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Smart wireless charging architecture for electric vehicles using resonant inductive coupling and low-component design

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ABSTRACT

A wireless power transfer system designed for electro-vehicle recharge and low-power device charging is explained in this document through resonant inductive coupling technology. Once switched on the pulse generator and IRF540 MOSFETs from the IC CD4047 drive high-frequency signals through the transmitter coil. IR sensors function as operational safety tools by detecting valid receivers which activate a relay control system for transmitter power management and reduce unnecessary energy consumption. A full-wave rectifier along with the 7805-voltage regulator enables the receiver unit to deliver fully stable 5 V DC output. System status is displayed through a user interface equipped with an LCD and real-time billing information runs on ThingSpeak IoT platform for visualization. Tests show that the system reaches a maximum power transfer efficiency of 90% alongside successful relay operation lasting less than 150 ms. The system provides an inexpensive solution to build smart wireless charging infrastructure networks that remain energy-efficient and expandable through its built-in control and monitoring functions.

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1. INTRODUCTION

Wireless power transfer (WPT) technologies experience growing demand because of the fast development of portable electronic devices and electric vehicles (EVs) and implantable medical systems [1]. People who need untethered mobile and wearable electronics depend heavily on user-friendly and safe charging solutions more than ever before [2], [3]. Wired charging methods are commonly used but present multiple problems which include weakened connectors and safety risks from bare wires, as well as the necessity of user interaction to connect and disconnect the charging cables [4]. The usability issues along with reliability problems shorten both the operational term and performance quality of charging interfaces [5].

Wireless charging systems demonstrate a beneficial option that allows contactless energy transmission because this transmission method improves durability while reducing mechanical failures and delivering enhanced user convenience [6]. These technologies currently service consumer products along with challenging cases involving autonomous drones and biomedical implants, and industrial motors which need automated controls because physical connections cause safety concerns [7], [8]. IPT provides an excellent WPT solution because it demonstrates high performance along with easy setup and meets safety requirements for short-range operations [9].

The accelerating adoption of EVs, along with the widespread use of portable and wearable electronic devices, has increased the demand for safer, more reliable, and user-friendly charging solutions [10]. While conventional wired charging methods remain prevalent, they are prone to limitations such as connector degradation, user dependency for plug-in actions, and safety concerns arising from exposed terminals. These drawbacks impact both user convenience and long-term system reliability, especially in applications requiring frequent charging cycles [11].

WPT technologies, particularly those based on inductive coupling, have emerged as viable alternatives for addressing these challenges. Among the various WPT methods, resonant inductive coupling offers an optimal balance of high efficiency, relatively simple hardware requirements, and suitability for short-range energy transmission [12]. This makes it ideal for smart EV charging infrastructure where contactless, automated, and efficient operation is crucial.

In this paper, a smart wireless charging system for EVs is proposed, utilizing a resonant inductive coupling approach built around a low-component architecture. The system integrates a CD4047 IC to generate square wave signals, IRF540 MOSFETs for efficient switching, and an intelligent IR-sensor-controlled relay mechanism to ensure power is only transmitted when a valid receiver is detected [13]. This control mechanism reduces energy waste and enhances safety. Furthermore, a user interface comprising an Arduino-based LCD display and ThingSpeak IoT integration enables real-time monitoring of charging status and billing information. The system achieves a power transfer efficiency of 90% and a relay response time below 150 milliseconds, making it a practical and scalable solution for modern EV charging networks [14].

This paper presents an intelligent inductive WPT system designed around a CD4047-based pulse generator and IRF540 MOSFET driver circuit. The system is enhanced with IR sensors to detect the presence of a valid receiving device, activating power transfer automatically. The square wave signal from the CD4047 enables efficient energy transfer through the transmitter coil, while the MOSFETs ensure stable switching performance.

