International Journal of
Electrical Power and Machine Systems

Volume 2, Issue 1, 2024
January—June
DOI (Journal): 10.37591/IJEPMS

https://journals.stmjournals.com/ijepms

Research IJEPMS

Smart Road Wireless Electric Vehicle Charging

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Abstract

Interest in electric vehicles (EVs) has increased recently due to worries about global warming and the depletion of petroleum resources. It is recognized that having access to wireless charging while traveling and EV charging stations systems are necessary for EV adoption and widespread use. Smart road for EV wireless charging using piezoelectricity is a novel technology that has the potential to revolutionize the transportation industry. When the EV is parked over the charging pad, electromagnetic induction is employed to transfer electricity wirelessly. Though it is currently slower than plug-in charging, wireless charging is widely utilized for speedy top-up charging at home or in parking lots. With the use of piezoelectric materials, this technology transforms the kinetic energy of moving cars into electrical energy, which is then utilized to wirelessly charge EV batteries while they are in motion. One of the key advantages of this technology is that it can provide EVs with continuous charging, even while they are in motion. This eliminates the need for EVs to stop and plug into charge, which can significantly reduce travel time and range anxiety.

Keywords: Smart road, Wireless electric vehicle charging, electric vehicle, ESP32,wireless charging, piezoelectric energy, piezoelectric material

INTRODUCTION

Concerns about global warming and the depletion of petroleum resources have led to a surge in interest in electric vehicles (EVs) in recent years [1].

It is acknowledged that the availability of EV charging stations and wireless charging while driving systems is essential to EV adoption and public penetration [2, 3]. There are two common ways to charge electric vehicles: plug-in charging and wireless charging [4–6]. Wireless charging sends electrical energy wirelessly from a charging pad to the EV's receiver pad, whereas plug-in charging requires physically attaching the EV to an external power source using a charging cable.

There are three EV charging levels that are widely used [7]: Level-1 charging is rather slow and adds 4 to 5 miles of range to a regular residential socket in an hour. With level-2 charging, which makes advantage of a higher voltage power supply, you may add about 25 to 30 miles of range in an hour of charging time. The quickest option is DC rapid charging, which may add a large amount of range in a matter of minutes, making it appropriate for long-distance travel. Conversely, wireless charging does away with the necessity of physical wires and plugs. It is made up of an EV-integrated reception pad and a charging pad that is placed in a parking spot. Electromagnetic induction is used to transfer electricity wirelessly when the EV is parked over the charging pad. Wireless charging is frequently used for quick top-up charging at home or in parking lots; however, it is currently slower than plug-in charging.

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Received Date: May 02, 2024
Accepted Date: June 04, 2024
Published Date: June 20, 2024

Citation: Saurabh Prakash Moon, Vaibhav Kalse, Anuragh Nagar, Y.M. Patil. Smart Road Wireless Electric Vehicle Charging. International Journal of Electrical Power and Machine Systems. 2024; 2(1): 1–7p.

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The ability of an EV to be charged depends on a number of variables, including the infrastructure for charging that is available. While wireless charging is more convenient for regular top-up charging in particular areas, plug-in charging offers speedier choices, such as DC fast charging for long-distance trips. This will have an impact on the number of fast EV charging stations when on-road wireless EV charging systems are taken into consideration as an alternative EV charging technique. The main goal of this article is to forecast EV charging loads and their distribution in space and time, taking into account both EV charging stations and on-road wireless EV charging. Because of their erratic charging demand, a lot of work has gone into simulating EV charging loads and examining their effects on the electrical grid. A technique for analyzing the plug-in charging infrastructure while taking drivers' behavior and price into account was created by Meher and Singh [8]. The goal was to forecast the energy consumption of certain EVs and match it with the supply that was available. When arranging the charging stations, the devised approach takes into account the EVs' starting state of charge (SOC) in addition to other variables. A framework was created by Gaur [9] with the goal of achieving a particular degree of user satisfaction while taking into account various demands for EV charging and energy sources, such as renewable energy with its unpredictable delivery. The created community-integrated energy system coordinated the reaction to changing EV charging loads based on the renewable energy that was available, acting as an energy internet system. Because there are many different sources of electrical energy, coordinating these sources can improve resource efficiency, lower the likelihood of an energy transfer deficit, optimize energy transfer tactics, and shorten peak hours. Sivaraj et al. [10] calculated the ratio of each facility by modeling the movement of energy through various facilities, including renewable energy sources. In light of the social welfare of the electricity market, the effect of wireless charging load on the location marginal price and retail price was examined and reported by Shabani et al. [11]. Piezoelectric materials are materials that can generate electricity when subjected to mechanical stress. This property is known as piezoelectricity. Piezoelectric materials find wide-ranging uses in several fields, such as energy harvesting, actuators, and sensors. Wireless charging of EVs is one possible use for piezoelectric materials. It is possible to insert piezoelectric materials on the surface of the road to capture energy from passing cars' weight. This energy can then be used to wirelessly charge EVs as they drive.

