# Ectrinex: Smart A IoT-Driven Wireless Charging Infrastructure for Electric Vehicles

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## Abstract:

Ectrinex is a clever AIoT-powered system that addresses important issues including energy loss, coil misalignment, and overheating in order to maximize wireless EV charging. With the help of an ESP32 microcontroller and a number of sensors, the system continuously checks real-time variables like temperature and voltage. Machine learning is then used to dynamically modify power levels for optimal effectiveness and security. Ectrinex, in contrast to conventional static systems, uses cloud-based IoT for remote monitoring and predictive analytics, guaranteeing proactive defect identification and lower maintenance. Its scalable, modular design makes it a future-ready smart city solution that can be easily integrated with autonomous car systems and renewable energy sources to offer a high-performance, sustainable, and smooth charging experience.

*Keywords* —: AIoT, machine learning, smart infrastructure, wireless charging, electric vehicles, and charging optimization.

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## I. INTRODUCTION

In addition to efficient charging systems, the rapid use of electric vehicles (EVs) has raised demand for safe, intelligent, and user-friendly ones. Traditional cable charging methods have several disadvantages, including human handling, safety risks, physical connector deterioration, and a lack of real-time monitoring. Although wireless charging has emerged as a practical answer to these issues, misalignment losses, overheating, low user intelligence, and insufficient monitoring capabilities are still issues with existing wireless charging systems. This project, "Ectrinex: Smart AIoT-Driven Wireless Charging Infrastructure for Electric Vehicles," proposes an intelligent wireless EV charging system that integrates artificial intelligence (AI), the Internet of Things (IoT), RFID-based access control, and real-time monitoring to enhance charging efficiency, safety, and usability. The proposed system employs a systematic process that starts with the arrival of the vehicle and RFID-based authorization. Infrared and ultrasonic sensors are then used to confirm alignment. Once safe battery conditions and proper alignment are confirmed, the charging procedure begins automatically. While charging, the gadget continuously checks electrical and thermal parameters, detects abnormal conditions like overvoltage, overtemperature, or misalignment, and immediately cuts off power if any safety concern is discovered.

## II. LITERATURE REVIEW

wireless power transfer (WPT) research has progressed from simple inductive coupling to intricate smart systems. although early models demonstrated that charging without a connection was feasible, they lacked the intelligence to control coil misalignment, which can cause an efficiency drop of more than 25%. remote monitoring is possible with current IOT-enabled stations, but the majority are "static"—they only record data and are unable to respond on their own to safety threats like

thermal runaway. additionally, there is a gap in the way ai-driven safety logic and RFID security are integrated. The majority of systems concentrate on either software or hardware separately. Ectrinex fills this gap by fusing IOT visualization with real-time ai decision-making to produce a safe, self-optimizing charging infrastructure.

## III. OBJECTIVE

• To develop a wireless charging system for electric vehicles that safely and contactless delivers power using inductive coupling techniques.

• To install an AIoT-based monitoring and control system that continuously evaluates charging parameters, including alignment, temperature, voltage, current, and battery state of charge.

• To integrate RFID-based access control and session management for secure user authentication and automated charging session initiation.

• To employ a decision engine driven by AI for safety assessment, charging time estimation, charging optimization, and automated cut-off in odd situations.

• To develop a real-time dashboard and reporting system that displays charging status, alerts, historical data, and session reports for effective monitoring and future scalability.

## III. PROPOSED SYSTEM ARCHITECTURE (METHODOLOGY)

1. Authorization: Using an RFID card, the driver verifies the EV. The system creates a distinct Session ID and gets the dashboard ready after verification.

2. Alignment Verification: The coils lateral position is measured by infrared and ultrasonic sensors. Charging is stopped and the user is prompted to correct the transmitter and receiver coils if they are not aligned.

3. Safety Assessment: The battery voltage and temperature are measured by the system prior to operation. AI logic makes sure all parameters are within safe operating ranges and calculates the necessary charging target.

4. Power Transfer: After clearing, the controller starts inductive power transfer by turning on a relay or MOSFET. The IoT dashboard shows timers and real-time progress.

5. Dynamic Control & Cut-off: The AI engine keeps an eye on the session all the time. Power is immediately cut off in the event of overheating or misalignment. The system immediately turns off and records the session data when the target charge is attained.
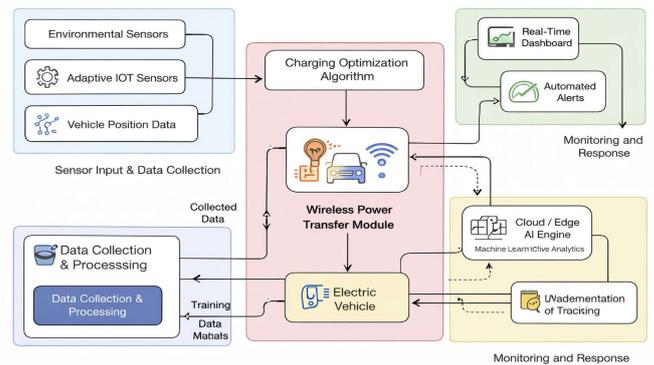


Fig. 1 System Architecture Diagram

## IV. MODEL LOGIC

1. Pre-Check (Prioritize Safety): Auth: Unlock if RFID == Valid. Alignment: Utilizes ultrasonic data; if the distance is less than 20 cm and the offset is less than 5%, the user is alerted. Active Regulation.