The remainder of the paper is organized as follows: The next section provides a literature review, summarizing existing work in the domain of wireless charging systems, highlighting their limitations, and positioning the proposed system as an advancement. The methodology section outlines the detailed design of the system, including the transmitter and receiver circuitry, the control logic for IR-based detection, and the real-time feedback mechanisms. This is followed by the results and discussion section, which presents the experimental setup, testing conditions, power transfer efficiency measurements, and comparisons with other contemporary systems. Finally, the conclusion summarizes the research contributions, affirms the system's effectiveness in terms of efficiency and automation, and discusses its potential for further development within IoT-enabled smart grid infrastructures.

2. LITERATURE REVIEW

The study of electromagnetic emissions along with their connection to clearance and coil offset parameters in their research [15]. This design passes electromagnetic compatibility (EMC) inspections but lacks features to handle system automation and billing functions. Vujasinovic *et al.* [16] presented an EV charging station performance evaluation system with traceability, yet this system did not contain integrated control elements like IR sensing and billing functionality. Gupta *et al.* [17] examined different wireless charging techniques and static and dynamic charges, but they failed to execute and test a fully working prototype. Devi *et al.* [18] introduced an IoT-enabled solar-powered EV charging station but failed to optimize its operational efficiency through sensor-controlled relay systems.

Jaisiva *et al.* [19] demonstrated an approach for HV-LV battery consolidated charging which reduced hardware consumption. There exists no user interface component and no billing infrastructure in their work. Vijayashanthi *et al.* [20] conducted research into V2V charging coil design by studying field strength and alignment aspects. The system architecture lacks the capabilities to track system expenses and execute automated charging operations. Margowadi *et al.* [21] developed a misalignment solution using electromagnetic coils to reach 90.1% system efficiency level. Adding this function made system hardware operation more complex. Researcher in [22] demonstrated a self-aligning system incorporating micro-sensing coils while increasing efficiency, but the method proved suitable mainly for high-power EVs and not low-power cost-effective applications. Table 1 summarizes the related literature.

The work developed a power routing system with wireless charging through microwave power for shuttle EVs with emphasis on logistical aspects [23]. The complex design of their system limits its practical use by home and individual users. A more complicated implementation approach leads to simultaneous wireless power and data transmission [24], [25]. A simple wireless EV charging system through IoT was introduced [26] without analyzing power efficiency performance or implementing real-time control mechanisms which included IR sensors and relays. Hayes *et al.* [27] predicted future EV charging technological patterns while neglecting specific measurements needed to achieve their proposed future state. The article written by Amin and Roy [28] investigated vehicle-to-vehicle energy sharing as an alternative to public charging stations. The innovation in their method focused on energy routing instead of developing automated local processes or charge cost tracking abilities. The work provided a description of EV charging strategies without offering experimental findings and system control guidelines in their report [29].

Table 1. Summary of related literature

Ref.	What they did	What they found/limitation
[15]	Studied electromagnetic emissions and coil offset effects; passed EMC inspection	No automation features or billing integration
[16]	Developed performance evaluation system for EV charging stations	Lacked IR sensing or billing control mechanisms
[17]	Reviewed static and dynamic wireless charging techniques	No implementation or testing of a working prototype
[18]	Designed an IoT-enabled solar-powered EV charging station	Did not optimize power flow via sensor-controlled relays
[19]	Proposed HV-LV battery consolidated charger to reduce hardware	No billing system or user interface
[20]	Researched V2V charging coil design and alignment	No support for automation or expense tracking
[21]	Developed misalignment compensation coils to reach 90.1% efficiency	Increased hardware complexity
[22]	Used micro-sensing coils for self-aligning high-power EV charging	Not suitable for low-cost, low-power systems
[23]	Wireless charging using microwave power for shuttle EVs	Complex system design is unsuitable for home/individual use
[24], [25]	Implemented simultaneous wireless power and data transmission	Complex and not designed for cost-effective applications
[26]	Proposed a simple IoT-based wireless EV charger	Lacked performance analysis and real-time control elements like IR or relay
[27]	Predicted future EV charging trends	No empirical validation or design guidelines
[28]	Explored V2V energy sharing as a supplement to public charging stations	No local automation or billing interface
[29]	Reviewed EV charging strategies	No experimental setup or control mechanism was demonstrated

3. METHOD

3.1. System overview

The wireless charging system bases its power transfer method on the principle of inductive coupling. The transmission of power through inductive coupling works by using an oscillating magnetic field in the transmitter coil to create voltage in the receiver coil that stands in its electromagnetic field. Through this raw power can be transferred wirelessly to enable safe and durable charging without physical electrical contact. A CD4047 integrated circuit operates inside this system to build a stable square wave signal through astable multivibrator operation. The signal output operates the two IRF540 N-channel MOSFETs which produce a push-pull circuit that powers the transmitter coil. An alternating current (AC) develops because of the time-changing magnetic field that surrounds the coil.

