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Shaping the Future of Electric Vehicles: Smart, Sustainable and Wireless Solar-Powered Charging System for Electric Vehicles

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Abstract
The adoption of electric vehicles (EVs) is rapidly increasing as a sustainable transportation solution. However, the accessibility and availability of charging infrastructure remain a significant concern, particularly in urban and remote areas. To address this challenge, our project proposes the development of a Solar Power Bank with Wireless Charging (SPB-WC) for Electric Vehicles, aimed at enhancing the convenience and sustainability of EV charging. The SPB-WC is a portable and self-contained charging solution that integrates solar panels, energy storage, and wireless charging technology. This project aims to provide a reliable, renewable, and on-the-go charging option for electric vehicle owners, promoting the wider adoption of clean energy transportation. This article present a strategic planning and innovative design of a solar-powered charging system tailored for electric vehicles (EVs), addressing the pressing issues of costly gasoline and detrimental emissions. The global presence of EVs is on a consistent ascent, attributed to both environmental concerns and the economic advantage they offer by significantly reducing transportation expenses compared to conventional fuel-powered vehicles. In this study, we propose a groundbreaking solution by conceptualizing an EV charging infrastructure that capitalizes on solar energy.

Our approach eliminates the need for stationary charging stations, enabling continuous charging while the EV is in motion. This self-sustaining system is driven solely by solar power, obviating the requirement for additional energy sources. The construction of this infrastructure incorporates various components such as solar panels, batteries, transformers, regulator circuitry, copper coils, AC to DC converters, a controller, and an LCD. Thus, our technology showcases the feasibility of integrating solar-powered, wireless charging systems seamlessly into road networks, thereby revolutionizing the paradigm of EV charging infrastructure.
Keywords: Electric Vehicles, Solar Power, Wireless Charging, EV Infrastructure

Introduction

In the realm of transportation, electric vehicles (EVs) present a pioneering concept that is poised to dominate the automobile market in the foreseeable future. As this transition unfolds, it becomes imperative to regulate the charging process for EVs to uphold the integrity of power networks. Paradoxically, the proliferation of EVs will result in a substantial reservoir of stored energy within batteries, offering a counterbalancing effect [1]. The interactive nature of EVs will play a crucial role in future smart grid systems, bolstering the resilience of the power grid. The electric vehicle has gained a competitive edge over traditional internal combustion engine vehicles due to the simultaneous reduction in carbon dioxide emissions and the escalation of fossil fuel prices. However, despite these advantages, widespread adoption of EVs has been hindered by factors such as high vehicle costs and the scarcity of fast-charging stations [2]. Electric vehicles come in two variants: those powered solely by electricity and those utilizing a hybrid powertrain. Noteworthy for their minimal environmental footprint and cost-effectiveness in terms of operating expenses, electric vehicles represent a sustainable mode of transportation for the future, bolstered by the continuous improvement of charging station efficiency. The lack of charging infrastructures acts as a major deterrent to potential EV owners [3]. One of the efforts for addressing this issue is testing of portable EV chargers for decreasing the charging time based on renewable energy source. Another is the need for new solutions such as wireless EV chargers that address the needs of long distance EV drivers in places where the stations along major highways are spread very far apart. The aim of our project is to create a system that uses solar energy to charge EV alongside the use of other renewable sources of energy that includes battery, transformer, copper coils, Ac to DC converter, regulator circuits, At mega controller and LCD display. Using this system, EVs may charge while on the move, leaving no reason to stop frequently. Solar cells use the DC electricity from the solar panel to charge a battery bank, an intermediary container necessary as a buffer — a charge controller — which connects the panel to the battery and stores DC electricity to be converted into AC power by a transformer. It is global imperative to transition to sustainable and environmentally friendly transportation [4]. The solution seems to be Electric Vehicles (EVs). Yet, to make EVs more ubiquitous, charging infrastructure capable of providing an efficient and convenient service is required. While the EV technology itself is already quite advanced, the availability and reliability of charging stations continue to be an issue in both urban and remote areas. This project attempts to address all these challenges by introducing the concept of a Solar Power Bank with Wireless

