Research Study on Transforming an electric vehicle charging station into a solar-powered system enhanced by IoT Capabilities

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Abstract— ***This paper introduces an innovative IoT-based Wireless EV Charging and Battery Monitoring System to support the growing demand for efficient electric vehicle (EV) charging infrastructure. The system integrates IoT technology with wireless charging capabilities to provide seamless charging experiences and effective monitoring of EV battery status. It consists of three main components: an EV charging station, IoT-enabled sensors, and a centralized monitoring system. The charging station utilizes wireless technology, enhancing user convenience and eliminating cable management concerns. IoT sensors continuously monitor parameters such as battery temperature, voltage, current, and state of charge, providing real-time data for battery health assessment. This data is transmitted to a centralized system for analysis using advanced analytics and machine learning algorithms to predict battery degradation, identify faults, and optimize charging protocols. Remote monitoring and management capabilities enable operators to oversee multiple stations simultaneously, while users benefit from personalized charging analytics and recommendations via mobile applications. Overall, the proposed system offers a comprehensive solution to improve EV charging infrastructure, promoting widespread adoption of electric vehicles.***

Keywords—

1. Introduction

In response to the increasing demand for sustainable transportation solutions, the automotive industry is undergoing a significant transformation, with Electric Vehicles (EVs) emerging as a promising alternative to traditional internal combustion engine vehicles. EVs offer various advantages, including lower emissions, reduced reliance on fossil fuels, and improved energy efficiency. However, their widespread adoption necessitates robust charging infrastructure capable of meeting the evolving needs of electric mobility.

Conventional EV charging stations typically rely on physical connections between the EV and the charger, often involving cumbersome cables and plugs. Additionally, monitoring the health and performance of EV batteries has been challenging, with limited real-time visibility into critical parameters such as temperature, voltage, and state of charge. These limitations present significant barriers to the seamless integration of EVs into existing transportation networks.

To address these challenges, this thesis proposes an innovative solution: an IoT-based Wireless EV Charging and Battery Monitoring System. This system represents a paradigm shift in EV charging infrastructure by leveraging the convergence of Internet of Things (IoT) technology and wireless charging capabilities to deliver enhanced user experiences and optimize battery performance.

The primary objective of this thesis is to design, develop, and evaluate the efficacy of an integrated system that seamlessly combines wireless EV charging with real-time battery monitoring capabilities. By harnessing the power of IoT, the proposed system aims to overcome the limitations of traditional charging infrastructure while providing actionable insights into battery health and performance.

This introduction sets the stage for exploring key concepts, challenges, and opportunities related to IoT-based wireless EV charging and battery monitoring. Subsequent chapters will delve into the theoretical framework, system architecture, implementation details, and performance evaluation of the proposed system.

In conclusion, this thesis contributes to the advancement of electric mobility and sustainable transportation by developing innovative solutions that address critical infrastructure needs, thereby accelerating the transition towards a greener, more efficient transportation ecosystem.

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In this experiment, we will focus on investigating a low-power Wireless Power Transfer (WPT) setup, exploring parameters crucial for its design. Goals include applying phasor analysis, designing impedance matching circuits, observing impedance changes with frequency, measuring time-domain signals, and studying changes in coupling between inductors.

2. PROPOSED WORK

The proposed system utilizes wireless charging based on electromagnetic induction, where an electric current through one coil generates a magnetic field, inducing a current in a second coil nearby, enabling electricity transfer without physical contact. This "near field" charging method ensures proximity between the charger and receiving device. The output is received by a TP4056 chip, serving as a lithium-ion battery charger with input voltage ranging from 4.5 to 5.5V and providing a 5V output. It safeguards the battery against over and undercharging, offers two status outputs for charging progress, and supports a programmable charge current of up to 1A.

