Solar Powered Wireless Charging with EV BMS and Charge Monitoring

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Abstract- As electric vehicles (EVs) are increasingly being adopted, there is an increasing demand for efficient, safe, and convenient charging systems. This project introduces a solar- powered wireless EV charging system with IoT-based monitoring to improve reliability, safety, and convenience. The system uses solar power from a photovoltaic panel and wirelessly transmits power through inductive coupling between transmitter and receiver coils. The energy that is transmitted is controlled and utilized to charge a 12V battery on the electric vehicle. For safe operation, the system features voltage and current sensors, temperature monitoring, and relay protection. An Arduino Uno microcontroller controls the logic, such as mode selection (slow or fast charging) and fault detection. Real-time information like voltage, current, and temperature is shown on a 16x2 LCD and sent remotely using an ESP8266 Wi-Fi module, allowing smart monitoring using IoT. This method eliminates physical connectors, lowering wear, the risk of fire, and maintenance while encouraging green energy consumption. It provides a scalable, green alternative to traditional plug-in chargers, particularly in off-grid or outdoor settings. The synergy of solar power, wireless charging, and IoT makes this system a leap ahead in contemporary EV infrastructure technology.

Indexed Terms—Solar Energy Harvesting Wireless Power Transfer, Electric Vehicle (EV) Charging, Battery Management System (BMS), Real-Time Charge Monitoring.

I. INTRODUCTION

With the world moving towards clean and sustainable energy in greater numbers, electric vehicles (EVs) have become a viable option to replace conventional combustion- engine vehicles. Yet, constraints in charging infrastructure and battery range are major hindrances to mass adoption. In order to solve these, this project comes up with a solar-powered wireless charging system along with an electric vehicle battery management system (BMS) and fire protection system based on the Internet of Things (IoT) technology. The novel system does away with the physical charge cables by utilizing wireless power transfer, which particularly comes in handy in public or roadside charging application. It utilizes solar energy as a green, renewable energy source, rendering the installation environmentally friendly and economical. It has slow and fast charging modes, real-time battery voltage and current moni- toring, and a fire sensor for extra protection. The Internet of Things (IoT) feature provides remote monitoring and control for improved efficiency and convenience to users. This project not only makes the EV charging process easier but also works towards ensuring safer and smarter energy consumption. With the integration of solar technology, wireless power transfer, and IoT, this system is a leap towards developing a more sustainable and intelligent electric mobility infrastructure.[1]

II. LITERATURE SURVEY

The shift to electric vehicles (EVs) has promoted extensive research into alternative charging systems, particularly those that are convenient and sustainable. Conventional plug-in charging systems, while common, are generally plagued by poor accessibility, user inconvenience, and grid dependency. In response, wireless power transfer (WPT) technology has emerged as a viable option due to its potential to transfer power without physical contacts, enhancing both user con- venience and system security. Research like that of Kurs et al. (2007) has proven the effectiveness of resonant inductive coupling for mid-range wireless power transfer, which is the basis for contemporary EV wireless charging systems. Solar energy integration into EV charging is also a well-studied topic, with research by A.K. Tripathi et al. (2016) investigating the feasibility of solar-powered charging stations to minimize reliance on traditional electricity and decrease carbon emis- sions. Battery management systems (BMS) play a significant role in monitoring the performance, temperature, and safety of EV batteries. A study by N. Omar et al. (2014) emphasizes the significance of BMS in maximizing battery life and maintain- ing operational safety, especially in high-power applications. The use of IoT in these systems provides an additional layer of functionality, supporting real-time data transfer and remote control, as discussed in research by S. Zanella et al. (2014) on IoT in smart energy systems. The integration of solar-powered WPT with IoT and BMS forms a holistic solution addressing range anxiety, safety, and efficiency of operation. Yet, real-time fire detection and programmable load cutoff, as exhibited in this work, are unmapped areas, leaving scope for research. This literature context justifies the suggested system as an innovative and pragmatic measure towards green and smart EV infrastructure.[2]

III. METHODOLOGY

A. Existing System

Traditional electric vehicle (EV) charging systems are predominantly wired-based and grid-based. The majority of these systems demand manual plugging of the vehicle into a charging station. Such arrangements are usually constrained by infrastructure limitation, number of charging points, and limited flexibility. Additionally, they pose risks like wear and tear on cables, weather exposure, as well as the risk of overheating or electrical malfunctions. The traditional systems also do not usually provide real-time battery condition updates or fire protection features. Remote monitoring is small or nonexistent, reducing proactive charging process management.