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Charging (SPB WC) for Electric Vehicles. The concept of a Solar Power Bank with Wireless Charging for Electric Vehicles is to connect the dots between the accessibility and sustainability of EV charging [5]. The idea of Energizer is to offer a portable, self sufficient charging device that collects renewable energy from the sun, stores it intelligently and wirelessly charges various EV models. In this work, an attempt is made to ameliorate ease of use, availability, and eco-friendliness of electric vehicle charging. At the time the world is doing all it can to fight climate change, no point is too strong to make the transition from internal combustion engine vehicles to EVs. The reduction of greenhouse gas emissions and the preservation of natural resources hinge on the mass adoption of electric vehicles. Currently, charging infrastructure needs to be as accessible and widespread as traditional gas stations for EVs to become the norm [6]. This project acknowledges the urgency to pursue innovative and sustainable solutions that will help in accelerating the electric vehicles adoptions. We introduce the SPB–WC concept as a step towards making this happen by providing a flexible and eco–conscious manner of providing charging infrastructure. By integrating solar panels for energy generation and wireless charging technology for user convenience, the SPB-WC addresses several critical challenges [7].
In this section, we introduce this project with Solar Power Bank with Wireless Charging for Electric Vehicles as the project that can benefit people and the society. We will delve deeper into the project's objectives, methodology, and what we expect as a result, which will allow us to understand how this innovative solution can help fulfill the larger goal of keeping sustainable transportation and the greener future.

Research Objective

The main goal of this research is design and development of solar wireless, smart and sustainable system that could charge the electric vehicles. The purpose of this system is to make charging more efficient, fast power transfer, and to provide overall better performance than what wired charging typically offers. Furthermore, the study attempts to show environmental advantages of the system and how it can lower carbon emission levels and promote adoption of renewable energy. The WPT technology will also be optimized so that the WPT can be reliable and energy efficient under various environmental conditions. Furthermore, feasibility of scaling up of this system for real world applications will be considered by evaluating the system's capabilities to be connected to existing EV infrastructure, and conducting a substantial cost benefited analysis. In general, this research aims to catalyze more use of sustainable energy solutions for electric vehicle charging and also towards a more positive energy future in transportation.

- Develop a wireless solar powered charging system for electric vehicles with a built in smart technology for optimal performance.
- Test the performance of the system with respect to the speed of charging, energy conversion, reliability, etc.
- Assess the environmental impact of using solar power to charge electric vehicles, including the reduction of carbon emissions compared to traditional charging methods.
- Investigate the system's scalability and potential for integration into existing electric vehicle infrastructure.

- Improve accessibility by designing a user-friendly, wireless charging solution that can be deployed in various locations, including remote or off-grid areas.
- Contribute to the advancement of sustainable transportation infrastructure by promoting the use of renewable energy in EV charging.

Dynamic Wireless Power Transfer in Electric Vehicles

It is possible for a hybrid or completely electric car to make use of a force move system in order to either provide power to the electric motor or charge the Rechargeable Energy Storage System (RESS) that is located on board [8]. While stationary, the batteries may be charged by remote force motion using charging pads. Although both alternatives are acceptable for use during an evaluation conducted at home or on the road, the vehicle must be located in an appropriate location to recharge the battery [9]. In this paper, we suggest a wireless charging system for electric cars that is not only kind to the environment but also enables the vehicle to be charged wirelessly while it is moving along the roadways. The suggested system is used to charge automobiles at garages, parking facilities, and shopping centres. An additional possibility is that the solar photovoltaic (PV) systems and wind turbines that have been installed along the highways will be required to provide the projected charging infrastructure with the necessary electrical energy [10]. Microgrids are created when renewable energy sources such as solar panels and wind turbines are connected to one another in order to provide power to necessary services such as wireless charging [11]. You can send the extra power back to the main power grid or use it to power lighting. An air-core transformer, including its primary winding embedded in the roadway and its secondary connected to the vehicle, is a component of the system for wireless battery charging. A rectifier and DC-DC converter stage transform the secondary's alternating current into a voltage and current suitable for charging the battery pack [12].

Effect of Coil Dimensions on Dynamic Wireless Power Transfer for Electric Vehicles

Utilizing advanced modeling tools, analyze the effects of changing the size and configuration of the receiver coil on power transfer efficiency and operating expenses [13]. This section indicates that the coupling coefficient exhibits a non-monotonic relationship with the coil size, attributable to the spatial dispersion of the magnetic field. The coil size at which the coupling coefficient attains its maximum is a crucial design element that influences the overall performance of the system shown in Figure 1 [14]. We also discuss the integration of our results into a multi-objective optimization system.

