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Design And Analysis Of Wireless Charging For Evs Using Solar Roadways

[1] Mayur Santosh Harnale, [2] Vaishnavi Vijay Chavan, [3]Rushita Babulal Raut

[4] Dr. Pabitra Kumar Guchhait

[1]Student, [2]Student, [3]Student, [4] Assistant Professor

[1] Department of Electrical Engineering,

[1] G H Raisoni College of Engineering and Management, Pune, India

Abstract: The purpose of this research is to investigate wireless communication over solar roads. Wireless communications can be transmitted by the renewable energy produced by solar panels installed in road surfaces. The production of energy, signal strength, range, and dependability are the main topics of the study. The initiative intends to use solar energy to construct a sustainable communication system that will help rural locations and encourage environmentally friendly infrastructure

Index Terms - Wireless power transmission, Solar roadways, Solar panel, Renewable energy

I. Introduction

The goal of this research is to investigate how solar panels can be installed on road surfaces to collect sunlight and produce electricity. After that, a base station receives the electricity. The vehicle get charged by WPT. The goal of this creative strategy is to produce a power generation and distribution system that is more efficient and sustainable. Sunlight is captured on vast surfaces when photovoltaic cells are embedded in highways. Prior to being wirelessly transported via inductive charging—a process that transfers energy through electromagnetic fields without physical contact the generated electricity is optimized by a power conditioning device. The energy is received by the base station, where it can be utilized to power other gadgets or charge electric cars. Because it does not use conventional power lines.

ROADWAYS are primarily composed of asphalt. Solar roadway is a newly established notion that designed to seek innovatively to better its construction and usage. Solar roadways, also known as smart roadways or solar highways, are composed of silicon wafers that generate electricity. They are durable and easily replaceable due to their excellent honeycomb structure. Highway space in a single layer could produce 61 MW of electricity. Solar highways could produce around three times the current electricity consumption with a minimum efficiency of 15%. When two solar panel layers are stacked one on top of the other, the yearly energy production of the same roads can increase to 229 GWH and 140 GWH, respectively.

II. Methodology

By integrating solar panels onto the surface of the road to collect sunlight, wireless power transmission via solar highways and a base station is made possible. Through the use of a base station, the electricity generated by the solar panels is wirelessly sent to cars or other devices. This eliminates the need for wires or charging stations and makes it easier to power gadgets and charge electric cars. The fundamental idea is to build solar roadways by integrating solar panels onto the surface of the roads. By absorbing sunlight,

these solar panels produce power. A base station is then used to wirelessly transfer this electricity to cars or other devices. This is a condensed, step-by-step explanation of the process.

- **Solar Roadways:** Instead of using regular asphalt or concrete, solar panels are embedded into the road surface. The sturdy construction of these solar panels allows them to support the weight of automobiles.
- **Sunlight Capture:** Photons from the sun are absorbed by the solar panels. An electrical current is produced in the solar panels by the photons' excitation of the electrons.
- **Conversion to AC:** The DC (direct current) electricity generated by the solar panels is converted into AC (alternating current) electricity using inverters. AC power is more appropriate for long-distance electrical transmission.
- **Wireless Power Transmission:** Using a base station, automobiles or other equipment get AC electricity wirelessly from the solar roads. The magnetic field produced by the base station's coils causes an electrical current to be induced in receiving coils mounted in cars or other devices.
- **Device Charging and Powering:** Next, electric car batteries are charged or other devices, like tablets or smartphones, are powered by the induced electrical current in the receiving coils.

III. Block Diagram

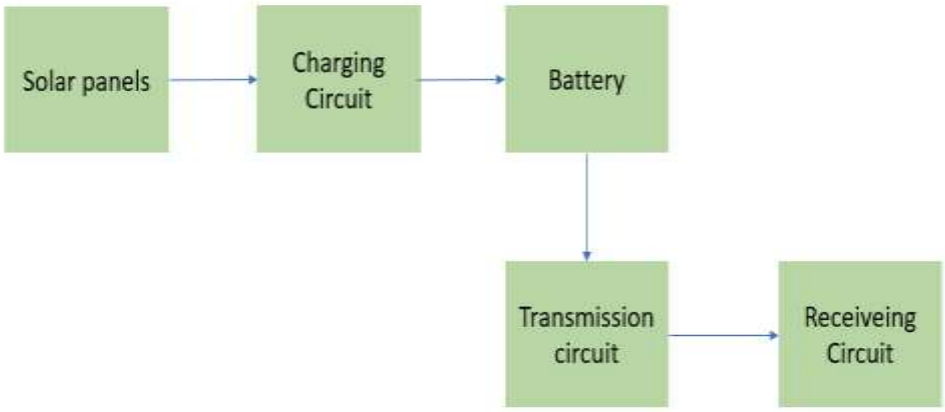

Fig 1: Block Diagram of Design And Analysis of Wireless Charging For EVs Using Solar Roadways