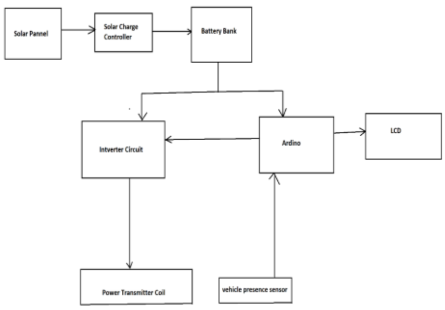


Fig.1 Block Diagram at Charging Point Side

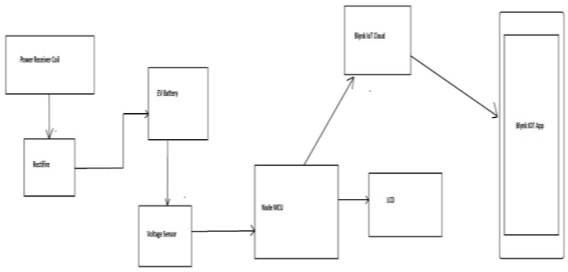


Fig.2 Block Diagram at Vehicale Side

So, it is then connected to battery which charges a battery and then collects to the its status like voltage, percentage of charging and temperature with the help of DHT 22. It sends the collected data to ESP82266 Wi-Fi module, which analyses it and delivers it to the OLED display as well as our smartphone via the Blynk server. Blynk shows all the parameters on your android, so that you can know your EV's battery status at the tip of your fingertip and also notifies whenever required. We can see the various efficiency of topologies mentioned in Table 1, and the efficiency at various positions of coils are given in Table 2.

Topology					
Topic	ref	p[W]	η[%]	f[MHz]	d[cm]
1-D slab	[10]	-	47	6.78	20
	[12]	40	47	27	50
	[13],[14]	15	40	6.78	60
2-D slab	[11]	80	34	27.12	50
	[12]	40	47	27	50
	[14]	15	40	6.78	60
3-D slab	[14]	15	40	6.78	60
	[14]	-	33	6.5	100/150
	[16]	-	80	23.2	150

Table 1: Various Efficiency of Topologies

Position					
	Ref	P[W]	η	F[MHZ]	D[cm]
Middle of path	[11]	80	34	27.12	50
	[13,14]	15	40	6.78	60
	[15]	-	33	6.5	100
Front of Colis	[14]	15	36.7	6.78	60
	[15]	15	40	6.78	60
	[16]	-	80	23.2	150
Back of coils	[17]	80	34	27.12	50

Table 2: Efficiency at various positions of coils

2.1 A 12-volt solar panel harnesses sunlight to produce around 12 volts of electrical energy, commonly used for off-grid applications like RVs and boats, as well as for charging batteries and powering low-voltage devices**.**

2.2 Lithium-ion batteries, characterized by high energy density and efficiency, have revolutionized portable electronics, electric vehicles, and grid-scale energy storage, with significant impact on human history and greenhouse gas emissions reduction efforts**.**

2.3 A buck converter is a DC-DC converter that produces an output voltage lower than its input by storing energy in an inductor. It operates by alternating between two states: when the switch is closed, current flows through the inductor, reducing the output voltage, and when the switch is opened, the inductor releases its stored energy to the load. Output ripple, a undesired phenomenon, is mitigated by adding a smoothing capacitor parallel to the output.

2.4 The Arduino Pro Mini is a microcontroller board with 14 digital I/O pins, 6 analog inputs, and options for PWM outputs, designed for semi-permanent installations with flexible connection options and two versions available: one operating at 3.3V/8MHz and the other at 5V/16MHz.

2.5 The Arduino Pro Mini supports UART TTL serial communication on digital pins 0 (RX) and 1 (TX), with additional serial communication possible using the Software Serial library. It also supports I2C (TWI) and SPI communication, facilitated by the Wire library for I2C and the ATmega328P datasheet for SPI.

2.6 The Arduino Pro Mini features automatic reset capability facilitated by a pin connected to the reset line via a 100nF capacitor, allowing for software-triggered resets during code uploads, and it resets upon connection to a computer, enabling seamless programming.

2.7 The IR Sensor is a multipurpose infrared sensor providing digital output indicating object presence, suitable for various applications like obstacle sensing, color detection, and line sensing, with a maximum range of approximately 40-50 cm indoors and 15-20 cm outdoors.