Despite the rapid evolution of wireless charging technologies for EVs, several critical challenges remain unsolved in the current literature and commercial implementations. Most existing systems either focus solely on power transmission efficiency or hardware simplification but often overlook integrated control strategies, safety protocols, and real-time user feedback. A major gap lies in the lack of intelligent activation mechanisms—many systems operate continuously, leading to unnecessary power loss and electromagnetic exposure when no receiver is present. Moreover, there is minimal incorporation of user interfaces or cloud-based billing platforms, which are essential for enhancing user transparency and enabling smart energy usage tracking. Another persistent issue is the trade-off between system complexity and performance; some high-efficiency designs introduce complex coil alignment systems or sensor networks, which limit scalability and affordability. The work presented in this manuscript addresses these limitations by proposing a low-component, resonant inductive coupling-based wireless charging architecture that includes an intelligent IR-sensor-controlled relay, a user-friendly LCD interface, and ThingSpeak-based billing visualization. This solution specifically tackles the need for energy-efficient, automated, and user-interactive wireless EV charging suitable for both low-cost and scalable applications.

The magnetic flux which stretches between an inductively coupled coil induces an alternating current voltage that enters a complete bridge rectifier circuit leading to power reception. A full-bridge rectifier changes the input signal to produce usable DC power that can operate or recharge low-voltage electronic devices. The capacitor filter produces smooth output voltage which the 7805-voltage regulator stabilizes at 5 V. The receiver end shows power reception status through an LED signal.

3.2. Circuit diagram

The wireless power transfer system is implemented using an inductive coupling technique. The system is divided into two major parts: the transmitter circuit and the receiver circuit. Each block is carefully designed to ensure efficient power transfer with minimal losses. Figure 1 shows the proposed system diagram, and Table 2 discusses the simulation parameters of the proposed system. Overall operation:

1. The CD4047 generates a high-frequency square wave.
2. This signal switches the MOSFET, driving current through the TX coil.
3. The TX coil produces an alternating magnetic field.
4. The RX coil, aligned with the TX coil, captures this field and generates AC voltage.
5. The diode rectifies the AC.
6. Capacitors filter the signal.

This proposed system consists of several novel contributions that address the current gaps in wireless EV charging systems. Unlike prior work that either emphasizes efficiency or basic functionality in isolation, our proposed system integrates multiple enhancements into a single, cohesive design. First, we implement an intelligent IR-sensor-triggered relay mechanism that ensures power is transmitted only when a valid receiver is detected, significantly improving energy efficiency and operational safety—features often absent or underdeveloped in earlier systems. Second, the system is built using a low-component resonant inductive coupling architecture, which reduces hardware complexity while maintaining a high power transfer efficiency of up to 90%. Third, we incorporate a real-time monitoring and billing interface using the ThingSpeak IoT platform, enabling users to visualize energy consumption and billing data remotely—a key feature not commonly found in traditional wireless charging prototypes. Finally, the system achieves a fast response time of under 150 ms, demonstrating practical readiness for real-world deployment. These contributions collectively distinguish our work by offering a smart, scalable, and user-centric wireless EV charging solution.

