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Wireless EV Charging Using Arduino

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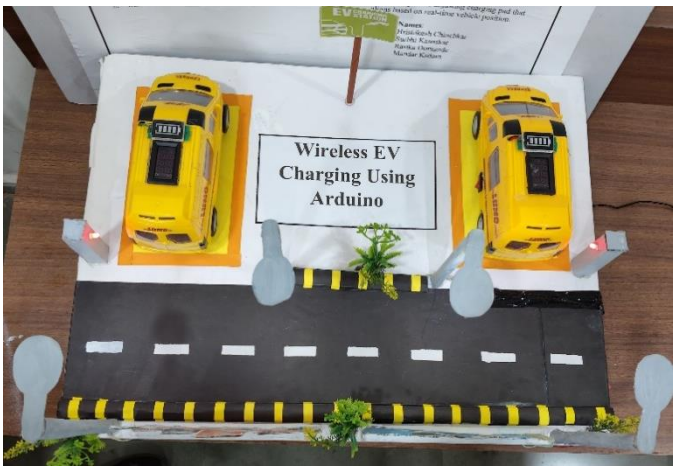
ABSTRACT :

Wireless Electric Vehicle (EV) charging is an innovative technology that eliminates the need for physical connectors, enhancing convenience and reducing wear and tear. This project implements a wireless EV charging system using Arduino Uno, relay modules, a Hall sensor, a battery level indicator, and other essential components. The system efficiently transfers power wirelessly to a small EV prototype, detecting the battery level and managing charging accordingly. Compared to conventional plug-in chargers, this approach enhances safety, reliability, and automation. The project explores the feasibility of cost-effective and efficient wireless charging for future electric mobility.

Keywords— Wireless Charging, Arduino, Electric Vehicles, Inductive Coupling, Battery Management, Automation

Introduction :

Wireless Electric Vehicle (EV) charging is an innovative technology that eliminates the need for physical connectors or charging cables, making the charging process more efficient and user-friendly. This project, "Wireless EV Charging using Arduino," aims to design and implement a wireless charging system that can automatically detect a parked EV and initiate the charging process without human intervention. The system is controlled using an Arduino Uno, an hall sensor for vehicle detection, and a relay module to activate the charging coil.



Define User-Based Problem

The primary challenge for EV users is the inconvenience of wired charging stations, which require manual connection and disconnection of charging cables. This can be problematic due to:

- Physical effort: Plugging and unplugging cables may be cumbersome, especially in bad weather conditions (rain, snow, or extreme heat).
- Misalignment Issues: If the charging port and cable are not correctly aligned, charging efficiency decreases.
- Wear and Tear: Continuous plugging and unplugging can lead to connector degradation, affecting performance over time.
- Automation Gap: Current EV charging solutions lack full automation, requiring manual intervention, which is not ideal for smart cities.

Problem Definition

The objective of this project is to develop a wireless EV charging station that can automatically detect an EV and initiate charging using an Arduino-based control system. The system comprises:

1. Arduino Uno – Controls the entire operation, processes signals from sensors, and activates charging.
2. hall Sensor – Detects the presence of an EV when it arrives at the charging station.
3. Relay Module – Acts as a switch to turn the wireless charging coil ON/OFF based on vehicle detection.
4. Wireless Charging Coil – Transfers energy wirelessly to the EV battery.

This project aims to improve charging convenience, safety, and efficiency by eliminating physical connectors and enabling a fully automated charging experience.

Literature survey :

Wireless Electric Vehicle (EV) charging is an emerging technology aimed at eliminating the need for physical connectors and improving the convenience and efficiency of EV charging. Several research studies and technological advancements have contributed to this field, focusing on inductive power transfer (IPT), resonant coupling, automation, and control mechanisms.

2.1. Existing EV Charging Methods

Currently, EV charging is primarily done using plug-in wired chargers. These chargers have the following limitations:

- Requires manual intervention, making it inconvenient for users.
- Wear and tear of connectors over time.
- Safety concerns due to exposed wiring in wet conditions.
- Inability to charge automatically without human assistance.

To overcome these issues, wireless charging systems have been proposed using electromagnetic induction and resonant inductive coupling.