System Overview

A smart road for EV wireless charging using piezoelectricity would typically consist of the following components:

- *Piezoelectric energy harvesters:* These harvesters are embedded in the road surface andconvert the mechanical energy of passing vehicles into electrical energy.
- *Rectifiers:* Rectifiers convert the alternating current (AC) output of the piezoelectric energy harvesters into direct current (DC).
- *Filters:* Filters remove any noise or ripple from the DC output of the rectifiers.
- *Voltage regulators:* Voltage regulators regulate the DC voltage to a level that is safe forcharging EV batteries.
- *Batteries:* Batteries store the electrical energy generated by the piezoelectric energyharvesters. *ESP32:* The ESP32 is a microcontroller that can be used to monitor and control the system.
- *Wireless charging TX (transmitter):* The wireless charging TX transmits power to theEV's wireless charging RX (receiver).
- *Wireless charging RX (receiver):* The wireless charging RX receives power from thewireless charging TX and charges the EV's battery.
- *Voltage sensor:* The voltage sensor monitors the voltage of the EV's battery.

OBJECTIVE

The primary objective was to wirelessly charge EVs while they are in motion, using the energy generated by piezoelectric tiles embedded in the road.

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The secondary objectives were the following:

- To maximize the efficiency of energy transfer between the road and the EV.
- To protect the EV's battery from overcharging and other damage.
- To provide real-time feedback to the driver and the charging system on the status of the charging process.

Block Diagram

Block diagram of smart road EV is shown in Figure 1.

METHODOLOGY

The envisioned smart road infrastructure seamlessly integrates two innovative methodologies, harnessing sustainable energy through piezoelectric materials while concurrently enabling wireless charging for EVs. Methodology 1 establishes a foundation by embedding piezoelectric tiles in the road, tapping into the piezoelectric effect to generate electricity when subjected to the weight of passing vehicles. This generated voltage undergoes a meticulous process, including rectification, filtration, and regulation, culminating in a stable DC voltage. This energy powers wireless charging transmitter (TX) coils, facilitating wireless energy transfer to receiver (RX) coils on EVs.

Complementing Methodology 1, Methodology 2 introduces an advanced layer of control and monitoring. Piezoelectric tiles, connected to a rectifier circuit, yield a filtered and regulated DC output, essential for charging batteries efficiently. The incorporation of an ESP32 microcontroller enhances the system's intelligence, overseeing battery voltage, communicating with wireless charging units, and dynamically adjusting the voltage regulator to prevent overcharging. The inclusion of voltage sensors ensures real-time monitoring, facilitating adaptive adjustments to maintain optimal battery health.

Together, these methodologies create a symbiotic system that maximizes energy harvesting potential while prioritizing the longevity and efficiency of EV batteries. The piezoelectric tiles capture energy from vehicular motion, while the wireless charging technology seamlessly transfers power to EVs, eliminating the need for physical connections. This holistic approach not only contributes to sustainable energy practices but also represents a forward-looking solution for a greener and more advanced transportation landscape.

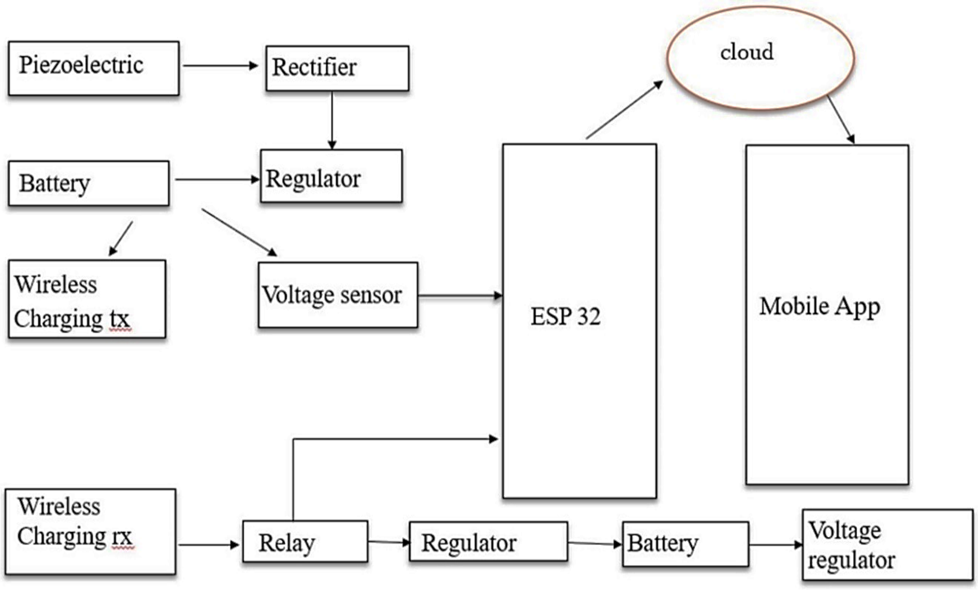

Figure 1. Block diagram of smart road electric vehicle (EV).