B. Proposed System

The suggested approach overcomes these drawbacks through the integration of a solar-powered wireless EV charging system with a Battery Management System (BMS), fire protection, and Internet of Things (IoT)-based monitoring. The system starts with solar panels producing power, which is stabilized and amplified through the use of a voltage booster. The power is transmitted wirelessly through inductive coils. The receiver coil mounted on the EV harvests this energy and utilizes it to charge the onboard battery. A charging process is monitored using an Arduino Uno microcontroller through voltage and current sensors. This information is represented on an LCD and also sent wirelessly through an ESP8266 Wi-Fi module for remote monitoring. A temperature sensor provides protection by sensing excessive heat; in case of a possible fire hazard, a relay will disconnect the load immediately to avoid damage.

The system also provides slow and fast charging modes, which can be chosen through manual input. All parts are designed to enable efficient energy transfer, real-time monitor- ing, and improved safety, making it a smart and eco-friendly charging option compared to traditional methods.

C. Transmitter Section

- Solar Panel[As shown in FIG-1,FIG-2] (5W) o Purpose: To transform sunlight into electrical power.
- Functionality: Serves as the green energy source for the wireless charging system, making off-grid functionality possible.

Voltage Stabilizer

- Purpose: To provide a constant voltage output from the solar panel.
- Functionality: Shields the system against voltage fluctuations caused by varying sunlight intensity.

Voltage Booster (MT3608 Module)

- purpose: To boost the stabilized voltage to a suitable level for power transmission.
- Functionality: Increases the voltage prior to passing it to the transmission coil to provide enough power for inductive transfer.
- Transmitter Coil (25-Gauge Copper Wire) o Purpose: To create an alternating magnetic field for wireless energy transmission.
- Functionality: Generates the field that induces current in the receiver coil through electromagnetic coupling.

- Charging Mode Switch (Push Buttons) o Purpose: To allow selection between slow and fast charging modes.

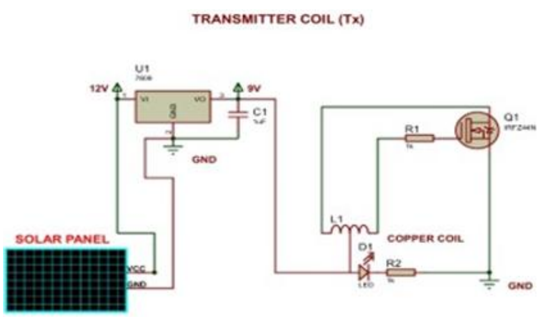

FIG-1: Circuit Diagram of Transmitter Coil

- Functionality: Users can control the charging speed based on battery condition or available power.
- Arduino Uno o Purpose: Serves as the controller for system logic and safety features.
- Functionality: Manages inputs from sensors and controls relays and charging modes accordingly.
- Positioned at the rear side of the front vehicle for effective power transfer.
- Relay Module o Purpose: To act as a safety switch in case of emergency.
- Functionality: Disconnects the output when triggered by abnormal temperature conditions or system faults.

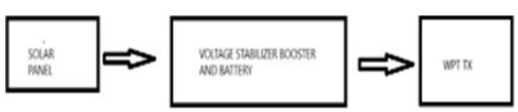

FIG -2: BLOCK DIAGRAM TRANSMITTER

D. Receiver Section

- Receiver Coil[As shown in FIG-3,FIG-4] (25-Gauge Cop- per Wire) o Purpose: Captures the magnetic field generated by the transmitter. o Functionality: Converts magnetic flux into alternating current through inductive coupling.
- Voltage Booster o Purpose: Raises the voltage received from the coil to a suitable level for battery charging. o Functionality: Ensures the battery receives sufficient energy regardless of minor losses during transmission.
- 12V DC Battery o Purpose: Stores the electrical energy for vehicle use. o Functionality: Receives controlled power input and supplies energy to the electric drivetrain or accessories.
- LM317 Voltage Regulator o Purpose: Adjusts output voltage based on selected charging mode (slow or fast). o Functionality: Protects the battery by maintaining optimal voltage levels for different charging speeds.
- Arduino Uno o Purpose: Acts as the brain of the system. o Functionality: Monitors sensor readings, controls the relay, and communicates with other modules.
- Voltage Sensor o Purpose: Monitors the voltage level of the battery in real-time. o Functionality: Prevents overvoltage conditions by sending data to the microcontroller.