2.2. Wireless EV Charging Technologies

Several wireless EV charging techniques have been explored in past studies:

1. Inductive Power Transfer (IPT):
    - Uses an electromagnetic field to transfer power from a primary coil (stationary charging pad) to a secondary coil (EV).
    - Challenges: Alignment precision is needed to ensure efficient charging.
2. Resonant Inductive Coupling:
    - Similar to IPT but operates at resonant frequencies to improve power transfer efficiency over a greater distance.
    - More flexible than IPT, but efficiency depends on coil design and tuning.
3. Dynamic Wireless Charging:
    - Enables EVs to charge while in motion by embedding charging coils within roads.
    - High infrastructure cost makes this method less feasible for early adoption.

2.3. Studies on Automated Wireless Charging Systems

- A study by J. Dai and D. C. Ludois (IEEE Transactions on Power Electronics, 2015) explored the feasibility of wireless power transfer for EVs using capacitive coupling, achieving moderate efficiency.
- Hui et al. (2018) developed a system that integrates automated vehicle detection using sensors to initiate wireless charging, reducing energy loss.
- Recent advancements in Arduino-based automation have enabled small-scale implementations of wireless charging systems with sensor-based activation mechanisms.

2.4. Implementation in Our Project

Based on existing literature, our project aims to develop a low-cost, efficient, and automated wireless EV charging system using Arduino Uno, an ultrasonic sensor, a relay module, and a wireless charging coil. The integration of sensor-based vehicle detection will improve automation and efficiency, aligning with recent research trends in the field.

This literature survey highlights the importance of automation and efficiency in wireless EV charging, demonstrating that our project is a step towards practical and user-friendly implementation.

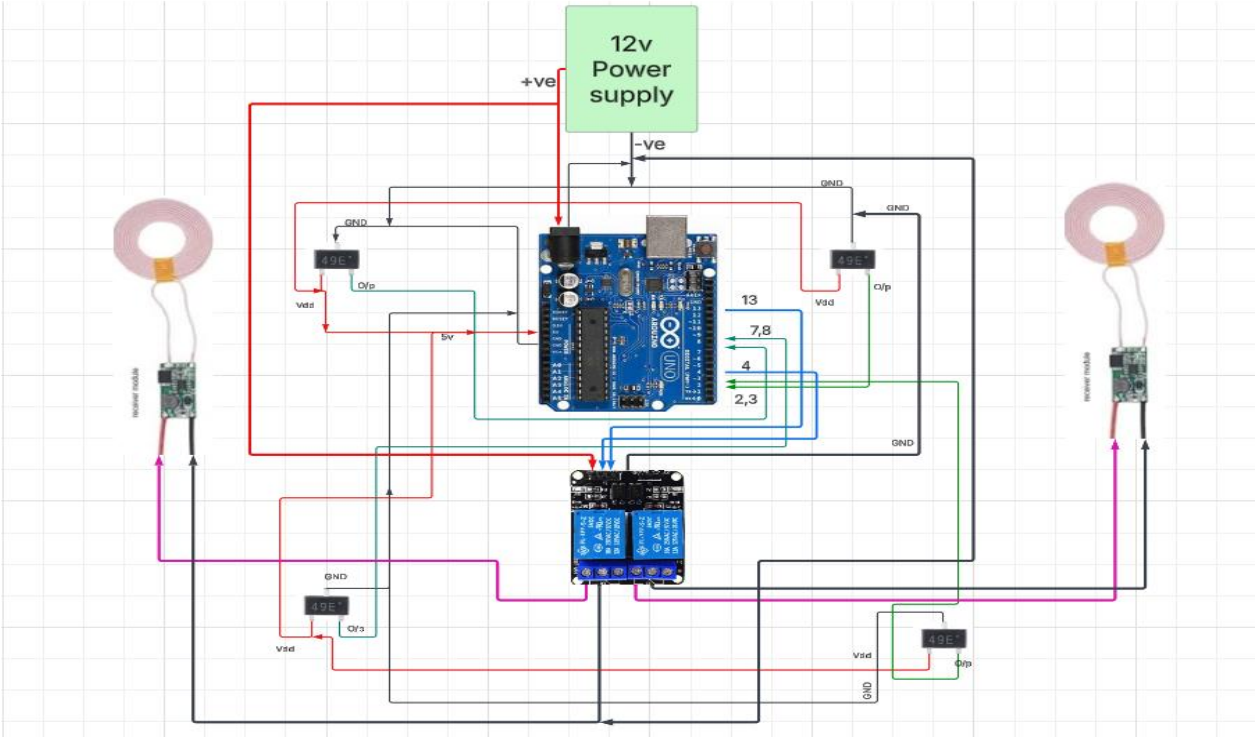
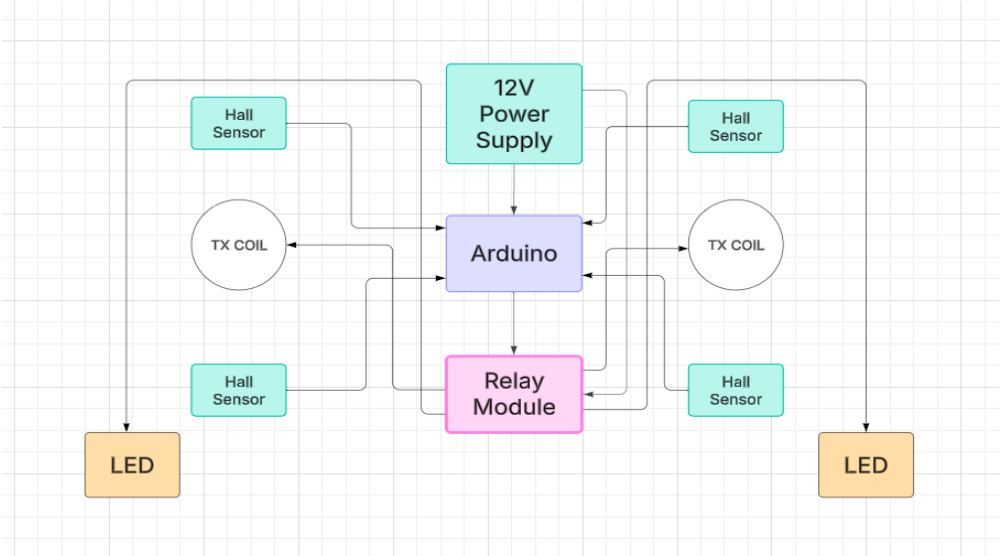