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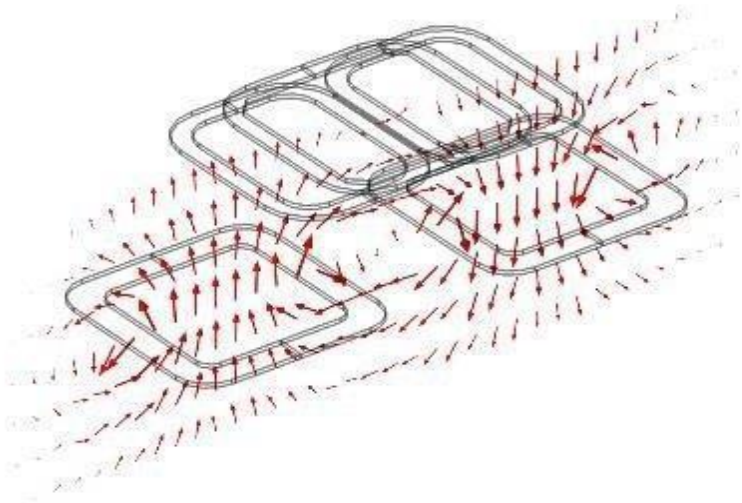

Figure 1: Flux lines generated in the bipolar transmitter coils [15]
There are 56% of all cars that run on gasoline, while the transportation industry is responsible for 29% of all energy use [16][17][18]. The combustion of gasoline leads in the emission of greenhouse gases, which are harmful to the overall environment [19][20]. Utilizing a segmented coil structure in DWPT necessitates overcoming many challenges. This paper examines several forms of magnetic couplers by modelling their functionality and modifying the coupling coefficient and misalignment, both with and without a protective shield [21]. Furthermore, a comparison is made among several vii reactive compensation circuits that exhibit tolerance to misalignment, load independence, power factor, and efficiency. Implementing dynamic wireless power transfer (DWPT) is challenging due to the need for automated identification of electric vehicles to avert efficiency loss and mitigate safety issues [22][23][24]. Figure 2 shows the timeline diagram of development of the Wireless Power Transfer