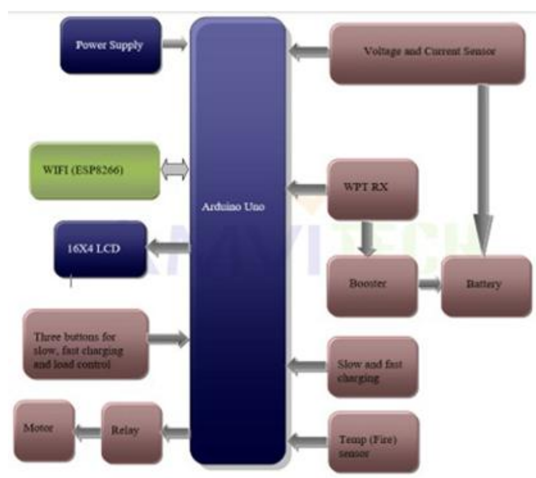

Fig -3: Block Diagram Receiver

- Current Sensor o Purpose: Measures the current flowing into the battery. o Functionality: Helps maintain safe charging rates and detect abnormalities.
- DS18B20 Temperature Sensor o Purpose: Detects over- heating or fire risks. o Functionality: Sends temperature data to Arduino, which can trigger emergency cutoff via relay.
- Relay Module o Purpose: Disconnects the battery from the circuit in hazardous situations. o Functionality: Acts as a safety mechanism controlled by the microcontroller.
- ESP8266 Wi-Fi Module o Purpose: Enables real-time data transmission to cloud or mobile apps. o

Functionality: Supports IoT features like remote monitoring of voltage, current, and temperature.

- 16x2 LCD Display o Purpose: Displays live system data. o Functionality: Shows battery voltage, current, temperature, and charging status to the user.[3][4][5]

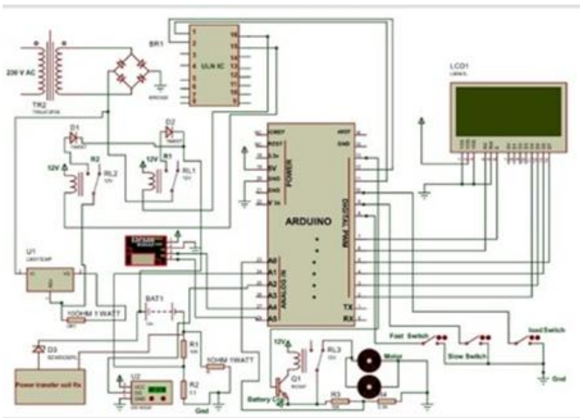

Fig-4: Circuit Diagram of Receiver Coil

IV. RESULT

The prototype solar-powered wireless electric vehicle (EV)[As shown in FIG-5] charging system was successfully developed and tested. As indicated in the above picture, the system includes all the major components explained in the design, such as the solar panel, voltage booster, transmitter and receiver coils, Arduino Uno, sensors,and LCD display. In operation, the solar panel produced DC power, which was regulated and amplified before being supplied to the transmitter coil. This coil produced a fluctuating magnetic field that allowed wireless energy transfer to the receiver coil on the vehicle side. The energy received by the receiver was stabilized with a voltage booster and LM317 regulator before being stored in the onboard 12V battery. The Arduino Uno efficiently tracked the important parameters like battery voltage, charging current, and temperature. All this information was continu- ously shown on the 16x2 LCD display, and the system could also be remotely tracked using the ESP8266 Wi-Fi module for smart IoT-based charge monitoring. Safety features, including automatic shutdown through the relay during overheat or overvoltage conditions, performed as designed. The prototype exhibited successful switching between slow and fast charging modes using push button inputs. In general, the hardware system was stable under test conditions and confirmed the idea of contactless EV charging using solar power and IoT integration. The visual and functional outputs were consistent with the design goals, demonstrating the viability of the proposed solution.[6]