Figure 2: Design of Charging circuit [5]

Working of the Circuit:

1. Power Supply Activation
   - A 12V power supply powers the Arduino Uno, relay module, and wireless charging circuits.
   - The Arduino operates at 5V, likely regulated internally.
2. Vehicle Detection Using Hall Sensor
   - A Hall sensor is placed at the charging station to detect the presence of the EV's magnetic field (from a magnet attached to the EV or metal parts).
   - When the EV arrives, the Hall sensor sends a signal to the Arduino, indicating that a vehicle is in position for charging.
3. Control Signal Processing (Arduino)
   - The Arduino processes the Hall sensor input to confirm that the vehicle is correctly positioned over the charging coils.
   - If an EV is detected, the Arduino activates the relay module.
4. Relay Module Activation
   - The relay module acts as a switch that connects or disconnects the wireless charging coils from the power supply.
   - When the relay is turned ON, power is supplied to the charging coils.
   - If the vehicle moves away, the relay turns OFF, stopping the charging process.
5. Wireless Power Transfer
   - The wireless charging modules transfer power inductively from the transmitter coil (charging station) to the receiver coil (EV battery system).
   - This is done using inductive power transfer (IPT), where an AC current in the transmitter coil creates a magnetic field that induces voltage in the receiver coil.
6. Charging Control & Safety
   - The Hall sensor ensures that charging only occurs when the EV is detected, preventing energy wastage.
   - The relay module isolates the power source, ensuring safe operation.