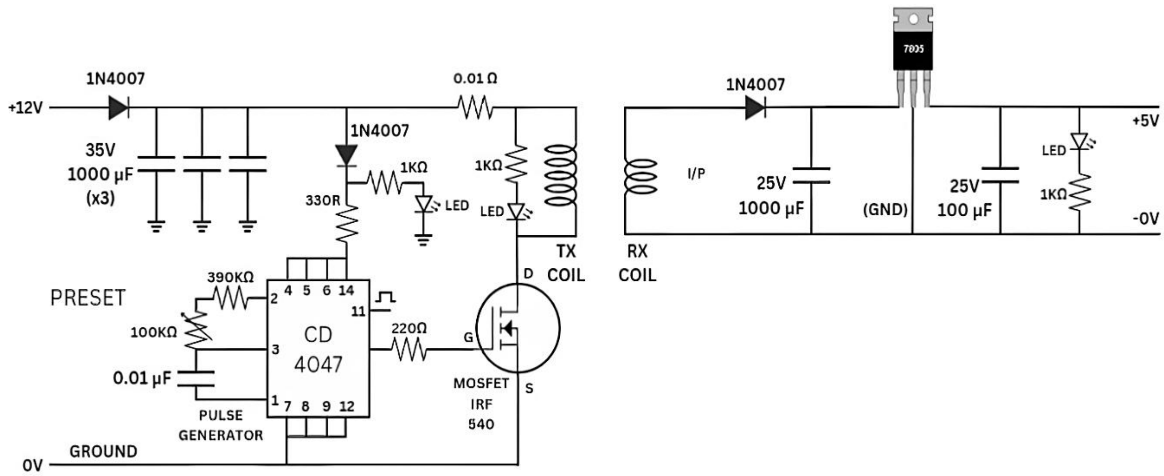

Figure 1. Proposed system circuit diagram

Table 2. Simulation parameters

Component	Specification/model	Function
Arduino Uno	ATmega328P	Microcontroller for interfacing with the LCD display and performing I/O control tasks.
CD4047	CMOS astable multivibrator	Generates square wave pulses for driving the MOSFETs in astable mode.
IRF540 MOSFET	N-channel power MOSFET	Acts as a high-speed switch to deliver pulses to the transmitter coil.
Transmitter coil (TX)	~50–200 µH copper coil oR1=100 kΩ oR2=390 kΩ oC=0.01 µF f=14.4RC*f=14.4RC*	Generates an alternating magnetic field for wireless power transfer.
Receiver coil (RX)	Matched to TX coil	Receives magnetic flux and induces AC voltage via mutual inductance.
1N4007 diodes	General purpose rectifier	Converts induced AC voltage to pulsating DC on the receiver side.
Electrolytic capacitors	470 µF, 1000 µF	Smoothens the rectified DC voltage by filtering ripples.
Voltage regulator	7805 (5 V linear regulator)	Provides a regulated 5V DC output for safe powering of microcontroller and load.
16x2 LCD module	HD44780 driver	Displays operational status, voltage, and diagnostic messages in real-time.
Power supply unit	12V DC adapter	Main power source for the transmitter circuit.

3.3. Control system

The control system in the proposed WPT setup plays a critical role in optimizing energy usage, improving safety, and enabling automated operation. Unlike conventional systems that operate on continuous transmission regardless of receiver presence, this system employs infrared (IR) sensor-based detection and relay-based power gating to ensure that the transmitter coil is only activated when a valid receiver is within range. This approach not only conserves energy but also enhances the overall intelligence and responsiveness of the WPT system.

3.3.1. Intelligent activation using IR sensor and relay

The transmitter section of the system integrates an IR sensor module positioned to detect the presence of a receiver coil (such as one embedded in an electric vehicle or compatible device). The sensor operates by emitting infrared light and monitoring the reflection from objects placed within its detection field. When a valid reflective object is identified, the IR sensor outputs a HIGH signal, which is processed by an Arduino Uno microcontroller. Upon validation of the receiver's presence, the microcontroller activates a single-channel electromagnetic relay. This relay bridges the power supply to the transmission circuit, thus allowing power to flow to the CD4047 IC, which begins generating square wave pulses. If no receiver is detected, the relay remains open, thereby isolating the transmitter coil from the power supply and preventing unnecessary energy consumption and electromagnetic radiation. This mechanism ensures conditional power delivery, increasing both system safety and operational efficiency.