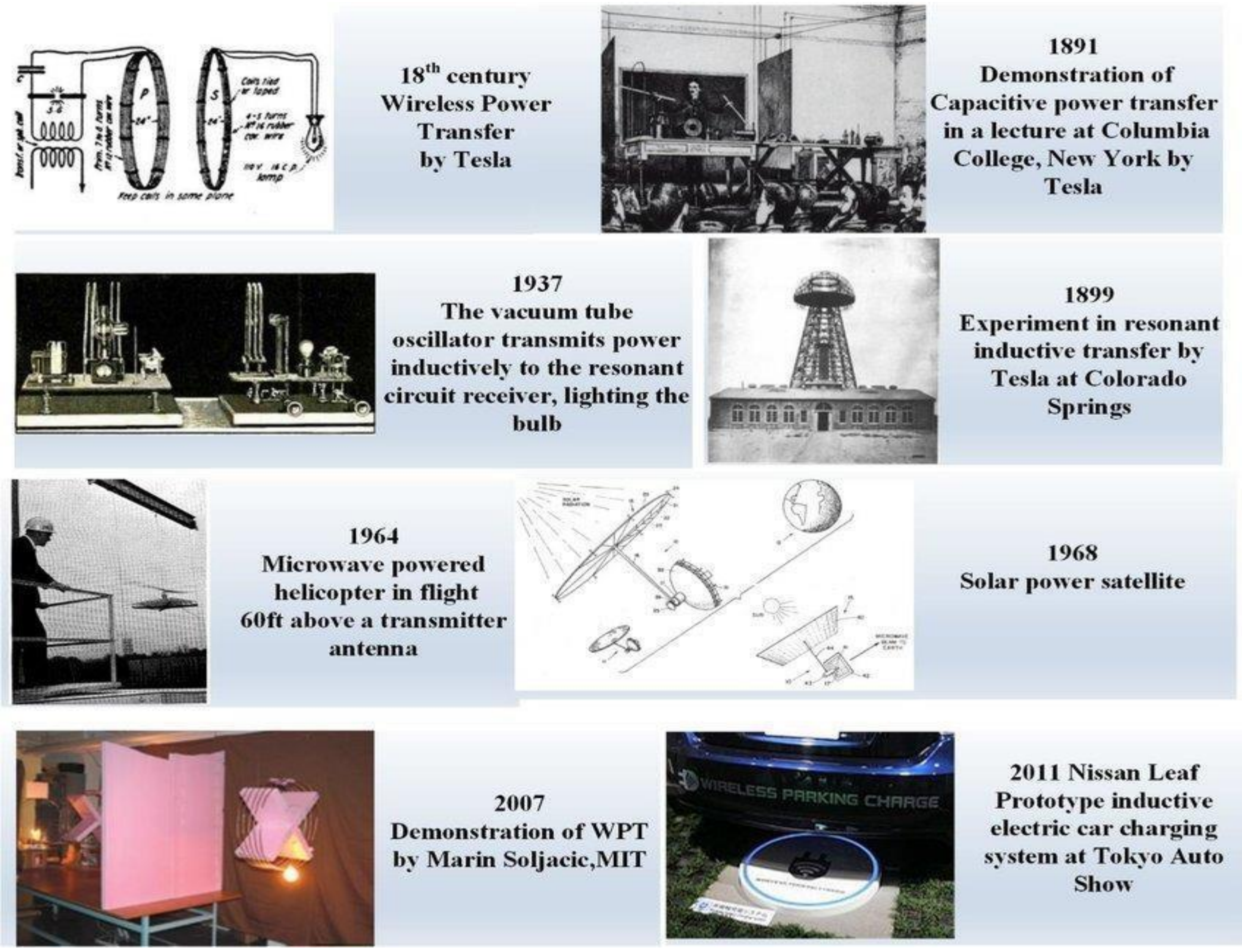

Figure 2: Timeline diagram of development of the Wireless Power Transfer [25]

The concept of wirelessly charging a moving vehicle through resonant inductive power transfer is termed as "dynamic wireless charging." This technology involves the installation of source coils in the road and a pickup coil in the vehicle, with the two coils linked to transfer energy efficiently [26]. Dynamic wireless charging systems offer a promising solution to the limitations of EV batteries, potentially providing unlimited range and allowing for the use of smaller, lighter, and more cost-effective batteries [27]. However, the widespread implementation of dynamic wireless charging faces significant hurdles, primarily due to the associated costs of establishing the requisite charging infrastructure [28]. Figure 3 shows the basic diagram of dynamic wireless electric vehicle charging system.

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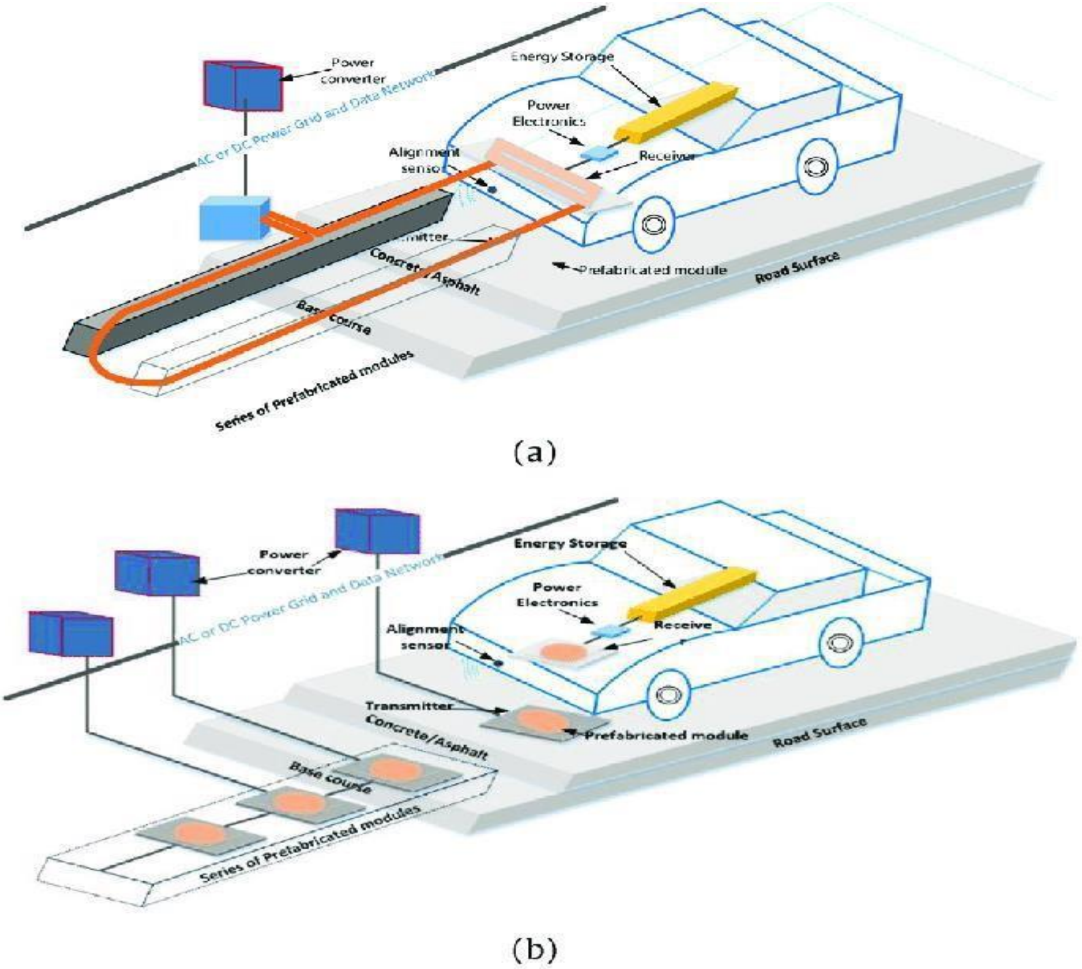

