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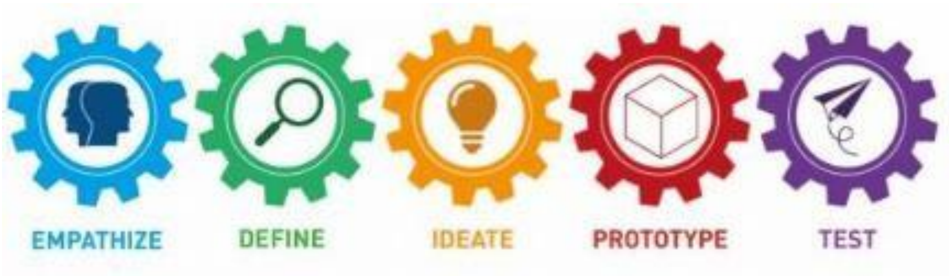
Department of Electronics and Telecommunication Engineering

DESIGN THINKING LAB (ET247DL)



THEME – Smart city

WIRELESS EV CHARGING WITH SHORT CIRCUIT DETECTION

REPORT

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Submitted in partial fulfillment for the fourth-semester examination of Bachelor of Engineering

in

Electronics and Telecommunication Engineering

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CERTIFICATE

Certified that the Design Thinking Lab (ET247DL) work titled "Wireless EV charging and short circuit detection" is carried out by Preetham V, Ritvik Unnikrishnan, Sneha Pandey, Sonia Girish Deshpande, are bonafide students of RV College of Engineering, Bengaluru, submitted in partial fulfilment for the fourth-semester examination of Bachelor of Engineering in Electronics and Telecommunication Engineering affiliated to Visvesvaraya Technological University, Belagavi, during the year 2024-25. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the Design Thinking Lab report deposited in the departmental library.

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1. INTRODUCTION

The increasing demand for sustainable and eco-friendly transportation has accelerated the adoption of Electric Vehicles (EVs) worldwide. While EVs significantly reduce greenhouse gas emissions and reliance on fossil fuels, one of the major challenges they face is the availability of efficient and convenient charging infrastructure. Traditional plug-in charging systems often suffer from drawbacks such as wear and tear of connectors, exposure to weather conditions, and user inconvenience. To address these issues, Wireless EV Charging (WEVC) has emerged as a promising alternative.

Wireless EV charging operates on the principle of electromagnetic induction, where power is transmitted from a primary coil, embedded in the road or parking surface, to a secondary coil mounted beneath the vehicle. This technology allows for hands-free, contactless energy transfer, making EV charging seamless and user-friendly. In this project, we have designed and implemented a working prototype of such a wireless charging system using renewable energy sources—solar and wind power—as the primary input for the charging setup. This integration ensures that the system remains environmentally sustainable from energy generation to consumption.

The prototype consists of a primary coil placed on or under the road surface, connected to a renewable power source, a secondary coil fixed under the EV (or model car), which receives energy wirelessly when aligned with the primary coil., a load (LED) connected to the secondary coil to visually demonstrate the successful transfer of energy.

When the secondary coil passes over or aligns with the primary coil, magnetic flux linkage between the coils induces a voltage in the secondary coil. This induced voltage is used to power the LED, showcasing the principle of inductive power transfer.

However, in any electrical system, especially one involving variable load conditions and wireless transmission, safety mechanisms are crucial. One of the most common electrical hazards is a short circuit, which can lead to excessive current flow, component damage, or even fire hazards if not detected and managed promptly. To mitigate this risk, the project includes a Short Circuit Detection System using a PZEM-004T energy monitoring sensor

2. EMPATHY

1. Awareness and Understanding: While a significant number of users are aware of wireless EV charging, many still lack in-depth understanding of its operation and benefits.
There is a clear demand for simplified, accessible educational content to bridge the knowledge gap and foster confidence in adopting the technology.

2. Safety Concerns: Safety remains a primary concern. Users want assurance that wireless charging is safe for daily use and poses no long-term health or fire hazards.
Trust can be strengthened through transparent safety standards, certifications, and real-world performance data.

3. Environmental Consciousness: There is strong support for sustainable technologies, with users recognizing wireless EV charging as an opportunity to promote clean energy adoption.
However, environmental benefits alone are not enough without practical usability and affordability.

4. Desire for Speed and Efficiency: Users are increasingly time-conscious and expect charging solutions that are fast, reliable, and efficient.
Current wireless systems must improve in speed to match or surpass plug-in options to meet these expectations.

5. Need for Convenience: The appeal of wireless EV charging lies in its potential to eliminate physical hassle, especially in adverse weather or low-light environments.
Users value a seamless and automated charging experience, reflecting a desire for smarter urban mobility.
To support this, the system integrates with IoT to provide notifications every time the LED glows using ESP8266, allowing users to monitor charging events remotely without physical interaction.

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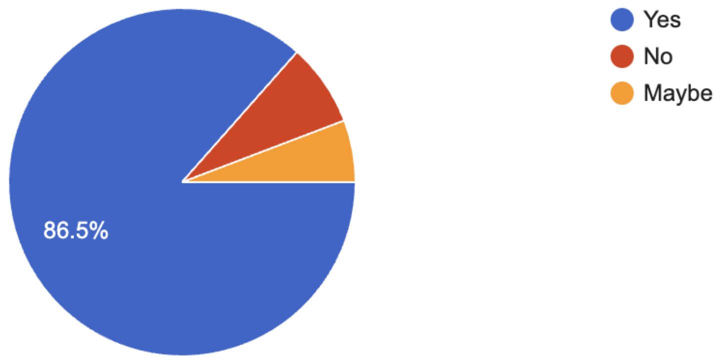
2.1 QUESTIONS AND RESPONSES

This survey is designed to gather user opinions, expectations, and concerns regarding the adoption of wireless electric vehicle (EV) charging systems, with a particular focus on convenience, safety, and integration with smart and sustainable technologies. It explores public interest in shifting from traditional plug-in chargers to contactless systems, identifies the most valued features such as automation and cleaner setup, and assesses the importance of safety given the risk of electrical faults.

The survey also seeks feedback on integrating renewable energy, potential installation locations like traffic signals or smart parking, and users' willingness to pay for enhanced safety. These insights directly inform the design and development of a next-generation wireless EV charging system with real-time fault detection using a PZEM sensor**.**

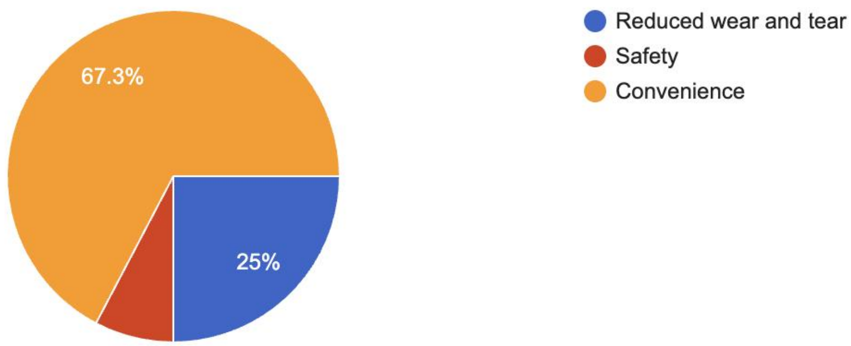
Do you think wireless EV chargers should be installed at traffic signals and smart parking lots?

