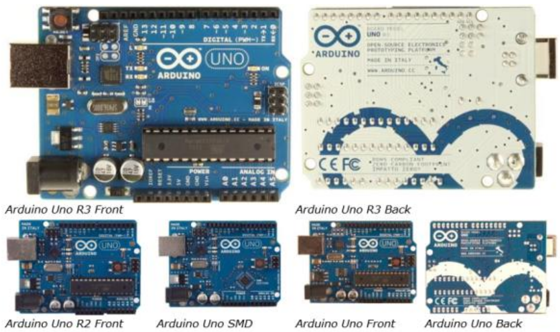

Fig.1 Arduino uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

The Arduino Uno can be powered via the USB connection or with an external power supply in the about fig.1. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

1.2Lead Acid Battery (12V):

Fig.2 Lead acid battery

12V lead acid batteries are popular in solar power systems and other 12V electrical systems. They're widely available and have a low upfront cost. Many car and marine batteries are 12V lead acid batteries in the fig.2. They are made by connecting six 2V lead acid cells in series. The minimum open circuit voltage of 12V sealed lead acid battery is around 12.2 volts, assuming 50% max depth of discharge. The minimum open circuit voltage of 12V flooded lead acid battery is around 12.1 volts, assuming 50% max depth of discharge.

1.3 ACS 712 current sensor:

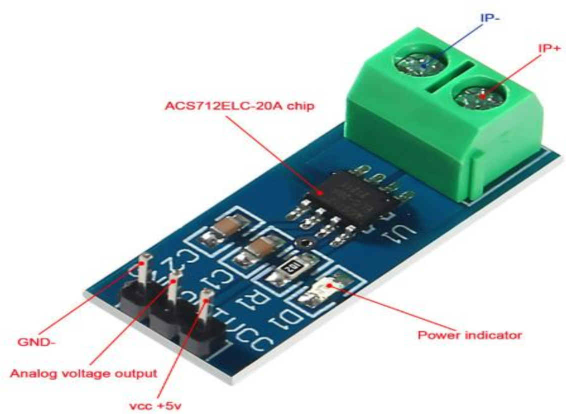

Fig.3 ACS 712 current sensor

ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection.

The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage in the fig.3. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging.(Zhang, W., & Liu, Y.)

The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the sensor leads (pins 5 through 8). This allows the ACS712 current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

1.4 16x2 LCD display:

Fig.4 LCD display

A 16x2 LCD (Liquid Crystal Display) is a widely used alphanumeric display module that can show 16 characters per line across 2 rows, making it ideal for embedded systems and microcontroller-based applications. It operates on a 5V DC supply and is controlled by an HD44780 or compatible controller, which simplifies interfacing with microcontrollers like Arduino, Raspberry Pi, and PIC. The display supports both 8-bit and 4-bit communication modes, with 4-bit mode being preferred for reducing pin usage.

The contrast of the display can be adjusted using a 10KΩ potentiometer, and a built-in LED backlight enhances visibility in low-light conditions in the fig.4. It communicates using control pins such as RS (Register Select), RW (Read/Write), and E (Enable), along with data pins (D0-D7) for sending commands and character data. The LCD operates based on electrical signals sent from the microcontroller, where the RS pin differentiates between command and data inputs, and the Enable pin triggers data transfer. It finds applications in various fields, including home automation, industrial controls, digital meters, and IoT-based projects due to its reliability, low power consumption, and ease of integration.

1.5 LED:

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are

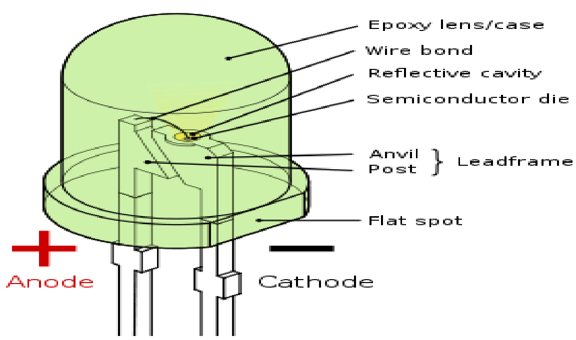

Fig.5 LED

increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

The LED is based on the semiconductor diode. When a diode is forward biased, electrons are able to recombine with holes within the device, releasing energy in the form of photons in the fig.5. Charge-carrier electrons and holes flow into the junction from electrodes with different voltages in the fig.5. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon. The wavelength of the light emitted, and therefore its color, depends on the band gap energy of the materials forming the *p-n junction*. In silicon or germanium diodes, the electrons and holes recombine by a *non-radiative transition* which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible or near-ultraviolet light.