Figure 3: Basic diagram of dynamic wireless electric vehicle charging system [29].

Methodology:

The methodology of this research involves a combination of theoretical design, system simulation, and practical experimentation to evaluate the performance of a smart, sustainable, wireless solar-powered charging system for electric vehicles (EVs). The approach is divided into the following key phases:

System Design and Conceptualization:

- **Solar Power Integration:** The system will be designed to integrate solar panels capable of harnessing solar energy to power the EV charging station. The solar panel specifications will be based on geographical solar irradiance data to ensure optimal performance in various environmental conditions.
- **Wireless Power Transfer (WPT):** In order to permit electricity to be transferred from a wireless charging station to a vehicle (and vice versa) without need for physical connections between (or ports on) the vehicle and charging station, the technology that would be chosen will include inductive or capacitive coupling [30]. A WPT system using the

electromagnetic field will be designed and optimized to carry out a high efficiency energy transfer.

Simulation and Modeling:

- **Energy Flow Simulation:** A simulation model to evaluate solar panels, wireless charging unit and EV battery energy transfer process will be created. The energy generation and storage efficiency will be predicted by the model depending on how many solar irradiance data and power conversion efficiencies are used (vary from weather, time of day, geographical location).
- **Charging Efficiency Analysis:** Efficiency of the system's charging efficiency is simulated by assessing the power loss between the energy transfer of solar panel to the vehicle's battery. This will aid in the finding of areas for future improvement on the wireless power transfer technology.
- **Smart System Algorithms:** Simulation tools (e.g., MATLAB, Simulink) will be used to develop algorithms for dynamic power management, including features such as energy optimization, load balancing, and fault detection.

Prototyping and System Implementation:

- **Prototype Development:** This project will be narrowed down to scaled down prototype to be developed on a laboratory scale for a controlled environment. The prototype includes a solar panel array, a wireless power transfer unit, and an electric vehicle mock-up with sensors that are relevant to test.
- **Testing and Data Collection:** System efficiency, power transfer rate and reliability of the prototype will be evaluated by varying operational tests. Analysis will be made of data collected on energy generation, conversion efficiency, charging time and vehicle performance.
- **Environmental Conditions Testing:** To assess the system's ability to adapt to different environmental conditions, the prototype will be tested under various weather scenarios (e.g., cloud cover, rain, sunlight intensity) to observe its performance and reliability.

Environmental and Sustainability Assessment:

- **Carbon Emission Reduction Analysis:** A comparative analysis will be made so as to calculate the carbon emission cut down using the solar powered wireless charging system and in comparison to conventional grid power charging means.
- **Life Cycle Assessment (LCA):** A life cycle assessment will be conducted to evaluate the environmental impact of manufacturing, deploying, and maintaining the solar-powered charging system, taking into account factors such as material extraction, energy consumption, and waste generation. The block diagram of this project are shown in fig. 4