52 responses



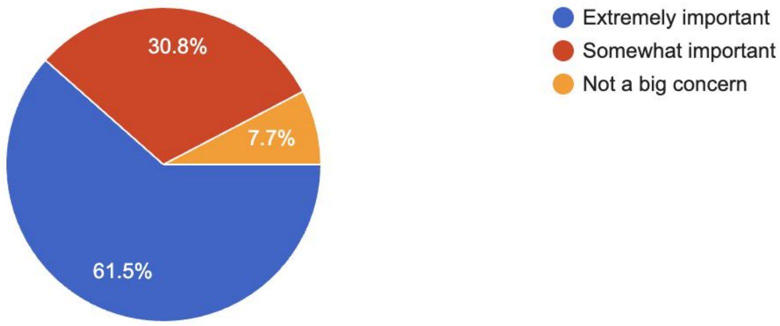
What do you perceive as the biggest benefit of wireless EV charging?

52 responses



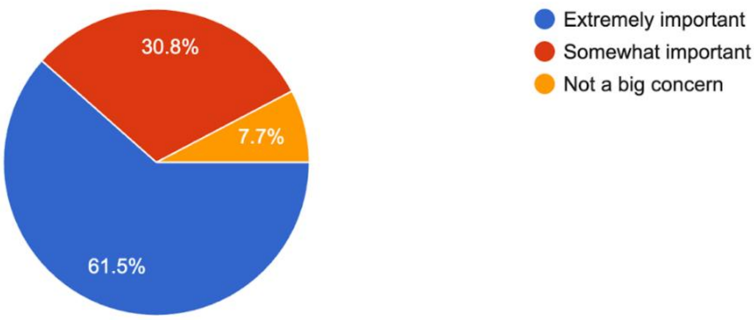
How important is safety in EV charging systems to you?

52 responses



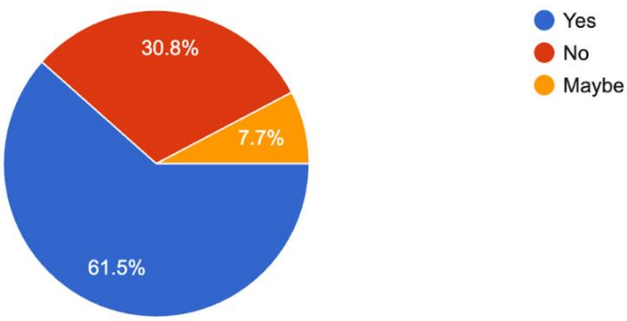
How important is safety in EV charging systems to you?

52 responses



Have you ever experienced or heard of any fire or electrical accidents during EV charging?

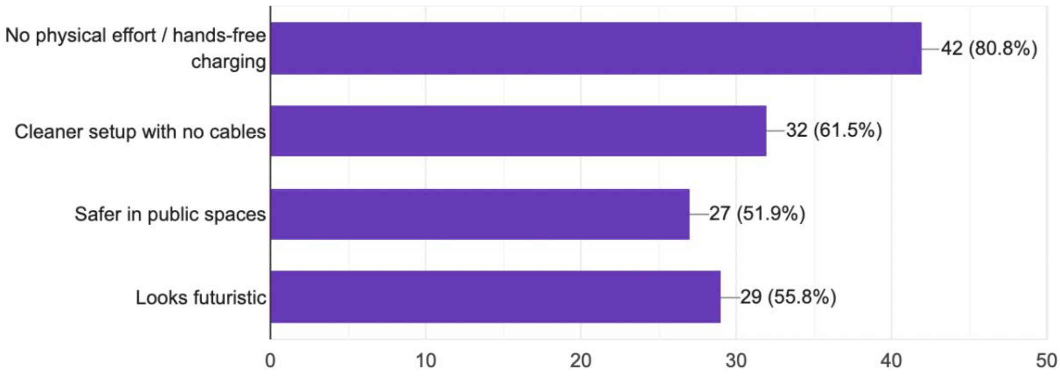
52 responses



Copy chart

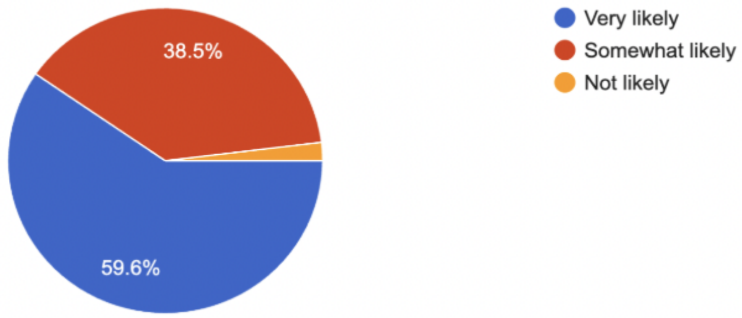
What do you think are the biggest benefits of wireless EV charging? *(Select all that apply)*

52 responses



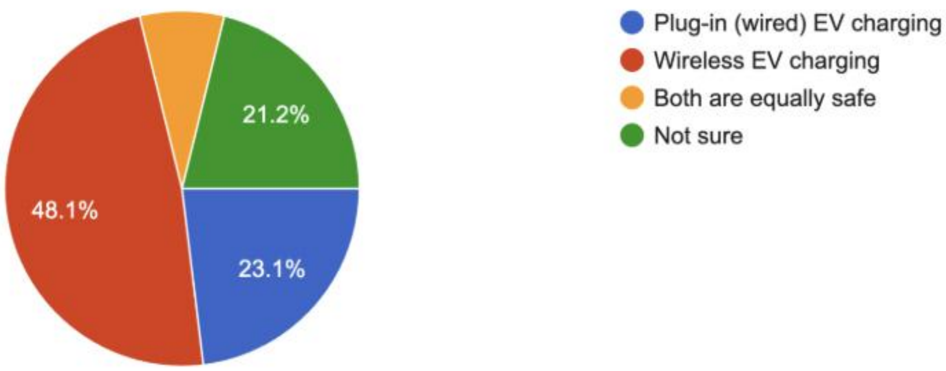
If wireless EV charging with safety features became widely available, how likely are you to switch to it?