1.6 MT3608 Booster:

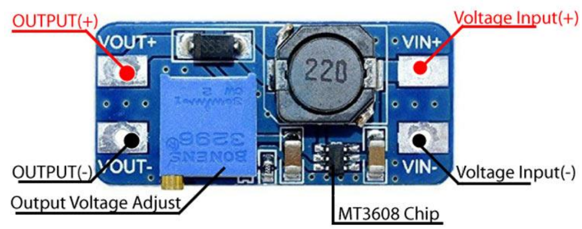

Fig.6 MT3608 booster

The MT3608 power module is a step-up (Boost) converter module intended for small and low-power applications. The module has the capability to regulate the output voltage up to 28V and deliver an output current of a maximum of 2A in the fig.6. The module consists of MT3608 IC which comes in a 6-Pin SOT23-6 Package switches at 1.2Mhz which allows the use of tiny capacitors and inductors leading to a compact size power boost module.

A boost converter (DC-DC step-up converter) is used to step up a lower voltage to a higher voltage level with quite a simple circuitry. It is a type of switch-mode power supply as it uses a switching device to regulate the voltage. In our case, the switching module is the MT3608 IC which has a high switching frequency of 1.2MHz. The higher switching frequency also opens up the possibilities to use smaller indicators making the module compact and also providing high power output simultaneously.

Whenever current is passed through the inductor(L1) it induces some magnetic field and when you change the current level passing through it, the magnetic field collapses and it generates a high voltage spike. Having a high switching frequency IC(MT3608) allows this principle to happen by generating and collapsing the magnetic field induced by the inductor. When the switching module is off, the voltage spike (high voltage level) passes through the Schottky diode(D1) and gets stored in the capacitor(C2) hence increasing the voltage of the capacitor and we obtain a higher voltage level output across the capacitor. The Schottky diode (D1) plays an important role in blocking a reverse current to the circuit.

2. EXPERIMENTAL RESULTS

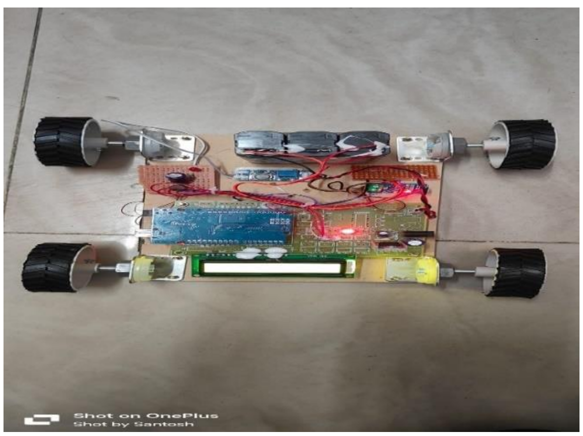

Fig.7 Vehicle section

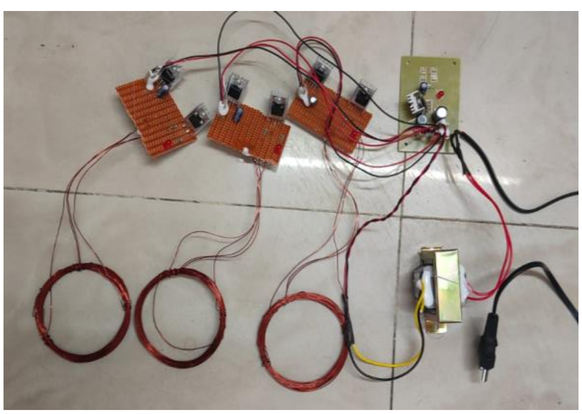

Fig.8 Transmitter

The Wireless Power Transfer and Charging Module can be used in electronic equipment in common use for close wireless charging or power supply in the fig.9. Consist of a Transmitter & Receiver and coil, it could serve as a replacement for the Wireless Power Supply with stable 5V output voltage and maximum 600mA output current in the fig.8. Its small size and insulation coil is more suitable for using in wireless project.

This module use an electromagnetic field to transfer electric energy between a transmitter circuit and a receiver circuit.