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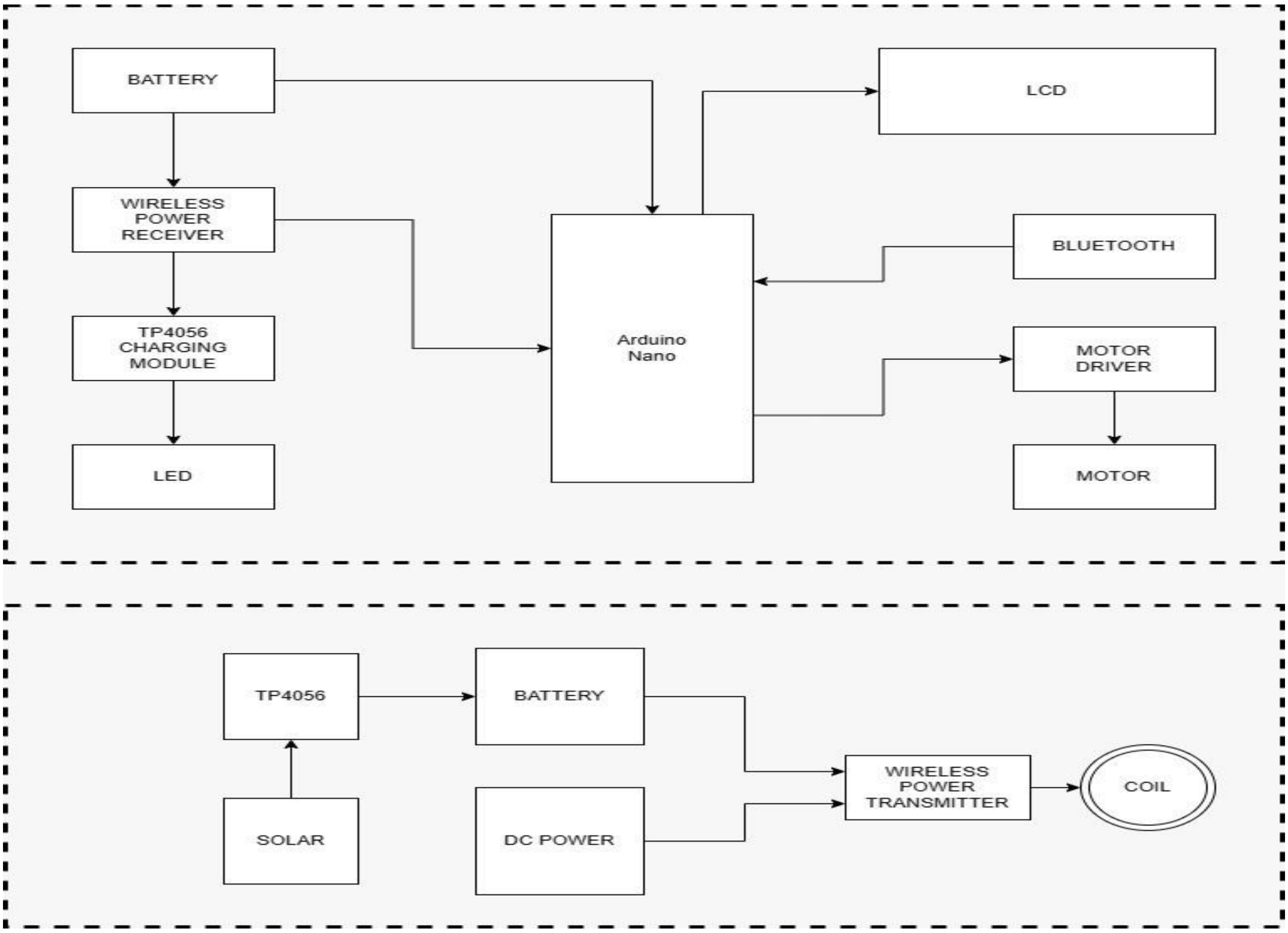

Figure 4: Block Diagram of this project

Result and simulation:

In this part we shall break down the solar power system and describe the details of how it works. It is the main source of energy which is the solar panel and a Buck converter is used as the pulse width modulation (PWM) converter to regulate the voltage from solar panel to the battery charge controller. The charge controller is very important to keep the voltage output of the solar PV panel and to keep charging condition of battery optimum and not to overcharge the battery. Specifically, a Maximum Power Point Tracking (MPPT) charge controller is utilized, acting as a DC-DC converter to maximize the power output of the solar panel. Given the dynamic nature of irradiance on the PV panel, the MPPT controller continuously adjusts the panel's voltage and current to identify the optimal operating point for maximum power generation. Employing a Perturbation Observation algorithm, the MPPT controller fine-tunes the battery charging process, ensuring efficient charging without the risk of overcharging [31]. By precisely regulating the current and voltage values, the MPPT algorithms facilitate the generation of gating signals for the boost converter, optimizing the module voltage for enhanced energy conversion efficiency. Overall, this solar power system integration underscores the importance of sophisticated control mechanisms to harness solar energy effectively and sustainably. The simulation model of this project are shown in figure 5 and 6.