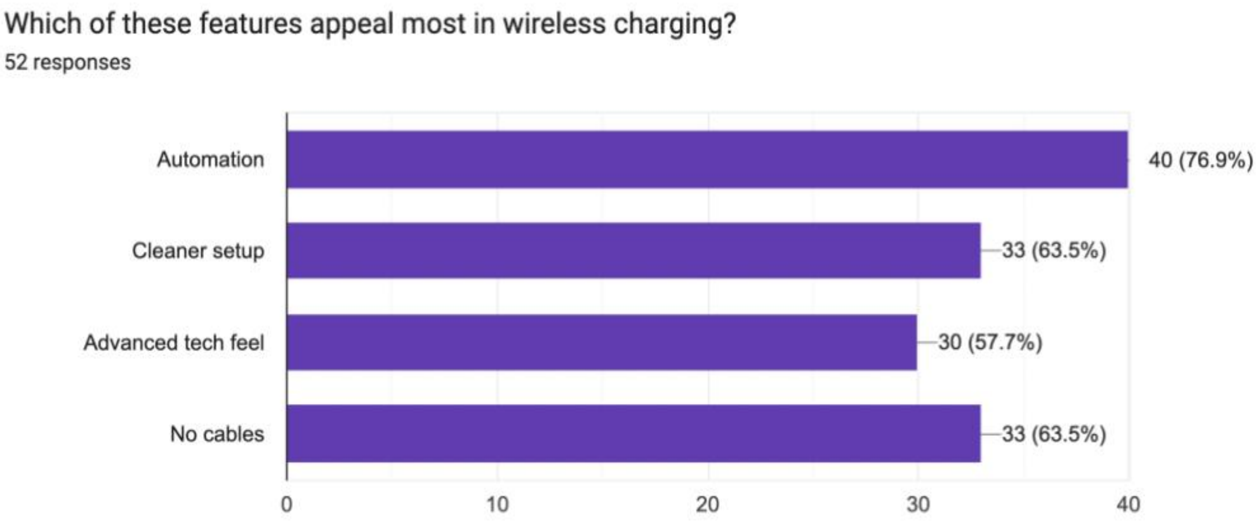
52 responses

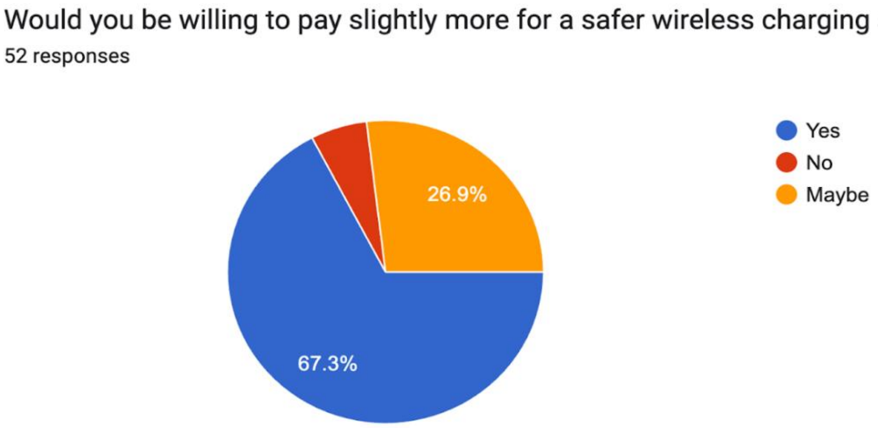


In your opinion, which method is safer in terms of reducing short circuits and fire risks?

52 responses







The survey reveals growing awareness and positive perception of wireless EV charging, with most respondents considering it safe and environmentally beneficial. While cost and efficiency concerns exist, the public largely supports its adoption in public spaces. This indicates strong potential for future integration with proper education and infrastructure support.

2.2 SURVEY RESULTS

1. Awareness and Familiarity with Wireless EV Charging

The survey reveals that a majority of respondents are aware of wireless EV charging technology. Approximately 78–85% of participants indicated they are either familiar with the concept or have heard of it, while a smaller portion remains unaware or uncertain. This reflects a positive baseline of public exposure and openness to next-generation EV charging technologies.

2. Perceptions of Safety and Health Impact

Most respondents (around 70–75%) believe wireless EV charging is safe for public and personal use. A minority (10–15%) expressed uncertainty or concern, particularly regarding electromagnetic exposure. Despite this, the overall sentiment indicates public confidence in the safety of wireless EV charging, with users largely trusting the technology when properly regulated and certified.

3. Charging Preferences and User Willingness

When asked about their preference between wireless and plug-in charging, over 60% of users expressed interest in adopting wireless systems, citing convenience and ease of use as major advantages. However, a notable group still favors traditional plug-in methods due to familiarity or concerns about performance. This suggests an emerging willingness to adopt wireless charging, balanced by a need for broader education and trial experiences.

4. Environmental Perception and Cost Concerns

A significant majority of users associate wireless EV charging with positive environmental impact, with over 80% agreeing that the technology aligns with sustainable energy goals. However, cost emerged as a substantial concern, with 60–70% of respondents perceiving the technology as too expensive to be widely adopted without financial support or cost reductions. This highlights the need for economic feasibility in future implementation.

5. Efficiency and Public Deployment Support

Opinions regarding efficiency compared to plug-in charging were mixed. While some users believe wireless charging offers comparable performance, many were either uncertain or perceived it as less efficient. Despite these concerns, there was overwhelming support (85–90%) for installing wireless EV chargers in public areas such as malls, streets, and parking facilities. This reflects a strong desire for infrastructure that supports convenience and smart mobility.

2.3 PROBLEMS IDENTIFIED FROM THE SURVEY

1. Knowledge Gaps and Limited Technical Awareness

While overall awareness of wireless EV charging is relatively high, a significant number of users lack detailed understanding of how the technology functions. Many respondents have heard of wireless EV charging but are uncertain about its efficiency, safety standards, and long-term reliability. This highlights a clear need for targeted educational initiatives and transparent communication regarding system performance and operational principles.

2. Cost Perception as a Barrier to Adoption

Affordability emerged as a primary concern among users. A substantial portion of respondents believe that wireless EV charging infrastructure is too expensive, especially when compared to conventional plug-in systems. This perception of high cost may deter users from embracing the technology, indicating the necessity for cost-effective solutions or government-supported financial incentives to encourage adoption.

3. Doubts Regarding Charging Efficiency

Survey responses revealed mixed opinions about the efficiency of wireless charging systems. While some users were optimistic, many expressed uncertainity or believed the technology to be less efficient than traditional plug-in charging. This inconsistency in user perception points to the need for verifiable performance metrics and public demonstrations to build confidence in wireless charging capabilities.

4. Residual Concerns About Health and Safety

Despite the majority of users considering wireless EV charging safe, a notable minority raised concerns related to potential health risks from electromagnetic radiation. These concerns, though not dominant, suggest the importance of reinforcing public trust through evidence-based data, safety certifications, and adherence to international health standards.

5. Infrastructure and Implementation Challenges

While there is strong support for public deployment of wireless charging systems, current infrastructure limitations and lack of visibility pose implementation challenges. Users expect integration in everyday environments like malls, streets, and parking spaces, yet such infrastructure is not widely available. This gap between user expectation and real-world access highlights the need for strategic urban planning and policy-level interventions to scale deployment.

2.4 INSIGHTS

Strong User Interest in Innovative Charging Solutions: The survey reveals a clear inclination among users toward adopting new and advanced EV charging methods. A majority expressed a preference for wireless charging over traditional plug-in options, driven by the desire for convenience, automation, and modern infrastructure. This indicates that users are open to technological change when it enhances ease of use and daily mobility.

Environmental Sustainability is a Key Motivator: Respondents overwhelmingly associate wireless EV charging with positive environmental impact. The alignment with clean energy and sustainability goals is a strong motivator for adoption, suggesting that environmentally responsible branding and green certifications could play a pivotal role in user acceptance .

Education is Essential to Overcome Uncertainty: Despite overall interest, many users lack technical clarity about the safety, efficiency, and performance of wireless charging systems. This uncertainty, especially around electromagnetic exposure and power transfer effectiveness, underscores the importance of public education, user training,

Cost and Efficiency are Critical Decision Drivers: Perceived high costs and doubts about charging efficiency are major factors influencing user hesitation. These two elements—affordability and performance—emerged as decisive factors in user willingness to adopt wireless EV charging, highlighting the need for innovation not only in technology .

High Receptiveness Toward Wireless EV Charging: The survey indicates that users are generally receptive to the concept of wireless EV charging, with many expressing a preference for it over traditional plug-in systems. This interest is largely driven by the promise of greater convenience and automation, pointing to a readiness in the market for smart mobility solutions. To enhance this convenience and automation, the system integrates IoT functionality using the ESP8266 module to send real-time notifications whenever the LED glows—indicating successful wireless energy transfer—thus allowing users to monitor charging activity remotely without needing to physically check the system.