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As vehicles drive over the road, the piezoelectric materials generate electricity. To create a pure DC voltage, the electricity produced by the piezoelectric materials is rectified and filtered. He DC voltage is regulated to a safe level for charging electric vehicles. The regulated voltage is then fed to a wireless charging transmitter. The wireless charging transmitter transmits the electrical energy to a wireless chargingreceiver on the electric vehicle. The wireless charging receiver converts the electrical energy back to DC voltage andcharges the electric vehicle battery. The entire system is monitored and controlled by an ESP32 microprocessor. It can be used to monitor the voltage and current output of the piezoelectric materials, the input and output voltage of the wireless charging transmitter and receiver, and the state of charge of the electric vehicle battery. The ESP32 can also be used to communicate with the electric vehicle to optimize the charging process.

The following is a more detailed description of each component of the system:

Piezoelectric Materials

A piezoelectric material is shown in Figure 2. Piezoelectric materials produce electricity when they experience mechanical stress. When a piezoelectric material is bent orcompressed, it produces a voltage. The kind of piezoelectric material and the amount of stress applied determine how much voltage is produced.

Rectifier

An apparatus that changes alternating current (AC) into direct current is called a rectifier (DC). The rectifier in this setup transforms the AC electricity produced by the piezoelectric materials into DC electricity that can be utilized to recharge the battery of an electric car.

Filter

An apparatus that eliminates undesirable frequencies from a signal is called a filter. Any high-frequency noise in the DC current produced by the rectifier in this system is eliminated by the filter.

Voltage Regulator

A voltage regulator is an apparatus that, in spite of fluctuations in the input voltage, keeps the output voltage constant. Even though the voltage produced by the rectifier fluctuates in this setup, the voltage regulator keeps the input to the wireless charging transmitter at a steady value.

Battery

The device that stores the electrical energy produced by the system is the battery. Under this arrangement, the electric car stores its battery and uses it to power the vehicle [7].

Figure 2. Piezoelectric material.

ESP32 Microcontroller

ESP32 is an inexpensive, low-power microcontroller that is perfect for embedded devices (Figure 3). The ESP32 is utilized in this system to monitor and manage every aspect of the system [12].

Wireless Charging Transmitter

An apparatus that sends electrical energy wirelessly and without the need of cables to a wireless charging receiver is called a wireless charging transmitter. The wireless charging transmitter in this technology is integrated into the surface of the road.

Wireless Charging Receiver

The wireless charging receiver is a device that converts electrical energy transmitted from a wireless charging transmitter to DC electricity that canbe used to charge a battery.

Technical Data

Table 1 shows the features of ESP32.

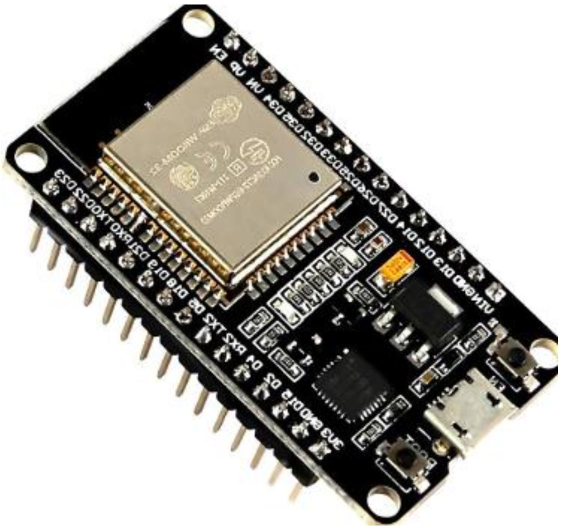

Figure 3. ESP32 microcontroller.

Table 1. Features of ESP32.

Specifications	**ESP32**
MCU	Xtensa® Dual-Core 32-bit LX6 600 DMIPS
802.11 b/g/n Wi-Fi	Yes, HT40
Bluetooth	Bluetooth 4.2 and below
Typical Frequency	160 MHz
SRAM	512 kbytes
Flash	SPI Flash, up to 16 Mbytes
GPIO	36
Hardware / Software PWM	1/16 channels
SPI/12C/I2S/UART	12-bit
Can	1
Ethernet MAC interface	1
Touch sensor	Yes
Temperature sensor	Yes
Working temperature	-40°C to 125°C

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RESULTS

A smart road for EV wireless charging using piezoelectricity is a promising technology that could revolutionize the way we power our vehicles. Certain materials have the property known as piezoelectricity, which allows them to produce electricity under mechanical stress. Because of this, they are perfect for use in energy-harvesting tasks like EV charging. One way to implement a smart road for EV wireless charging is to use piezoelectric materials embedded in the road surface. As vehicles drive over the road, the piezoelectric materials would generate electricity, which could then be used to charge EVs wirelessly. Another way to implement a smart road for EV wireless charging is to use piezoelectric materials to generate electricity from the vibration of bridges and other structures.