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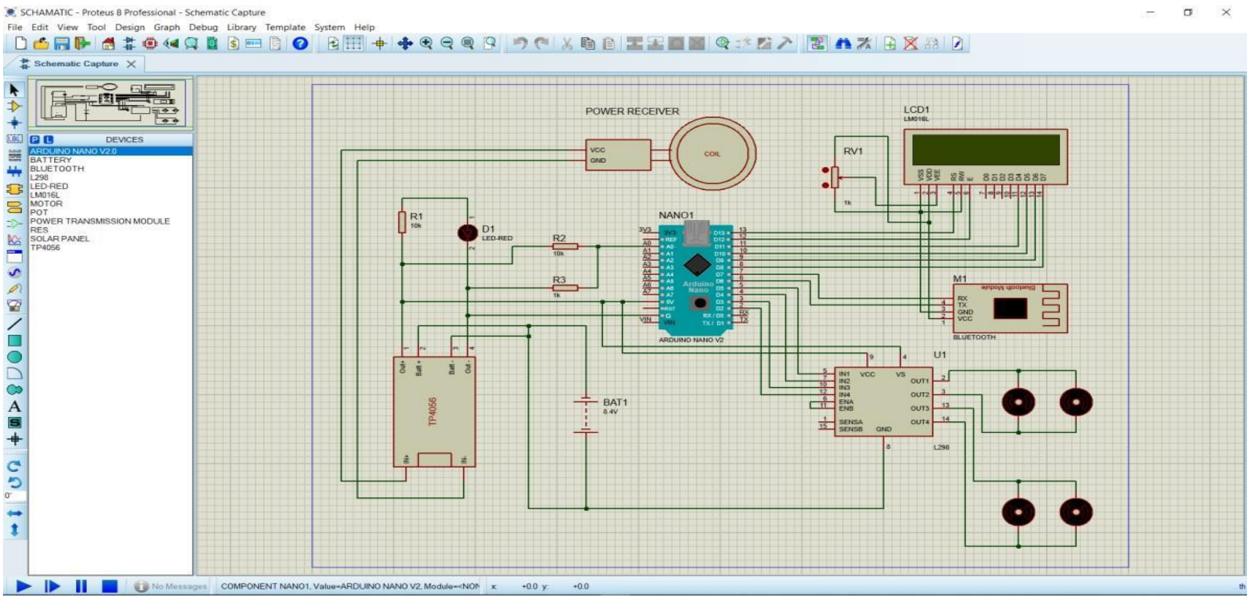

Figure 5: Proteus based simulation model of this project

This figure shows the proteus simulation of the vehicle control device. Here it can be seen that Arduino Nano is been used along with all the components of the project.