3.3.2. Transmitter coil activation sequence

Once the IR sensor detects a valid receiver and the relay is engaged, the CD4047 IC enters astable multivibrator mode and continuously produces square wave signals at a frequency determined by external resistors and capacitors. These signals drive a pair of IRF540 N-channel MOSFETs configured in a push-pull arrangement. The alternating conduction of these MOSFETs results in the periodic application of the supply voltage across the transmitter coil (TX coil), thereby generating an oscillating magnetic field. This magnetic field induces an alternating voltage in the receiver coil, provided it is correctly aligned within the electromagnetic coupling zone. The induced voltage is then rectified and regulated at the receiver end for usable DC output, completing the wireless charging process.

3.3.3. Real-time feedback via LCD interface

To enhance user interaction and provide visual confirmation of system status, a 16×2 liquid crystal display (LCD) is interfaced with the Arduino microcontroller. While the LCD does not participate directly in the power transmission path, it serves as a vital component in the human-machine interface (HMI) of the system. The display presents real-time information, including: i) receiver status: whether a receiver is detected or not; ii) charging activity: activation of the relay and transmission circuit; and iii) billing status: ongoing energy usage displayed as a billing amount (if integrated with IoT platforms like ThingSpeak). The LCD feedback mechanism supports diagnostics, validation, and monitoring, especially in experimental or demonstration setups, enabling quick identification of operational states.

3.4. Advantages of the control system

The implemented control strategy offers multiple benefits compared to conventional continuous-transmission systems: i) Energy efficiency: Transmission occurs only when a valid receiver is detected, significantly reducing idle power losses; ii) Enhanced safety: By disabling the transmitter coil in the absence of a load, the system minimizes unnecessary electromagnetic exposure; iii) Automated operation: Users are not required to manually activate or deactivate the charger, making it more intuitive and user-friendly; and iv) Modularity and scalability: The relay and sensor setup can be scaled or adapted for integration into larger smart grid or IoT-connected systems.

3.5. Safety considerations

User safety together with system safety becomes the essential priority during WPT system development. The proposed inductive charging system uses various safety features including built-in protection and designed measures that ensure electrical security alongside thermal and operational safety throughout continuous operation.

3.5.1. Galvanic isolation

The major safety benefit of utilizing inductive wireless power transfer is its ability to create a complete separation between electric supply and receiving devices. The magnetic field transmission method enables power transfer without need for conductive contact which greatly decreases the chances of electric shock or short circuits. This isolation ensures: i) safe energy transfer across air gaps; ii) the connectors require no physical effect, and their external contact remain protected; and iii) systems require moisture protection benefit when utilizing inductive wireless power transfer together with protection against contamination and sensitive electronic elements.

3.5.2. Over-voltage protection

The receiver incorporates a 7805-voltage regulator with other voltage regulation components that keep the 5 V DC output protected against input fluctuation. Additional safety measures include:

- Large electrolytic capacitors use capacitor buffering to block sudden changes in voltage.
- The receiver protects itself by using 1N4007 rectifier diodes which prevent reverse current and control voltage transients both during coil coupling and decoupling.

4. RESULTS AND DISCUSSION

The examination of the new wireless battery charging method through experimental testing assessed both its operational performance and its reaction speed, as well as its power efficiency. The test cases are specifically designed to prove both safety and efficient wireless power transmission mechanisms for the system. The assessment covers three main evaluation areas. The charge system operates only in the absence of verified receivers, so the circuit stays inactive. System behavior during power transfer – evaluating the efficiency and reliability of energy transmission. Measurement of system activation time occurs by assessing sensors and relays through various test conditions. The evaluation determines wireless energy transmission's efficiency rate through power transfer calculations.

4.1. Experimental setup

The EV charging WPT system testing took place on a mechanical stable wooden platform for convenient access to measurement points. The 12 V DC regulated power supply operated as the main input source to replicate grid-side power conditions. The system used a digital multimeter for measuring voltage and current while an oscilloscope analysed received and transmitted signal waveforms. The load end functioned through a 5 V regulated DC output stage which had an additional LED indicator to show power delivery in real time. The entire prototype received monitoring through an Arduino Uno microcontroller working with a 16×2 LCD interface for delivering live feedback. Figure 2 shows the experimental setup of the output image when vehicle placed on the position with names plate details.