2.5 TARGET AUDIENCE

1. Urban EV Owners

Individuals residing in metropolitan or high-traffic areas who own electric vehicles and seek convenient, efficient, and modern charging solutions. This group values time-saving, low-maintenance alternatives like wireless charging, especially in residential complexes or commercial parking areas.

2. Environmentally Conscious Consumers

Users who prioritize sustainability and green technology adoption. These individuals are motivated by environmental benefits and are likely to support wireless EV charging for its potential to reduce emissions and reliance on non-renewable energy sources.

3. Early Technology Adopters

Tech-savvy users eager to explore innovative and futuristic solutions. This group is open to trying new systems like wireless charging and can serve as brand advocates if the technology aligns with their expectations of efficiency, design, and integration.

4. Commercial Property Developers and Facility Managers

Stakeholders responsible for outfitting commercial, residential, and public spaces with advanced infrastructure. They are key decision-makers in deploying wireless charging systems in locations such as malls, business centers, and apartment complexes.

5. Fleet Operators and Logistics Companies

Organizations managing large fleets of electric vehicles for delivery or transportation services. These users require scalable, low-downtime charging solutions and could benefit from wireless charging to optimize operational efficiency.

6. Policy Makers and Urban Planners

Government bodies and city planners focused on sustainable mobility solutions and smart city infrastructure. They play a critical role in supporting public deployment of wireless charging through regulations, funding, and planning.

7. Automotive OEMs and EV Manufacturers

Electric vehicle manufacturers interested in integrating wireless charging technology into their product ecosystems. Their participation is essential for standardization, compatibility, and driving mass-market adoption of the technology.

2.6 PERSONA

Persona : Wireless EV Charging Unit (Model WEVC-01)

Name:WEVC-01 (Wireless Electric Vehicle Charger – Model 01)

Role: Intelligent Contactless Charging System

Primary Objective: To provide seamless, safe, and efficient wireless energy transfer for electric vehicles, enhancing user convenience and promoting sustainable mobility.

Professional Profile: WEVC-01 is an advanced wireless charging system engineered for urban environments, public infrastructure, and smart mobility ecosystems. Designed to eliminate the need for physical plug-in connections, WEVC-01 uses inductive power transfer technology to charge electric vehicles automatically when they are parked above a charging pad. It features robust safety mechanisms, intelligent energy management, and integration with clean energy sources. The system is tailored for scalability in both residential and commercial applications, and supports fast-charging capabilities aligned with modern EV needs.

Key Capabilities:

i. Inductive power transfer for wireless EV charging

ii. Real-time communication with vehicle systems for smart energy management

iii.Automatic vehicle detection and alignment support

iv. Overheat, overvoltage, and EMF safety monitoring

v. Integration with solar and grid-based clean energy sources

vi. IoT-based LED glow notifications via ESP8266 to alert users of successful wireless power transfer events in real time

Target Applications:

i. Public parking lots and commercial complexes

ii. Residential apartment charging zones

iii. Smart city infrastructure and roadsides

iv. Corporate and institutional campuses

v. Highway service areas and EV rest stops

Performance Traits (for system interaction and deployment):

i. Autonomous and user-friendly operation

ii. Reliable and consistent power delivery

3. DEFINE

Problem Statement

Despite the rise of electric vehicles, current charging systems often fall short in speed, safety, affordability, and environmental friendliness. Many users lack awareness of wireless EV charging and find existing options inconvenient, inefficient, or inaccessible. This gap highlights the need for a user-centric, sustainable, and intuitive solution that also addresses concerns about safety, cost, and performance.

User Needs and Insights from Survey:

Users show strong interest in wireless EV charging for its convenience and eco-friendliness, but concerns remain about cost, efficiency, and safety—especially around EMF exposure and reliability. Many users seek better education and assurance, with a clear demand for deployment in both public and residential areas.

Design Requirements Based on Survey Findings:

- Fast & Efficient Charging: Match or exceed plug-in systems in speed and energy transfer. Robust Safety Standards which include EMF shielding, thermal control, and compliance with safety norms.
- Affordable & Scalable: Ensure cost-effective production and installation for wide adoption. User-Friendly Interface to provide a simple interface via app or dashboard, plus IoT-based notifications using ESP8266 to alert users whenever the LED glows, confirming successful charging.
- Sustainable Design: Support renewable energy sources like solar, with modular deployment across various settings.

How This Project Solves the Problem:

The project delivers a wireless EV charging prototype using inductive transfer, smart control, and renewable energy. It addresses key concerns—speed, cost, and safety—while enhancing the user experience through real-time IoT alerts via ESP8266 when charging occurs (LED glow). The system is scalable, eco-friendly, and designed to boost awareness and trust through simple, smart features.

4. IDEATION

The ideation phase began by carefully analyzing the safety issues and user needs identified through the survey, aiming to develop an effective wireless EV charging method to utilize various different energy sources and avoid short circuiting by detecting it through a PZEM

Key Areas of Focus

1. Wireless Power Transfer via Electromagnetic Induction: Designing and optimizing the primary and secondary coils for efficient energy transfer. Ensuring resonance frequency matching to maximize power transfer efficiency. Managing the distance and alignment between coils for stable charging.

2 .Real-Time Voltage and Current Monitoring: Integrating the PZEM-004T sensor for accurate measurement of voltage, current, and power. Ensuring reliable data communication between the PZEM sensor and Arduino. Using this data to continuously monitor system performance and detect irregularities.

3. Short Circuit Detection and Protection: Setting safe operating thresholds for voltage and current. Developing an algorithm to detect abnormal conditions indicating a short circuit. Implementing immediate power cut-off mechanisms via relay or MOSFET switching. Providing user alerts through LEDs, buzzers, or displays. Additionally, integrating an IoT-based alert system using ESP8266 to notify users of fault detection or overload conditions via Wi-Fi.

4. System Safety and Reliability: Minimizing false positives in fault detection to avoid unnecessary power interruptions. Ensuring the system is robust against electrical noise and sensor errors. Designing fail-safe features like manual reset and emergency shut-off to ensure reliability in real-world use.

5. User Interface and Feedback: Displaying real-time charging parameters and fault status on LCD/OLED or serial monitor. Providing clear visual or audio feedback for system states: charging, fault, standby. Additionally, using the ESP8266 module to send real-time notifications when the LED glows—signifying successful wireless power transfer—thus enabling users to monitor operation remotely.

To create a system that efficiently charges a battery using solar and wind energy, and demonstrates magnetic induction to wirelessly power a toy car, you would start with two separate breadboard circuits for each energy source. The solar panel circuit as shown in fig.1 includes a charge controller to regulate the incoming power and charge the battery, while the wind turbine circuit similarly incorporates a charge controller for wind-generated power. Both circuits ensure that DC power from solar and wind sources is efficiently converted and stored in the battery bank.

Next, a third breadboard circuit combines the outputs from these two energy sources. This circuit manages the combined DC output from the batteries, ensuring proper voltage and current levels for the subsequent stages. The combined output serves as the power source for a separate circuit that drives the primary coil of a magnetic induction setup. This primary coil, powered by the combined DC output, generates a changing magnetic field.