Block Diagram :



Working of Block Diagram:

1. Power Supply (12V) – Powers the entire system, including the Arduino, relay module, Hall sensors, and TX (transmitter) coils.
2. Hall Sensors – Detects the presence of an EV over the charging station.
3. Arduino – Acts as the control unit, processing signals from the Hall sensors and activating the relay module when an EV is detected.
4. Relay Module – Switches the TX coils ON/OFF based on input from the Arduino.
5. TX Coils – Wireless charging coils that transfer power inductively to the EV battery.
6. LED Indicators – Turn ON when charging is active, providing a visual indication.

Working Flow:

- EV detected → Hall sensor sends signal to Arduino → Arduino activates relay → Relay powers TX coil → Wireless charging begins → LED turns ON.
- When EV leaves → Hall sensor detects no vehicle → Arduino turns OFF relay → Charging stops → LED turns OFF.

Hardware Description :

Arduino Uno

- Function: The Arduino Uno is the brain of the system, responsible for processing signals from the Hall sensors and controlling the relay module.
- Features:
    - Operates at 5V with a 16 MHz clock speed.
    - Has multiple digital I/O pins for connecting sensors and relays.
    - Compact size, making it ideal for embedded applications.

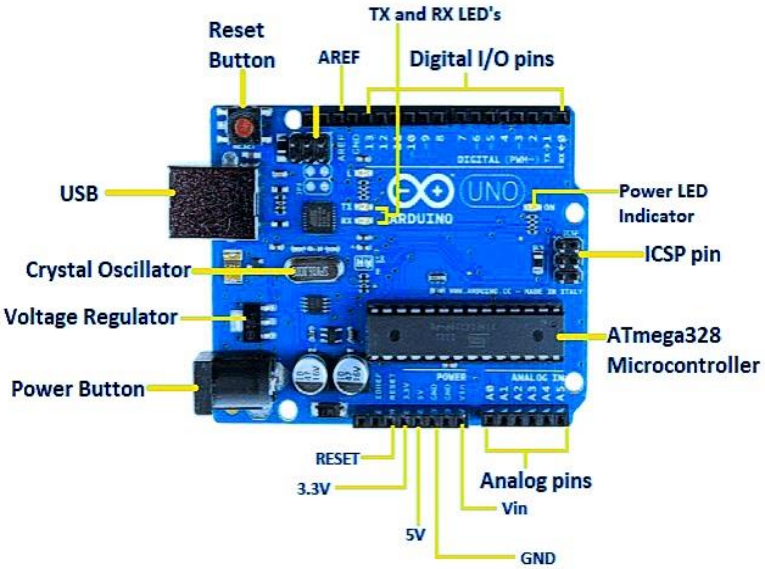


Fig. 4.1 Arduino Uno[1]

- Function: The Hall sensor is used to detect the presence of the EV by sensing changes in the magnetic field when a vehicle is parked over the charging station.
- Features:
    - Works based on magnetic flux detection.
    - Provides a digital output (HIGH/LOW) to the Arduino.
    - Helps in automating the charging process without manual intervention.

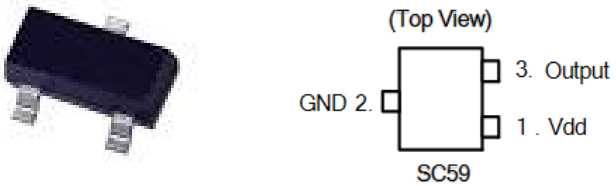


Fig. 4.2 hall sensor[2]

Relay Module

- Function: The relay module acts as an electronic switch to turn the wireless charging coils ON/OFF based on signals from the Arduino.
- Features:
    - Can handle high-power loads (e.g., 12V charging coils).
    - Electrically isolates the Arduino from the high-power circuit.
    - Controlled by a low-voltage (5V) signal from the Arduino.