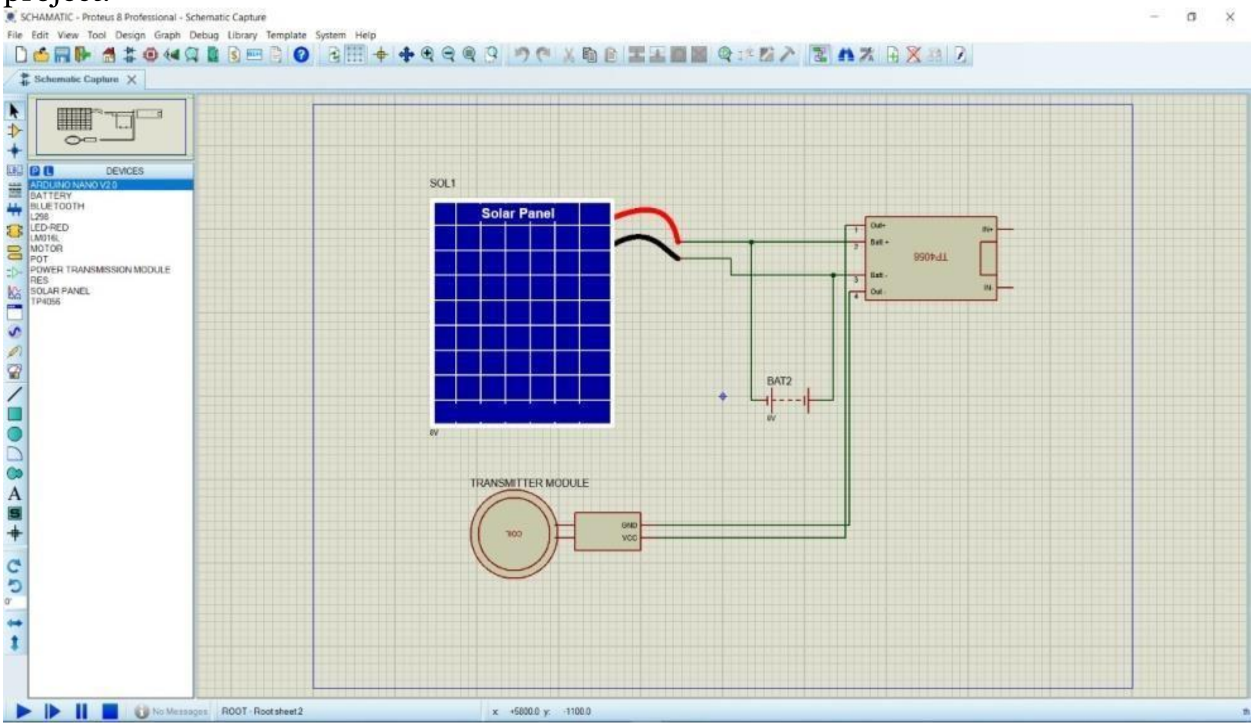

Figure 6: Proteus Simulation Transmission Part

This figures illustrated the power distribution of the project. Solar and the wireless system of the vehicle. While table 1 shows the different calculation drawn from MATLAB simulation.

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Air Gap between Coils	TRANSMITTING COIL VOLTAGE AC	RECEIVING COIL VOLTAGE AC	POWER INPUT TRANSMITTING COIL	POWER OUTPUT RECEIVING COIL	EFFENCIENCY Of System.
2 CM	185 V	71.35 V	370 W	142.7 W	38.56 %
4 CM	185 V	27.74 V	370 W	55.48 W	14.99 %
6 CM	185 V	15.61 V	370 W	31.22 W	8.437 %
8 CM	185 V	10.24 V	370 W	20.48 W	5.535 %
10 CM	185 V	4.31V	370 W	8.62 W	2.329 %
12 CM	185 V	1.30 V	370 W	2.6 W	0.702 %

Table 1: Calculation drawn from MATLAB simulation.

Future work

While this research lays the foundation for a smart, sustainable, and wireless solar-powered charging system for electric vehicles, there are several areas for further exploration and improvement. The following points outline key directions for future work:

- **Enhanced Wireless Power Transfer Efficiency:** Future work should focus on optimizing the efficiency of the wireless power transfer system, particularly by improving the alignment and energy conversion process. These may include investigation of more complicated resonant inductive and capacitive coupling schemes to reduce energy losses and extend power transfer range.
- **Advanced Energy Storage Solutions:** Better energy management during low solar irradiance periods could be realized by introducing high performance energy storage solutions, for instance, advanced batteries or super capacitors, in series with the photovoltaic modules. This will be a key moment to investigate energy storage technologies that are not only both efficient and cost effective, but also that will contribute to create a reliable charging experience.
- **Smart Grid Integration:** A next step for further research would be to combine the wireless solar powered charging system with existing smart grids. This would allow for dynamic energy distribution, real time load balancing, and the excess solar power can be fed back into the grid increasing the sustainability of the system as a whole.
- **Scalability and Commercial Viability:** The scalability and economic viability of the wireless solar-powered charging system need to be determined to ensure that scalability and economic viability in real world projects. Additionally, this comprises testing the system in regions having different sunlight conditions and different infrastructure requirements, and does a detailed cost benefit analysis.
- **Regulatory and Policy Frameworks:** As the adoption of wireless solar-powered charging systems increases, it will be essential to establish regulatory standards and policies to ensure safety, compatibility, and uniformity across the EV charging infrastructure. Research in this area

could help guide government and industry decision-making to support widespread implementation.

Conclusion

The development of a smart, sustainable, and wireless solar-powered charging system for electric vehicles presents a promising solution to the challenges of clean energy integration and efficient EV infrastructure. By combining wireless power transfer technology with solar energy, this system not only reduces the reliance on traditional grid-based power sources but also contributes to the broader goal of decarbonizing the transportation sector. The research demonstrates that such systems can offer increased convenience, scalability, and environmental benefits while promoting the adoption of electric vehicles. However, further advancements in wireless power efficiency, energy storage, and smart technologies are necessary to fully realize the potential of this innovative charging approach. As electric vehicles become more prevalent, integrating sustainable charging solutions like this one could play a pivotal role in shaping a greener and more sustainable future for transportation.

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