An induction coil creates an alternating electromagnetic field from within the transmitter circuit powered with 12V. The second induction coil takes power from the electromagnetic field and converts it back into electrical current to the receiver circuit that outputs 5V - 600mA.

During any energy conversion there will be losses in going from one form to another. The magnitude of those losses is what dictates the practicality of any type of wireless charging. Magnetic or inductive charging, in particular has been effectively used for some time to power various kinds of biomedical implants. Presently it is the safest and most enduring method to accomplish the job of transferring power to the inside of the body. In these systems, oscillating current in an external coil of wire generates a changing magnetic field which induces a voltage inside an implanted coil. The current resultant from this voltage can charge a battery or power the device directly.

While a moving magnet might just as well be used to externally generate the field, an external coil is simply more practical. Apple has just filed a patent for hardware which could make the shake to charge concept a reality, at least in theory. They claim a unique design incorporating internal moveable magnets, and a flat printed circuit board coil. Current

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chip efficiencies will however preclude practical implementation of this scheme for some time.

Many smartphone users will be wondering wonder whether their near field communication (NFC) chip can be used to harvest power from a dedicated external source, or perhaps an ambient electromagnetic source like wifi in theory it is possible and such systems are on the market already, however not every NFC chip would be up to the task in the fig.7. To achieve maximum efficiency the system should be optimized for a use at a particular separation distance, angle of incidence, phase, and frequency such that it is in a resonant condition.(Wang, M., & Zhao)

Resonance in an electromagnetic system can be likened to pushing a child on swing only when the swing is at the high point. Anywhere else and the energy transferred to the child will be reduced. If the separation distance is no more than a quarter of the wavelength, such a system can operate at efficiencies up to 35%.

One thing to keep in mind when considering wireless charging: If your charging system is throwing away

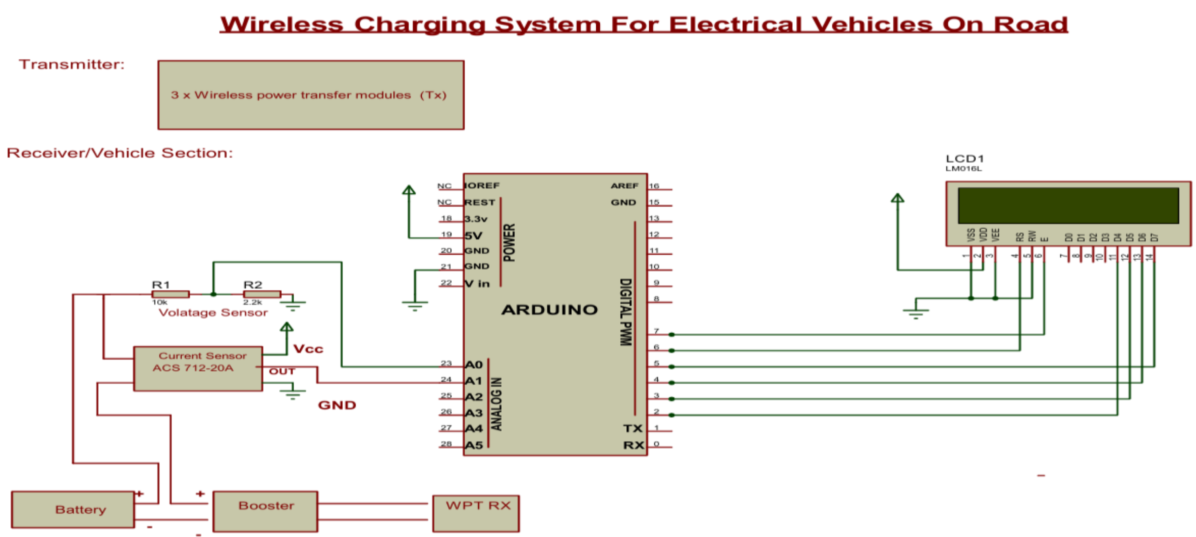

Fig.9 Circuit diagram

nearly all of the 10 or so amps available from your wall outlet just to provide you with convenient at-a-distance charging, not only will charging be wasteful but it will be slow. Other wireless charging technologies relying on ultrasound or solar power are being developed, for example by ubeam. For the time being, however, magnetic inductive charging technologies — spearheaded by the Qi consortium and smartphones like the Nokia Lumia 920 — such have taken the stage.(Anderson, M., & Choi)

The transmitter coil and the receiving coil distance suitable is from 1mm to 20 mm. Increase the number of turns of the receiver coil to increase the transmission distance when low current is suitable in your application. As distance increase current capacity of receiver will drop.