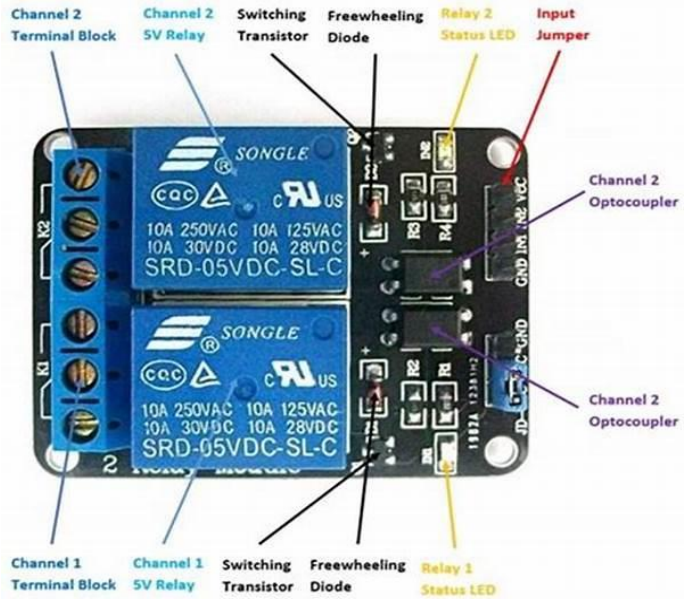


Fig. 4.3 relay module[3]

4.4. Wireless Charging TX Coil

- Function: The transmitter coil (TX Coil) generates an alternating magnetic field, which transfers power wirelessly to the receiver coil in the EV.
- Features:
    - Works on inductive power transfer (IPT) principle.
    - Provides contactless energy transfer, eliminating the need for physical connectors.
    - Requires precise coil alignment for efficient power transfer.

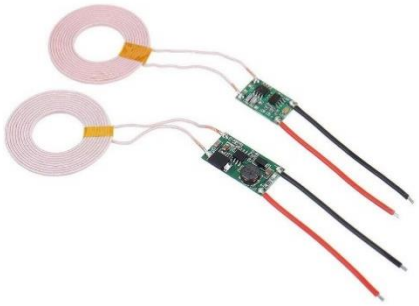


Fig. 4.4 Power transfer coil [4]

4.5. 12V Power Supply

- Function: Provides power to the entire system, including the Arduino, relay module, and wireless charging coils.
- Features:
    - Converts AC mains power to 12V DC.
    - Delivers sufficient current for efficient charging.
    - Ensures stable operation of all components.

3.6. LED Indicators

- Function: LEDs serve as visual indicators to show when the charging process is active.
- Features:
    - Turns ON when charging is in progress.
    - Turns OFF when no vehicle is detected or charging is inactive.
    - Provides real-time status feedback to the user.

Future Directions :

- *Enhanced Charging Efficiency* – Optimize coil design and use *resonant inductive coupling* for better energy transfer.
- *Dynamic Wireless Charging* – Implement charging on *moving vehicles* using embedded road coils.
- *IoT & Smart Monitoring* – Integrate *real-time monitoring* via mobile apps and cloud platforms.
- *Solar-Powered Charging* – Use *solar panels* to make the system eco-friendly and grid-independent.
- *Improved Safety & Automation* – Upgrade to *AI-based vehicle detection* and add overheat protection.
- *Vehicle-to-Grid (V2G) Technology* – Enable *bi-directional power transfer*, allowing EVs to return energy to the grid.

Conclusion :

The Wireless EV Charging System using Arduino demonstrates an efficient, contactless method for charging electric vehicles. By integrating Hall sensors for automatic detection, relay modules for power control, and inductive coils for wireless energy transfer, the system ensures safe and seamless charging. This project highlights the potential of wireless power transfer in reducing reliance on physical charging ports, making EV charging more convenient and maintenance-free. Future advancements, such as IoT integration, solar power utilization, and dynamic charging, can further enhance its efficiency and scalability.

Overall, this system represents a step toward smart, automated, and sustainable EV infrastructure, paving the way for next-generation transportation solutions

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[3] https://www.thingbits.in/products/2-channel-relay-module-with-high-low-trigger-optocoupler (relay module)
[4]2-Pcs-Wireless-Charging-Module-Mat-Jitterbug-Smart-Phone-Power-Supply-Modular-Coils-Charge-Launcher-Copper-Iron_3cd9f3fa-7937-4ed6-a98f-d9df5163fce2.ffc3513efe9014c4fc7a79d8ad01ecf6-1600x1600.jpeg (1600×1600) (tx/rx coils)
[5]Free Flowchart Maker - Create Flowcharts Online | Lucidchart (block diagram and circuit diagram)