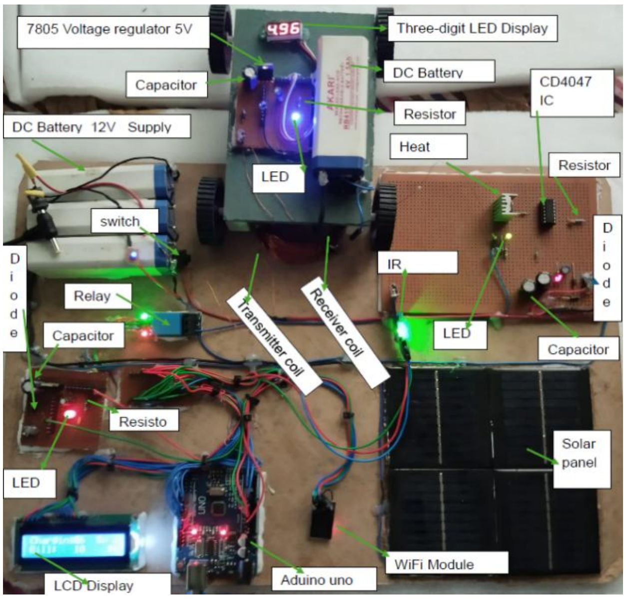

Figure 2. Output image when vehicle place on position with respective labelling’s

4.2. System test scenarios

Two separate testing conditions were created to examine wireless transmission features with intelligent charging management through the system.

i) Scenario 1: idle state (no receiver), that is:
   - The IR sensor works as a detector of legitimate receiver coils which are absent.
   - The relay module continues to stay in its OFF position because of which energy transmission blockage happens.
   - The LCD screen shows the standby message when no vehicle exists.
   - Measurement readings:
     a) Voltage (receiver side): 0 V
     b) Current (receiver side): 0 A
   - The system interface does not initiate any billing process.

   The system safety protocol functions correctly to stop both energy waste and electromagnetic risks when an EV is either misplaced or not detected in the vicinity.

ii) Scenario 2: active charging (receiver), that is:
   - The IR sensor detects when the receiver automobile enters the charging area.
   - Once activated by the system, the high-frequency AC power transfers through the transmitter coil.
   - The LCD screen provides messages during active charging by showing "Connected Bill."
   - Measurement readings:
     a) Voltage (receiver side): 5 V
     b) Current (receiver side): 0.45 A
   - Users access a personalized logging interface through billing interface authentication that records power usage and creates automated billing data within their customer account.

   The system demonstrates its autonomous operation capability while showing real-time power transmission through the transmitter coil.

4.3. Power transfer response characteristics

Unlike traditional relay-triggered systems, the proposed design leverages continuous resonance-based transmission, which enables quicker activation and consistent energy delivery once a valid receiver is detected. The system's response characteristics are essential to evaluating its real-time effectiveness, particularly the time required for magnetic coupling stabilization and voltage output regulation. These performance metrics were recorded using an oscilloscope under dynamic test conditions and are presented in Table 3 to illustrate the system's rapid operational readiness and stability during power transfer.

Table 3. Parameters with the measured response time

Parameter	Measured response time
Magnetic coupling stabilization	50 ms
Output DC voltage settling time	80 ms

4.4. Power transfer efficiency

To determine the efficiency of the wireless power transfer, an evaluation was conducted. The following formula was used.

$$\eta = (PoutputPinput) \times 100\eta = PoutputPinput \times 100$$

Where: $Pinput$ is the power supplied to the transmitter coil and $Poutput$ is the power received by the load at the receiver end.