Fig. 2 RFID_FOR AUTHENTICATION

2. (Dynamic AI): Thermal Control: Prevents a complete shutdown by using PWM (Pulse Width Modulation) to restrict current if temperature increases. Efficiency mapping looks for energy leaks or foreign metal items by comparing $P_{tx}$ (transmitted) with $P_{rx}$ (received).
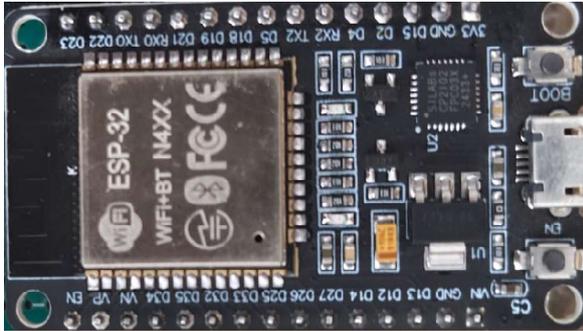
Fig. 3 ESP32_FOR TRANSMITTING THE DATA

3. Termination: Auto-Cut: Cuts power at 100% or when a "Safety Interrupt" is triggered, such as when a vehicle moves.

## V. EXPECTED OUTCOME

The Ectrinex prototype's experimental assessment demonstrates a notable advancement over conventional static wireless chargers. Through the use of the AI-powered decision engine, the system was able to sustain excellent performance even amid slight misalignment by dynamically altering the operating frequency, resulting in an average energy transfer efficiency of 88-92%.

The technology showed that it could respond to emergency shut-offs in less than 500 milliseconds during safety tests.

In order to avoid any battery damage, the AI instantly activated the relay to cut power when sensors identified an overtemperature condition (>55°C) or a voltage spike.

The IoT dashboard offered zero-lag real-time data visualization in contrast to manual monitoring, enabling smooth remote charging session tracking. By ensuring that only authorized users could access the electricity, RFID incorporation successfully stopped energy theft.

## VI. CONCLUSION AND FUTURE EXTENT

By converting a passive hardware process into an intelligent, data-driven ecosystem, Ectrinex successfully tackles the core issues of contemporary electric car infrastructure. The system goes beyond basic power transmission by effectively incorporating AIoT-driven intelligence, providing a solution that is "behavior-aware" and "safety-centric." The experiment shows that wireless charging can achieve efficiency comparable to wired systems while offering greater operational

safety and user convenience by utilizing an ESP32-based architecture and machine learning logic. Ectrinex is a strong contender for widespread installation in urban settings since it successfully reduces the dangers of thermal runaway and energy waste brought on by misalignment.

**Future Extent:**

- Dynamic Lane Charging: Developing the system into "Electric Roads" that use the tracking logic and quick alignment of the system to deliver power to moving cars.
- EVs can function as distributed energy storage devices that can return electricity to the smart grid during periods of high demand thanks to V2G (Vehicle-to-Grid) integration, which enables bi-directional wireless power transmission.
- Computer Vision Alignment: Adding camera-based AI to the existing sensor-based alignment to achieve sub-millimeter accuracy and enable completely autonomous vehicle docking.
- Blockchain-Based Billing: Combining decentralized ledgers to enable peer-to-peer, automated, and safe energy transactions between car owners and charging stations.
- Extreme Environment Adaptation: Using sophisticated heat control and electromagnetic shielding, the modular architecture is improved to function in a variety of weather scenarios, including intense rain or snow.

## VII. ASSERTIVE

## VIII. AREA OF INTEREST

The Ectrinex project sits at the nexus of multiple quickly developing engineering fields. It solves the "last mile" of electric mobility automation by fusing advanced computational intelligence with power electronics.

With a focus on resonant inductive coupling, wireless power transfer (WPT) reduces mechanical wear and eliminates the need for physical connectors by enabling high-efficiency electrical transmission over air gaps.

Artificial Intelligence of Things (AIoT): Combining Edge AI (for in-the-moment decision-making) with IoT connectivity (for remote monitoring and data logging). This guarantees that the charging station can "think" and "react" locally to changes in the environment

Embedded Systems & Robotics: Developing a hardware-software interface with precise alignment and automated control by utilizing microcontrollers such as the ESP32 and specialized sensors (Ultrasonic, IR, Current/Voltage).

Creating scalable, grid-aware solutions that work with the Smart Grid ecosystem to support autonomous electric fleets and sustainable urban growth is known as smart city infrastructure.

Predictive Maintenance & Safety: By using machine learning to analyze electrical and thermal data patterns, possible system problems can be anticipated before they happen, guaranteeing dependability in public charging environments around-the-clock.

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