2.8 The Arduino IDE is a software platform tailored for programming Arduino microcontroller boards, offering a user-friendly interface for writing, compiling, and uploading code. It supports simplified versions of C and C++, features syntax highlighting and auto-completion, and includes a built-in compiler and serial monitor for debugging. With a vast library of code examples and libraries, the Arduino IDE simplifies prototyping and project development, catering to both beginners and experienced developers

3. RESULT

TRANSMISSION RANGES AT DIFFERENT DISTANCES

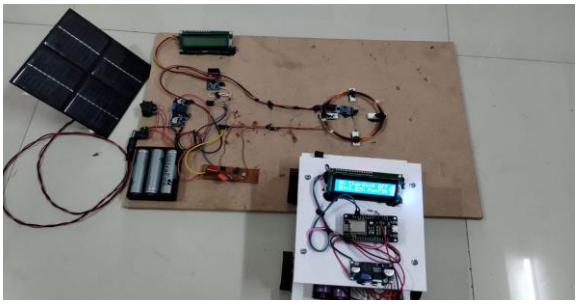
Distance between transmitting and receiving coil	Transmitting Coil Voltage (AC)	Receiving Coil voltage
2 CM	185V	71.35V
4 CM	185V	27.74V
6 CM	185V	15.61V
8 CM	185V	10.24V
10 CM	185V	4.31V
12 CM	185V	1.30V

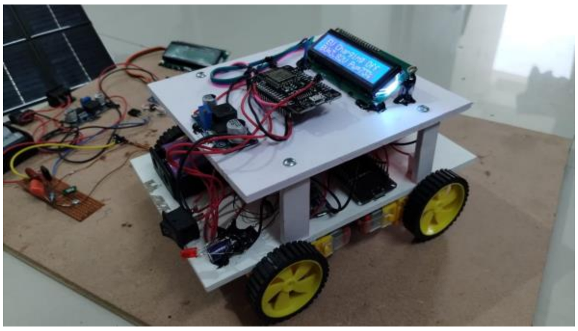
Efficiency

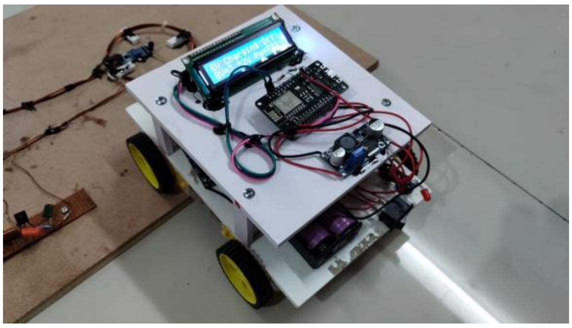
FROM ABOVE RESULT WE ARE GETTING EFFICIENCY OF ABOUT 38.56% AT 2 CM DISTANCE

Display at Charging Point

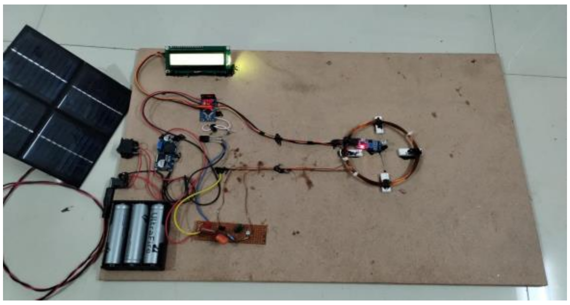
Display on the EV







Electric Vehicle with wireless charging utility



Solar powered Wireless EV charging station

4. CONCLUSION

In addition to reducing greenhouse gas emissions and air pollution, electric vehicles (EVs) offer the advantage of decreasing oil consumption, thereby enhancing energy security. With EVs gaining prominence in the market, the transition to wireless charging systems for vehicle replenishment is underway. This shift showcases the efficiency and advancement of future charging station technology. Through this innovative system, battery condition monitoring is enabled via IoT technology, accessible through an Android phone interface. Furthermore, Battery Management Systems (BMS) play a crucial role in prolonging the lifespan of EV batteries. By constantly monitoring battery health, BMS helps prevent failures or explosions, ensuring stability and reliability in EV operations.

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