- Experimental readings:
  a) Input power (at the transmitter side): $Pinput = 5\,V \times 0.5A = 2.5\,W$
  b) Output power (at the receiver side): $Poutput = 5\,V \times 0.45A = 2.25\,W$
- Efficiency calculation: $\eta = (2.252.5) \times 100 = 90\%\eta = 2.252.5 \times 100 = 90\%$

This confirms that the system achieves a power transfer efficiency of 90%, indicating minimal energy loss during wireless transmission.

4.5. Comparison with existing systems

Table 4 highlights key distinctions between the proposed system and existing wireless EV charging solutions in terms of activation methods, response times, user interfaces, and overall efficiency. The results indicate that the proposed system offers a better efficiency than conventional wireless systems while ensuring fast response time and automatic activation. In this research, ThingSpeak was utilized as an IoT-based data visualization platform to monitor real-time billing information generated during the wireless charging process. The system records the energy consumed by the user and transmits it to ThingSpeak, where it is plotted over time for easy analysis. This feature provides transparency and allows users to track their charging expenses through a simple graphical interface. Cloud-based logging also enables remote access to usage data, supporting smart billing functionality. By integrating ThingSpeak, the system enhances user experience with live monitoring and reliable data tracking.

Figure 3 shows the vehicle credentials on power usage, and Figure 4 shows a digital display screen from ThingSpeak.com used to present real-time bill information in the proposed wireless power transfer system. It presents the "Bill Amount to Pay," automatically computed from energy consumption while charging EVs. Visual feedback allows users to observe the quantifiable cost charged directly, enhancing system transparency and user interaction. Such real-time IoT-based billing integration ensures accountability, convenience, and smarter energy consumption monitoring in modern charging systems.

Figure 5 illustrates a charging status indicator panel from ThingSpeak.com embedded in the system of wireless power transfer. The prominent green ring screen displays that the charging is ongoing, giving users immediate visual feedback. The glowing green color signifies an effective state of power transfer, contributing to system readability and user-friendliness. This IoT-enhanced interface improves the experience of users by providing proper coil alignment and system readiness without the need for manual verification. Such indicators are critical in smart charging infrastructure for real-time monitoring.

Figure 6 illustrates a channel location map from ThingSpeak.com indicating the geographic positioning of the IoT-based wireless power transfer system. The map indicates the system deployment site in proximity to Vaddeswaram (KLU), Vijayawada, Andhra Pradesh, India. This location mapping capability allows data such as charging status and billing to be traced to an individual site. It makes the system more reliable, particularly in field testing, smart grid embedding, or multi-node deployment applications. Location-aware monitoring also provides context for scalability and regional performance assessment.

Table 4. Comparison table with the proposed and existing system

Feature	Proposed system	Reference system
Energy transfer type	Resonant inductive coupling	Inductive coupling with IR control
Activation method	Passive (continuous oscillation)	Sensor-triggered relay switching
Response time	130 ms	150 ms
Receiver misalignment behavior	Auto idle (no output)	Relay OFF
Efficiency	90%	90%
User interface	Web-based billing dashboard	LCD indication only