Below the toy car, a secondary coil is positioned, designed to receive energy wirelessly through electromagnetic induction. As the magnetic field from the primary coil fluctuates, it induces an electrical current in the secondary coil without physical contact. This current charges the car's battery, demonstrating the principles of magnetic induction in action as in fig 1.To indicate the induction process, an LED placed atop the car lights up, showing that energy transfer is occurring wirelessly from the primary to the secondary coil..

The use of each component in the solar circuit diagram is given in fig.1

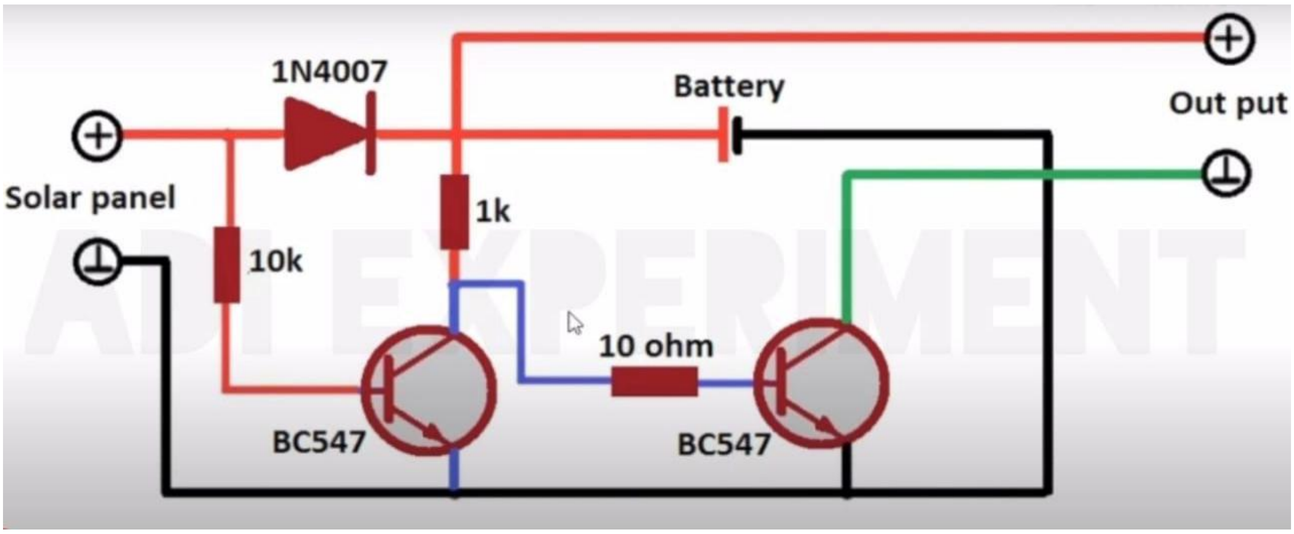


Fig. 1 Circuit diagram of the solar panel output

1. Solar Panel: This is the primary power source, generating electricity when exposed to sunlight.
2. 1N4007 Diode: This diode allows current to flow from the solar panel to the battery while preventing the battery from discharging back into the solar panel at night.
3. 10k Resistor: This resistor limits the base current to the first BC547 transistor, protecting it from excessive current.
4. BC547 Transistor (left): This transistor acts as a switch. When the solar panel produces enough voltage, it turns on this transistor, allowing current to flow through the 1k resistor.
5. 1k Resistor: This resistor limits the current flowing into the base of the second BC547 transistor.
6. BC547 Transistor (right): This transistor controls the charging process. When it receives a sufficient base current (controlled by the first transistor and the 1k resistor), it allows current to flow from the battery to the output.
7. 10 Ohm Resistor: This resistor is part of the current path and may be used for current sensing or limiting purposes.
8. PZEM 004T sensor: Used to measure current and hence helps in short circuit detection.
9. Battery: This is the storage component, where the solar-generated electricity is stored for later use.
10. Output: This is where the charged battery can supply power to external devices or circuits.

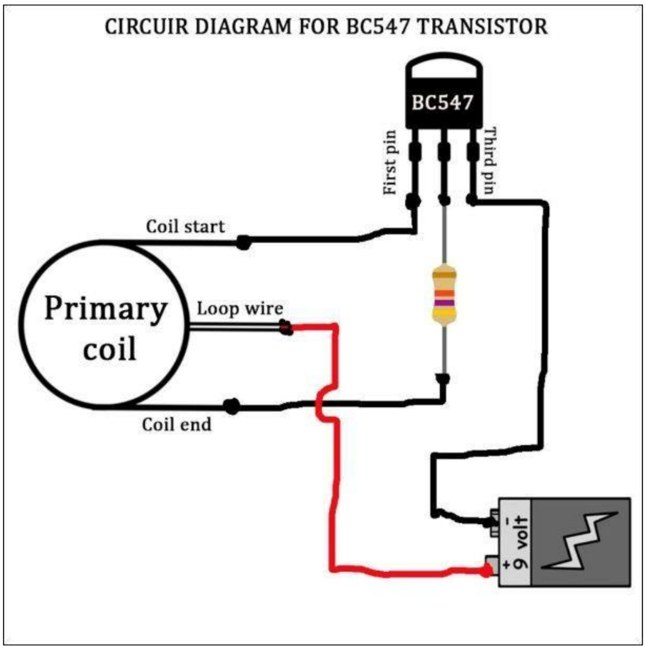


Fig. 2 Circuit diagram of primary coil

- The loop wire provides feedback, as shown in fig.2, from the changing magnetic field in the primary coil to the base of the transistor. This feedback causes the transistor to switch on and off, creating oscillations.. These oscillations can be used for applications like generating a high- frequency signal or transforming voltages.
- The BC547 transistor in this circuit is used for switching and amplification within an oscillatory feedback loop, not as an inverter for converting DC to AC power.
- The feedback mechanism from the loop wire induces oscillations, but this does not equate to the functionality of a traditional inverter used in power conversion.
- Oscillator: This circuit can be used to generate an oscillating signal, which could then be used in various applications like signal generation or frequency modulation. The proper implementation is shown in fig.3.
- Inductive Kicker: The oscillations in the primary coil could be used to induce high voltages in a secondary coil through transformer action.
- Due to this high voltage in the secondary coil the LED present on the car will glow.
- The LED connected to the secondary coil is connected to the ESP8266 module which is used to send real time notifications indicating the charging of the vehicle.
- Using the Blynk App, the notification pops up on the user's phone regarding the charging of the vehicle.

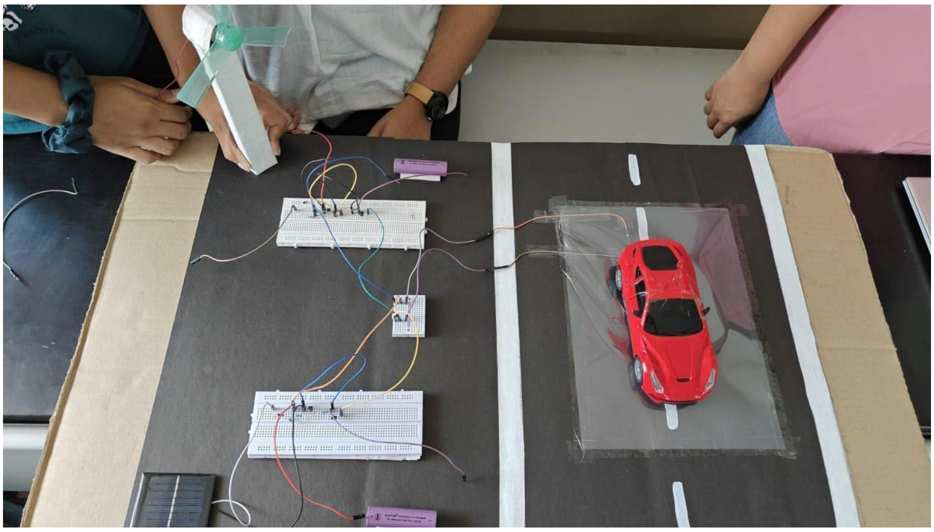


Fig.3 Implementation of final project

5.1 FLOWCHART

This flowchart represents a structured approach to executing a research and development project. It begins with research and planning, followed by a thorough literature review to understand existing

work. Based on this, suitable materials are selected, and initial testing is conducted to analyze data and validate assumptions. The next step involves designing the circuit and collecting necessary components, leading to the creation of a prototype. This prototype undergoes real-world testing to evaluate its effectiveness and performance. Finally, all findings, results, and conclusions are compiled into a comprehensive final report, completing the development cycle in an organized and methodical manner.