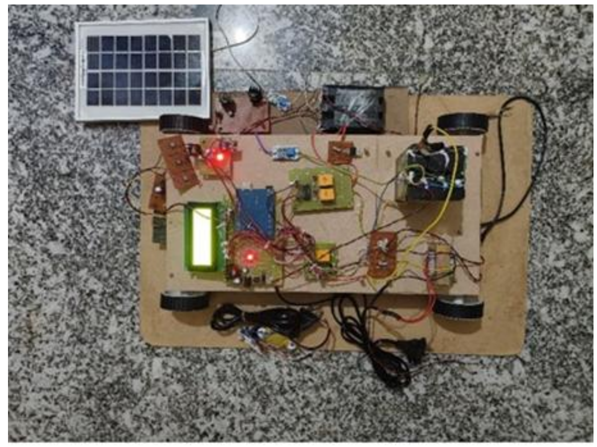

FIG-5 PROTOTYPE OF PROJECT

CONCLUSION

Implementation of solar-powered wireless electric vehicle (EV) charging system integrated with IoT-based monitoring has been effectively proved using this project. The proposed prototype establishes the potential use of renewable solar power and wireless power transfer as a credible, environment- friendly solution for replacement of conventional plug-in charging technique. Hardware installation effectively trans- ferred energy from the transmitter coil powered by the solar cell to the vehicle-mounted receiver coil through inductive coupling. Central components such as the voltage booster, LM317 regulator, sensors, and microcontroller collaborated to provide safe and regulated charging. Real-time visualization of data on the LCD screen and remote monitoring via the ESP8266 Wi-Fi module reflected the efficiency of IoT inte- gration. The prototype also featured protection elements like automatic relay shutdown in case of overheat or abnormal voltage conditions, which improved system security. Also, the facility to switch between slow and fast charge modes provided user flexibility. Overall, the project successfully integrated clean energy, wireless power transfer, and smart control into a space-saving EV charging technology. It lessens the reliance on wired infrastructure, encourages green technology, and provides scalability for smart grid integration in the future. This innovation promises prospects for real-world applications in contemporary EV infrastructure, particularly in off-grid and urban settings.[7]

REFERENCES

[1] Kurs, A. Karalis, R. Moffatt, J. D. Joannopoulos, P. Fisher, and M. Soljacˇic´, "Wireless power transfer via strongly coupled magnetic resonances," Science, vol. 317, no. 5834, pp. 83–86, Jul. 2007. https://doi.org/10.1126/science.1143254

[2] A. K. Tripathi, A. K. Raj, and P. Nema, "Solar pow- ered electric vehicle charging station: A review," International Journal of Renewable Energy Research (IJRER), vol. 6, no. 4, pp. 1191–1199, 2016.

[3] N. Omar, M. Daowd, P. Van den Bossche, J. M. Timmermans, and J. Van Mierlo, "Assessment of perfor- mance of lithium iron phosphate oxide, nickel manganese cobalt oxide and lithium manganese oxide batteries for plug- in hybrid electric vehicles," IEEE Transactions on Vehicu- lar Technology, vol. 63, no. 7, pp. 2513–2523, Sep. 2014. https://doi.org/10.1109/TVT.2013.2291328

[4] S. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, "Internet of Things for smart cities," IEEE Internet of Things Journal, vol. 1, no. 1, pp. 22–32, Feb. 2014. https://doi.org/10.1109/JIOT.2014.2306328

[5] M. Budhia, G. A. Covic, and J. T. Boys, "Design and optimization of circular magnetic structures for lumped inductive power transfer systems," IEEE Transactions on Power Electronics, vol. 26, no. 11, pp. 3096–3108, Nov. 2011. https://doi.org/10.1109/TPEL.2011.2143690

[6] Y. Hori, H. Fujimoto, and Y. Kawamura, "Wireless power transfer system for electric vehicles," in Proc. IEEE PESC, ２００７, pp. 1218–1224. https://doi.org/10.1109/PESC.2007.4342152

[7] M. S. Ehsani, Y. Gao, and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 2nd ed. CRC Press, 2009.