CONCLUSION

Smart roads for EV wireless charging using piezoelectric energy harvesting have the potential to revolutionize the way we power our vehicles. Piezoelectric materials can be used to produce effective EV charging systems by transforming the kinetic energy of moving vehicles into electrical energy. One way to implement a smart road for EV wireless charging is to use a combination of piezoelectric energy harvesters, rectifiers, filters, voltage regulators, batteries, ESP32 microcontrollers, wireless charging transmitters and receivers, and voltage sensors. The piezoelectric energy harvesters would be embedded in the road surface and would generate electricity as vehicles drive over them. The rectifiers would convert the alternating current (AC) generated by the piezoelectric harvesters to direct current (DC). The filters would remove any noise or ripple from the DC signal. The voltage regulators would ensure that the DC voltage is at the correct level for charging the vehicle's battery. The batteries would store the energy generated by the piezoelectric material.

Acknowledgements

We feels immense pleasure gratitude. It will be unfair to bind the precious help and support which I got from many people in a few words. But words are the only medium of expressing one’s feelings and my feeling of gratitude is absolutely beyond these words. It would be my pride to take this opportunity to say thanks. Firstly, I would thank my beloved guide Dr. Y.M. Patil for his valuable guidance patience and support. He was always there to force me a bit forward to get the work done properly and on time. He has always given me freedom to do dissertation work and the chance to work under his supervision. It is the love and blessings of my family and friends which drove me to complete this dissertation work. Thank you all!

REFERENCES

1. Sbordone D, Bertini I, Di Pietra B, Falvo MC, Genovese A, Martirano L. EV fast charging stations and energy storage technologies: a real implementation in the smart micro grid paradigm. Electris Power Syst Res. 2015; 120: 96–108.
2. Conti J, Holtberg P, Diefenderfer J, LaRose A, Turnure JT, Westfall L. International Energy Outlook 2016 with Projections to 2040. Technical Report. Washington, DC, USA: USDOE Energy Information Administration (EIA); 2016.
3. Colombo CG, Miraftabzadeh SM, Saldarini A, Longo M, Brenna M, Yaici W. Literature review on wireless charging technologies: future trend for electric vehicle? In: Proceedings of the 2022 Second International Conference on Sustainable Mobility Applications, Renewables and Technology (SMART), Cassino, Italy, November 23–25, 2022. pp. 1–5.
4. Rotering N, Ilic M. Optimal charge control of plug-in hybrid electric vehicles in deregulated electricity markets. IEEE Trans Power Syst. 2010; 26: 1021–1029.
5. Lee KB, Ahmed MA, Kang DK, Kim YC. Deep reinforcement learning based optimal route and charging station selection. Energies. 2020; 13: 6255.
6. Zhang J, Yan J, Liu Y, Zhang H, Lv G. Daily electric vehicle charging load profiles considering demographics of vehicle users. Appl Energy. 2020; 274: 115063.
7. Tuttle DP, Baldick R. The evolution of plug-in electric vehicle-grid interactions. IEEE Trans Smart Grid. 2012; 3: 500–505.

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8. Meher SR, Singh RK. Single-phase wireless electric vehicle charger using EF2 inverter. Int Trans Electric Energy Syst. 2023; 2023: Article 6038394. doi: 10.1155/2023/6038394.
9. Gaur S. A research paper on wireless charging. J Emerging Technol Innov Res. 2019; 6 (5): 648–655.
10. Sivaraj K, Dhivya Bharathi M, Beth Preethi S, Gajendiran V, Gokul Prasanth S. Wireless power transfer (WPT) forelectric vehicles charging (EVs) using piezo electric sensors. Int J Eng Res Technol. 2016; 4 (11): 1–3.
11. Ahmed S, Ahn E, Taha MR, Dessouky S, Genedy M, Fernandez D, et al. Smart charging of future electric vehicles using roadway infrastructure. Transportation Consortium of South-Central States, United States; 2019.
12. Ching TW, Wong YS. Review of wireless charging technologies for electric vehicles. 2013 5th International Conference on Power Electronics Systems and Applications(PESA), Hong Kong, China, 2013, pp. 1-4. DOI: 10.1109/PESA.2013.6828235.

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