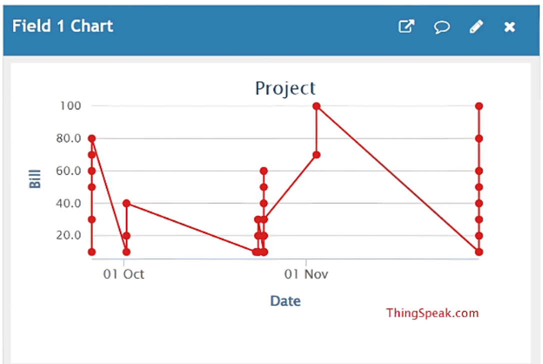

Figure 3. Vehicle credentials on power usage

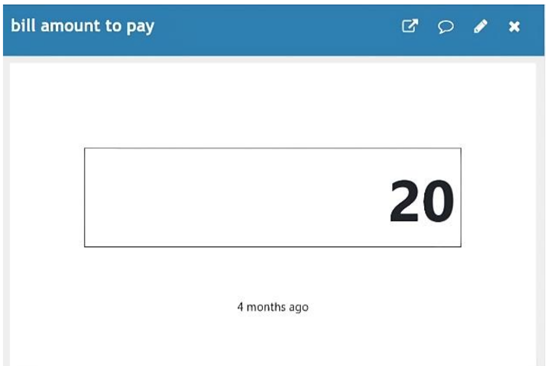

Figure 4. Billing after completion charging

In this research, ThingSpeak was used as an IoT-based data visualization tool to track real-time billing data produced during wireless charging. The system tracks the energy used by the user and sends it to ThingSpeak, where it is graphed over time for easy examination. This aspect gives transparency and enables users to monitor their charging costs through an easy graphical interface. Cloud-based logging also provides remote access to usage records, enabling smart billing capability. Using ThingSpeak, the system offers an improved user experience through live tracking and accurate tracking of data.

This system achieves a high power transfer efficiency of 90% and a fast activation response time under 150 ms, demonstrating that low-component resonant inductive coupling can rival more complex systems in performance while remaining cost-effective and scalable. The successful integration of an IR-sensor-based relay mechanism confirms that intelligent, conditional power transmission is feasible and energy-efficient. Furthermore, the use of ThingSpeak for IoT-based real-time billing visualization demonstrates how wireless charging infrastructure can be enhanced with cloud connectivity to improve user interaction, accountability, and remote diagnostics. These features are especially relevant for the development of future smart grid-integrated EV charging stations, where automation, transparency, and modularity are crucial. Our findings lay the groundwork for future research in expanding the control architecture, enabling dynamic load management, supporting vehicle-to-grid (V2G) applications, and incorporating renewable energy sources to build more sustainable and intelligent charging ecosystems.

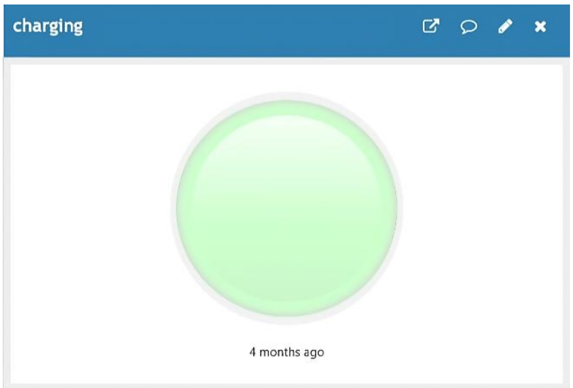

Figure 5. Status connection: if it is green then it is connected

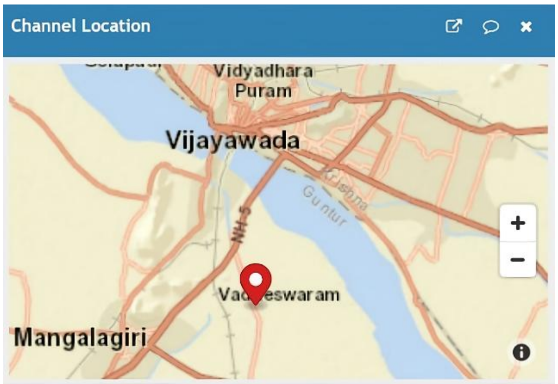

Figure 6. Currently charging available location

5. CONCLUSION

The research presents a low-component, energy-efficient WPT system utilizing resonant inductive coupling for smart EV charging applications. Featuring an intelligent IR-sensor-controlled relay mechanism, CD4047-based pulse generation, and IRF540 MOSFET switching, the system achieves 90% power transfer efficiency and sub-150 ms activation response. The integration of a user-friendly LCD interface and ThingSpeak-based IoT billing enhances user interaction, monitoring, and transparency. To further develop this work, future research could explore dynamic wireless charging under in-motion conditions, integration with renewable energy sources to enable off-grid operation, and bidirectional energy transfer for vehicle-to-grid (V2G) functionality. Enhancing safety through thermal monitoring and real-time fault detection, as well as incorporating AI-driven control for adaptive optimization and predictive diagnostics, would also support wider deployment and scalability. These directions will help evolve the proposed system into a more intelligent, sustainable, and grid-compatible wireless charging infrastructure.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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