Table 1: Ratings of the components

Transmitter Input Voltage	+12V DC
Maximum Transmitter Input Voltage	+13.5V DC
Receiver Output Voltage	+5V DC regulated fixed
Maximum Receiver Current Capacity	600mA (Based on distance)
Coil Inductance	30uH
Transmit Receive Distance	1-20mm
Coil Dimensions	38mm Diameter x 2mm Height

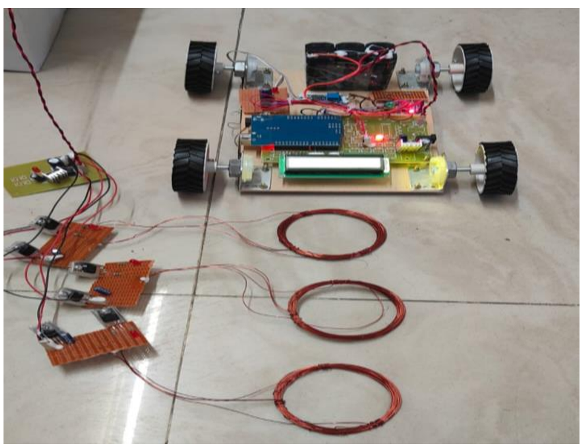

Fig.10 Working model

Transmitter Board has two ICs,

1) XKT-408A / 1215A - It is Generates sinewave signals - Same can be emulated by a custom programming in microcontroller to generate sinewave.

2) T5336 from elcoteq - Seems like Mosfet Driver in SOIC8 package to drive coils upto 60V peaks on sinewave. Same can be designed with discrete mosfets in H-Bridge.

Receiver Board has one IC

1) T3168 from Elcoteq

Receiver Board Circuit - Seems like a MC34063 type design for power regulation but more efficient.

3.ADVANTAGES AND DISADVANTAGES

1. **Cost Efficiency:**

   The operational cost of electric vehicles (EVs) is 80% lower compared to traditional gas-powered vehicles. Electricity is generally cheaper than gasoline or diesel, leading to significant savings in fuel expenses.

2. **Lower Maintenance:**

   EVs have fewer moving parts compared to internal combustion engine (ICE) vehicles, leading to less wear and tear. The absence of components like engine oil, spark plugs, fuel injectors, and exhaust systems reduces maintenance needs.

3. **Eco-Friendly:**

   EVs produce zero tailpipe emissions, making them an environmentally friendly alternative to gasoline-powered vehicles. The reduction in air pollution contributes to better public health and a cleaner atmosphere.

4. **Unlimited Range (on Grid Roads):**

   When operating on a grid-connected roadway, EVs can achieve continuous charging while driving, eliminating the need for frequent stops. This system enables an unlimited driving range, overcoming the biggest limitation of conventional EVs.

Disadvantages:

1. **High Initial Cost:**

   Initial installation cost is very high. The cost of integrating grid-powered roads or public wireless charging stations is significantly higher than traditional charging setups.

2. **Limited**

Coverage: Wireless charging is location-dependent and requires designated charging stations or specially constructed roads.

3. **Heat**

Issues: Wireless power transfer leads to higher energy losses, generating more heat compared to traditional wired charging.

4. CONCLUSION

we have explored the concept of wireless power transmission for charging electric vehicles (EVs). Wireless charging presents a more convenient and efficient alternative to traditional wired charging systems, addressing several limitations associated with plug-in methods. By eliminating physical connectors and cables, wireless charging enhances user experience by reducing wear and tear, minimizing maintenance, and eliminating potential safety hazards such as electrical shocks or exposed wiring.

Additionally, wireless charging systems contribute to a cleaner and more sustainable environment by reducing reliance on fossil fuels and promoting the adoption of EVs. One of the major concerns for EV users, range anxiety, is significantly reduced through the implementation of dynamic wireless charging technology, where vehicles can be charged on the move without the need for frequent stops. This ensures a more seamless and efficient transportation system.

Although the technology still faces challenges such as high installation costs and infrastructure requirements, ongoing research and advancements in power transfer efficiency, battery technology, and smart grid integration are expected to drive widespread adoption. With further innovations, wireless EV charging has the potential to revolutionize modern transportation, making it more sustainable, convenient, and efficient for future mobility solutions.

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