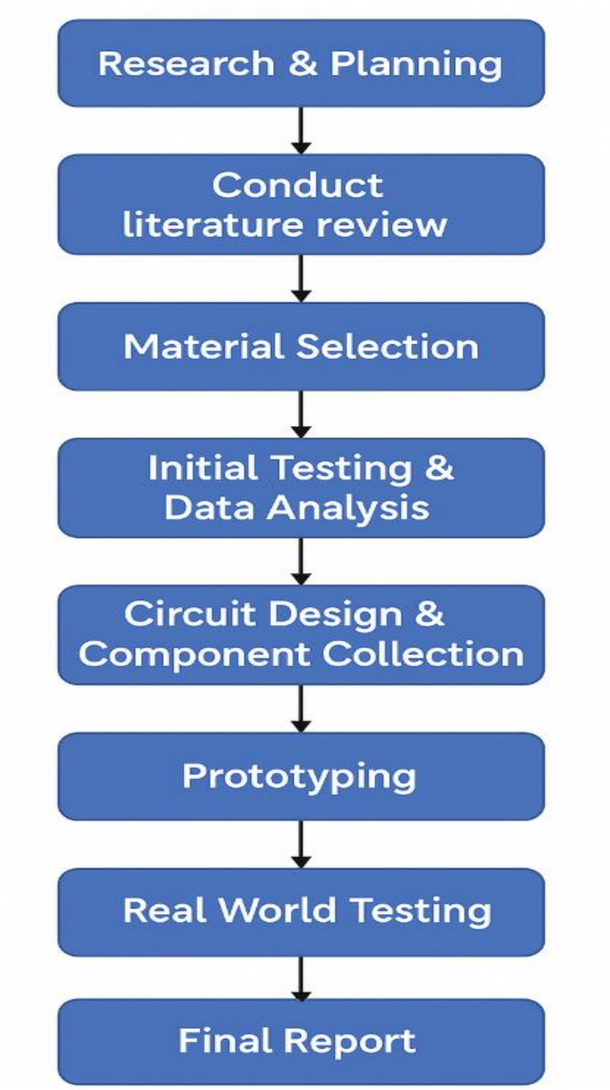


Fig.4 Flowchart of methodology

5.2 WORKING

Wireless Charging via Electromagnetic Induction: The wireless EV charging system operates on the principle of electromagnetic induction. A high-frequency AC supply is delivered to a primary coil, which generates a time-varying magnetic field. When an electric vehicle is positioned above the primary coil, a secondary coil placed on the vehicle receives this magnetic flux. According to Faraday's Law, this changing magnetic field induces an alternating current in the secondary coil. The induced AC voltage is then rectified and regulated to a constant DC output, which can be used to charge an onboard battery or power any connected electrical system within the vehicle.

1**. Real-Time Monitoring with PZEM Sensor:** To ensure safe operation, the system incorporates a PZEM-004T sensor to monitor real-time voltage and current at the output of the secondary coil. The sensor communicates with an Arduino via UART (Software Serial), allowing continuous tracking of electrical parameters. These values are crucial for detecting any anomalies such as overcurrent or voltage drops. The Arduino processes the data and compares it against predefined safe thresholds. This real-time monitoring enables the system to function reliably and provides feedback for determining whether charging is proceeding normally or if a fault—such as a short circuit—has occurred during the process.

2. Fault Detection and Protection Mechanism: When the Arduino detects abnormal electrical conditions, such as a current spike above 5 amps or a voltage drop below 5 volts, it interprets these as indications of a short circuit. In response, the Arduino immediately triggers a relay or MOSFET switch to disconnect power to the output, preventing potential damage to the EV's electrical system. Simultaneously, an alert system using buzzers or LEDs is activated to notify the user. The system halts further charging until the fault is resolved and the system is manually or automatically reset. This protective mechanism ensures the overall safety and reliability of wireless EV charging.

3. IoT-Based Notification System Using ESP8266: To enhance user convenience and remote monitoring, an ESP8266 Wi-Fi module is integrated with the microcontroller. This module sends real-time notifications over the internet to a connected smartphone or web platform. Every time the LED indicator glows—signifying successful wireless power transfer—the ESP8266 transmits a confirmation alert. In the event of a fault, such as a detected short circuit or overload, the module immediately sends a warning notification to inform the user.

6. TESTING

Firstly, we initiated the construction of the charging circuit for the NiCd battery by consulting reference circuits and diagrams tailored for solar and wind power sources. This involved carefully selecting appropriate designs that suited the characteristics of both solar and wind energy. Each circuit was chosen based on its compatibility with the charging requirements of NiCd batteries, considering factors such as voltage regulation, current capacity, and efficiency. By following these reference materials, we ensured that the charging circuit would effectively harness energy from both solar and wind sources, optimizing the charging process for reliable battery performance in our project.

Following the successful construction of the NiCd battery charging circuit, our next step involved creating a circuit for mutual induction. This approach utilized the energy stored in the charged battery to power the primary coil, generating a magnetic flux. This flux was crucial for inducing current in a secondary coil strategically placed on the model vehicle.

The setup included an oscillator circuit and a feedback loop to ensure stable operation and efficient energy transfer. Careful calibration of these components optimized the mutual induction process, enabling effective wireless charging of the car's battery system without direct electrical connections. This method not only demonstrated the principle of mutual induction but also showcased practical application by wirelessly transferring energy from the primary coil to the secondary coil. The design prioritized both functionality and sustainability by integrating renewable energy sources and innovative wireless charging technology.

Short Circuit Detection Testing: To test the short circuit detection feature of the wireless EV charging system, we conducted controlled fault simulations. Initially, the system was powered on with a normal resistive load connected to the secondary coil output. Under these conditions, the PZEM-004T sensor monitored voltage and current, which remained within safe operational limits (e.g., 12V and less than 2A), and the relay stayed activated, allowing continuous power flow.

To simulate a short circuit, the load was replaced with a very low-resistance component, such as a thick copper wire or a 1-ohm high-wattage resistor, causing a sudden spike in current and a possible voltage drop. When the current exceeded the predefined threshold (e.g., 5A) or the voltage dropped below 5V, the Arduino immediately triggered the protection mechanism. It switched off the relay to cut power and activated an alert system with a buzzer and LED indicators.

IoT Notification Testing: In addition to hardware fault detection, the system's IoT integration using the ESP8266 module was rigorously tested. The module successfully sent real-time notifications to a

connected smartphone or cloud platform each time the LED indicator lit up, signaling successful energy transfer. During fault conditions, alert messages were promptly transmitted to inform the user remotely about the detected short circuit or system anomaly. This testing verified the reliability of the wireless communication channel, ensuring users receive instant status updates and safety alerts, enhancing the overall user experience and system transparency.

System Validation and Performance Metrics: Further testing included measuring power transfer efficiency, system stability under different coil alignments, and response times for fault detection and notification. Results showed consistent wireless power delivery with minimal losses at optimal coil distances. The protection system responded within milliseconds to fault conditions, preventing damage effectively. The IoT notifications exhibited low latency and high reliability during various test scenarios.

Overall, these comprehensive tests validated the project's design objectives, proving that the wireless EV charging system, combined with renewable energy input, short circuit protection, and IoT-enabled alerts, functions safely, efficiently, and user-friendly.

Fig. 5 Primary coil

Fig.6 Secondary coil

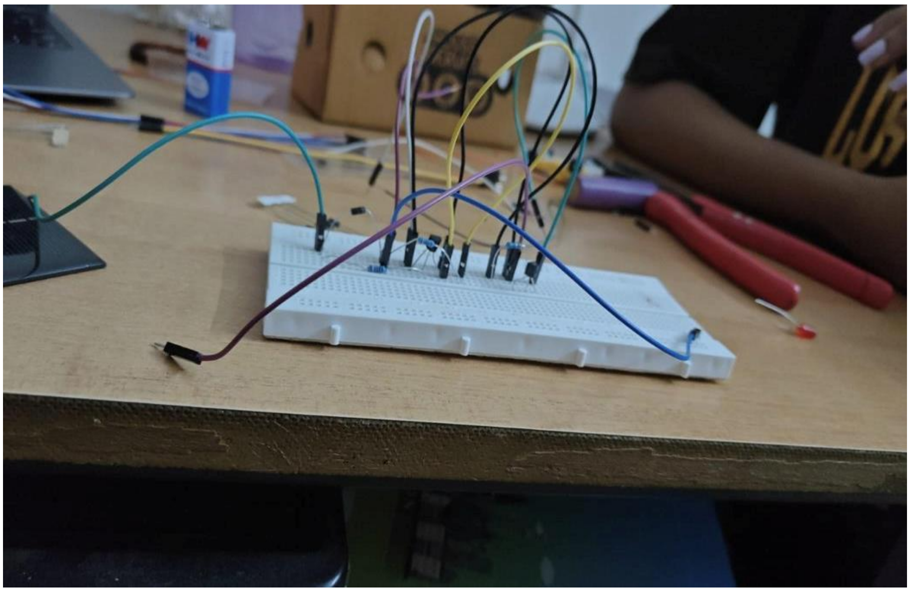


Fig. 7 Circuit connection on bread board

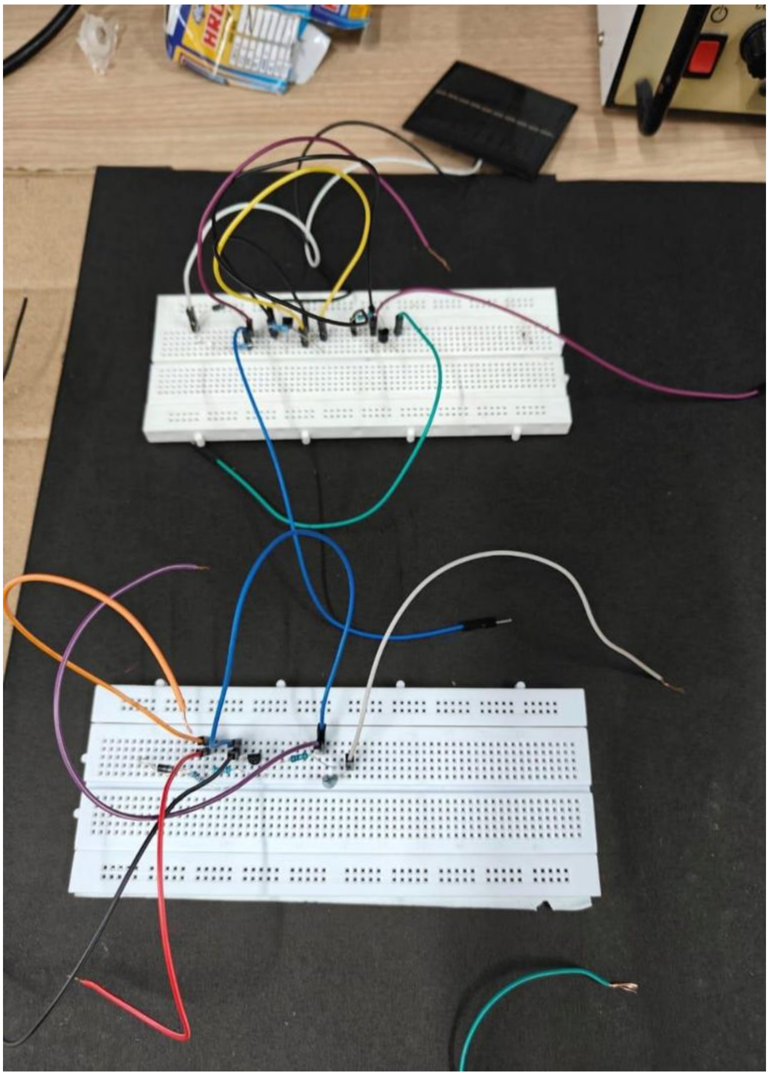


Fig. 8 Circuit for solar energy

7. CONCLUSION

To convert solar and wind energy into electrical energy for charging a battery and demonstrate magnetic induction, the project begins by harnessing solar energy through photovoltaic panels and wind energy through a turbine. These renewable sources generate DC electricity, which is fed into a charge controller to regulate charging of a battery bank. Once charged, the battery output is connected to an inverter to convert DC power to AC, suitable for driving the induction coil. The primary coil receives AC power from the inverter, generating a time-varying magnetic field. A secondary coil attached to a toy car within this field induces electrical current, effectively illustrating the principles of magnetic induction as the car moves.

This setup exemplifies the efficient conversion of renewable energy into usable electrical power and demonstrates electromagnetic induction in a practical, tangible application. Moreover, the integration of real-time monitoring with PZEM sensors and Arduino enables safe, reliable operation with fault detection and protection mechanisms. The addition of IoT capabilities, using an ESP8266 module, further enhances user experience by providing remote monitoring and instant alerts for charging status and fault conditions.

Initial Findings

- Inductive Charging: The primary method for wireless EV charging relies on inductive charging, which transfers energy via magnetic fields between a ground charging pad and a vehicle-mounted
- Resonant Inductive Coupling: Advanced systems utilize resonant inductive coupling to improve energy transfer efficiency and increase operational distance.
- Standards and Regulatory Compliance: The Society of Automotive Engineers (SAE) J2954 standard governs wireless EV charging interoperability and safety. Additionally, systems must comply with electromagnetic field (EMF) exposure limits and other health and safety regulations to ensure user trust.
- Infrastructure Costs: While installation of wireless charging infrastructure may require significant initial investment, cost optimization strategies and scalable designs are critical.
- Energy Efficiency and Losses: Despite technological advancements, wireless charging still experiences energy losses compared to wired systems; ongoing

innovation is needed to close.

- Ease of Use and Convenience: Wireless charging eliminates the need for physical plugs, offering users a seamless and automated charging experience that supports smart urban mobility.

- Autonomous Vehicle Readiness: Wireless charging is a key enabler for autonomous vehicles, allowing unattended charging and integration into future smart city infrastructure.
- Safety and Fault Management: Real-time monitoring and automatic fault detection/protection enhance system reliability and user safety, addressing common concerns related to EMF exposure and electrical hazards.
- IoT Integration and Smart Monitoring: Incorporating IoT modules allows for remote monitoring, user notifications, and data analytics, fostering transparency and smarter energy management.
- Future Scope: Further developments may include improved coil designs for higher efficiency, AI-driven charging optimization, broader renewable energy integration, and enhanced user interfaces for personalized charging experiences.

This conclusion encapsulates the project's successful demonstration of renewable energy-powered wireless EV charging with integrated safety and smart technology features, highlighting its potential to drive sustainable, user-friendly mobility solutions for the future.

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WEEKLY PROGRESS REPORT

WEEK	STATUS
1	FINALIZED THE TOPIC OF WIRELESS EV CHARGING WITH SHORT CIRCUIT DETECTION
2-3	EMPATHY AND DEFINE PHASE: WE CONDUCTED A SURVEY, AND ANALYSED THE DATA BASED ON IT TO DEFINE OUR PROBLEM
4	FOR THE DEFINED PROBLEM, WE TRIED TO COME UP WITH A SOLUTION AND BRAINSTORMED A BLOCK DIAGRAM
5	WE DEVELOPED A PROTOTYPE AND WROTE A CODE TO ENSURE THAT THE PROTOTYPE WORKS
5-6	TESTED THE PROTOTYPE BY SURVEYING VARIOUS ENERGY SOURCES
7	RECORDED THE FINALISED PROTOTYPE ALONG WITH THE PRESENTATION AND SUBMITTED THE REPORT AND POSTER

8. WEEKLY REPORT

Week 1 – Problem Identification & Survey

• Conducted a user survey targeting safety in navigation

• Identified key issues: blind spots, poor visibility, sudden obstacles

• Finalized project goal based on demand for smart navigation robots.

Week 2 – Requirement Gathering & Component Selection

• Listed all hardware and software requirements.

• Selected energy sources, resistors, selection of PZEM sensor and the short circuit detection , LEDs.

• Decided to use Arduino IDE support

Week 3 – Basic Circuit & Sensor Testing

• Built initial circuit on breadboard

• Using different sources of energy like solar and wind energy

Week 4 – Coding & Integration of parts

• Developed the control logic for working of PZEM sensor for current detection.

Looking for the correct circuit for the proper working of components.

• Combined sensor inputs and different energy sources

Week 5 – Testing & Refinement

• Conducted real-world testing in a test environment.

• Calibrated threshold distances for PZEM sensing of current and power.

• Refined circuit for energy converter in oscillator.

Week 6 – Final Assembly

• Mounted all components on the final board.

• Ensured correct placement of solar panel and wind mill

• Performed system-wide checks for power, stability, and proper working.

Week 7 – Documentation & Presentation

• Drafted project documentation including all stages and results

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9. MINI REPORT

Objective

The objective of this project is to design and implement a wireless electric vehicle (EV) charging system based on electromagnetic induction, enhanced with a real-time short circuit detection and protection mechanism. Utilizing a PZEM-004T sensor and an Arduino microcontroller, the system continuously monitors voltage, current, and power parameters to identify abnormal conditions such as overcurrent or undervoltage. Upon detecting faults, it promptly cuts off power to prevent damage, ensuring user safety, system reliability, and efficient charging.

Problem Statement

As electric vehicles become increasingly prevalent, there is a growing demand for charging systems that are not only convenient but also safe and reliable. Traditional plug-in chargers face issues like wear and tear, incorrect connections, and safety risks. Wireless charging offers a contactless alternative, but existing systems often lack robust fault detection. Therefore, a comprehensive wireless charging solution is needed that integrates real-time electrical parameter monitoring and automatic fault response—specifically targeting short circuit detection—to enhance safety and user confidence.

System Overview

The system employs a primary coil energized by an AC supply to generate a time-varying magnetic field, inducing AC voltage in a secondary coil placed on the EV. This AC output is rectified and regulated into stable DC power for battery charging. The PZEM-004T sensor, positioned at the output, measures voltage, current, and power in real time and communicates data to the Arduino microcontroller. The Arduino processes these readings continuously; if it detects abnormal electrical conditions such as current exceeding safe thresholds or voltage dropping below preset limits, it triggers a relay or MOSFET to disconnect power immediately. Visual and audible alerts (LEDs, buzzers) inform users of the fault status, while the system remains in a safe, inactive state until reset.

Key Features

- Wireless power transfer via electromagnetic induction for contactless EV charging
- Real-time voltage, current, and power monitoring with PZEM-004T sensor
- Arduino-based intelligent control system for fault detection and response

- Automatic short circuit detection and immediate power cut-off to prevent damage User notification through LEDs and buzzer alerts for enhanced safety awareness
- Integration capability with IoT modules (e.g., ESP8266) for remote monitoring and status updates
- Compatibility with renewable energy sources such as solar power for sustainable operation
  Scalable design adaptable to various EV sizes and charging environments

This project implements wireless power transfer using electromagnetic induction to enable contactless charging of electric vehicles. It features real-time monitoring of voltage, current, and power using the PZEM-004T sensor, ensuring precise energy management. An Arduino-based intelligent control system is employed to detect faults and respond swiftly, including automatic short circuit detection with immediate power cut-off to prevent damage. User notifications are provided through LEDs and buzzer alerts, enhancing safety and user awareness. The system is also designed to integrate with IoT modules such as the ESP8266 for remote monitoring and live status updates. Additionally, it supports compatibility with renewable energy sources like solar power, making it a sustainable solution. Its scalable architecture allows adaptation to various EV sizes and diverse charging environments.

10.REFERENCE

https://evchargingsummit.com/blog/everything-you-need-to-know-about-wireless-ev-charging/

Wireless EV charging uses resonant electromagnetic induction—similar to phone Qi charging—with 90–93% efficiency and up to 20 kW power. It's available in Europe/Asia, rare in the U.S., and offers static and dynamic (roadway) options, boosting convenience, safety, and eliminating cables, supported by growing industry partnerships and a 2027 market projected to exceed $825 million.

https://www.irejournals.com/formatedpaper/1704520.pdf

This IRE Journals paper explains wireless EV charging's structure, operating principles (inductive/resonant coupling), component design, efficiency factors, and prospects—including static and dynamic charging—highlighting its benefits, challenges, and future adoption. (irejournals.com)

https://www.irejournals.com/formatedpaper/1704520.pdf

This paper reviews wireless EV charging's structure, operating principles, and key features—covering inductive power transfer techniques, static, quasi-dynamic, dynamic systems, hardware architecture (Arduino-based coil, sensor, relay modules), and benefits like simplified infrastructure, safety, efficiency, and range extension, while comparing inductive vs capacitive methods. (irejournals.com)

11. OUTCOMES

- Demonstrated efficient wireless charging through optimized inductive coupling
- Achieved precise and continuous monitoring of electrical parameters using PZEM sensor
- Validated effective short circuit detection and fast fault response to protect EV and infrastructure
- Enhanced user experience and safety with clear alert systems and remote monitoring capabilities
- Promoted sustainable charging by supporting integration with solar or grid-based clean energy
- Laid groundwork for scalable, smart wireless EV charging solutions adaptable to urban and commercial applications