IV. Block Diagram Description

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- **Solar Roadways:** The surface of the road has solar panels integrated in it. They are employed to harvest solar energy and transform it into electrical power. The charging circuit is then supplied with this energy.
- **Power Conversion and Conditioning:** Power conversion and conditioning steps are applied to the DC electricity that is created. This entails transforming the DC current into AC electricity and making sure it is sent at the proper voltage and frequency.
- **Charging circuit:** The charging circuit is in charge of managing and regulating the electricity flow from the solar panels to the battery. It ensures battery charging that is both secure and efficient.
- **Battery:** The battery stores the electrical energy generated by the solar panels. As a power reserve, it can be used as needed, for example, during periods of low sunshine or high demand for electricity.
- **Power Transfer:** Wireless power transfer is made possible by the magnetic field's ability to produce an electrical current in the receiving coils. Other equipment or the batteries of electric cars can be powered by this current.
- **Wireless Power Transmission (WPT):** Power is wirelessly transferred from a base station to receiving coils in gadgets or automobiles using the WPT method. It generates a magnetic field using electromagnetic induction, which causes an electrical current to flow through the receiving coils. Other equipment or the batteries of electric cars can be powered by this current.

- **Solar Panel:** Also known as photovoltaic (PV) panels, these devices use sunshine to generate electricity through the photovoltaic effect. Electric current is produced when sunlight strikes the silicon material of the solar cells inside the panels, exciting the electrons.
- **charging circuit:** The charging circuit designed to efficiently harvest energy from solar panels and store it in a battery bank. At the heart of the charging circuit is a boost converter, which utilizes a capacitor to boost energy from the solar panel to the required voltage level
- **Power Source:** Because Li-ion batteries offer backup power during times of low sunlight or peak demand, they are essential for using solar roads and a base station for wireless power transfer. In Li-ion batteries, which consist of an anode, cathode, and electrolyte, lithium ions flow back and forth between the two. In this process, energy is stored. These batteries are a better option because to their increased energy density, improved energy efficiency, and longer lifespan. However, because of their chemical makeup, Li-ion batteries need to be handled carefully and under the right supervision to prevent thermal runaway.
- **Transfer Circuit:** A circuit controls the flow of power from the base station to the solar roadways. The switching circuit acts as a conduit between the power supply and the roadways, enabling efficient power transmission. The Circuit responsible for converting DC power from the battery bank to AC power and transmitting it wirelessly to electric vehicles. The transmission circuit consists of an inverter, which converts the DC power to AC power, and a wireless power transfer.
- **Receiving Circuit:** The Receiving Circuit is a crucial component of the Wireless Power Transfer (WPT) system, responsible for receiving the transmitted power from the Transmitter Coil and converting it into DC power to charge the vehicle's battery. The circuit consists of a Receiver Coil, Rectifier Circuit, Filtering Circuit, Voltage Regulator, and Battery Management System (BMS). The Receiver Coil receives the magnetic field generated by the Transmitter Coil, inducing a voltage that is sent to the Rectifier Circuit, which converts the AC voltage into DC power. The Filtering Circuit filters out unwanted AC components, smoothing the DC output, while the Voltage Regulator regulates the DC output voltage to match the vehicle's battery voltage.

❖ **Flow-Chart**

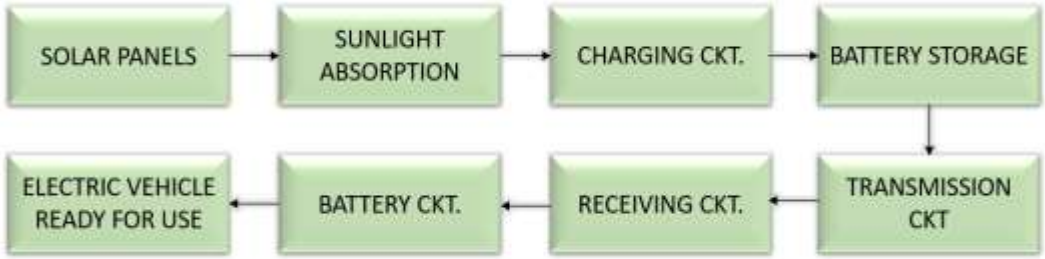

Fig 2 : Flow Chart

V. Components Used

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VI. Working Mechanism

- Solar Panels Integrated into Road Surface
- Battery Charging
- Energy Transmitted to Base Station
- Wireless Power Transmission

VII. Wireless Power Transmission

Solar energy must first be converted into electrical energy, then into electromagnetic waves for wireless transmission, and finally back into electrical energy so that receiving devices may use it. This process is known as wireless power transmission. As listed below, there are multiple steps involved.

Energy generation → Energy Conversion → Transmission

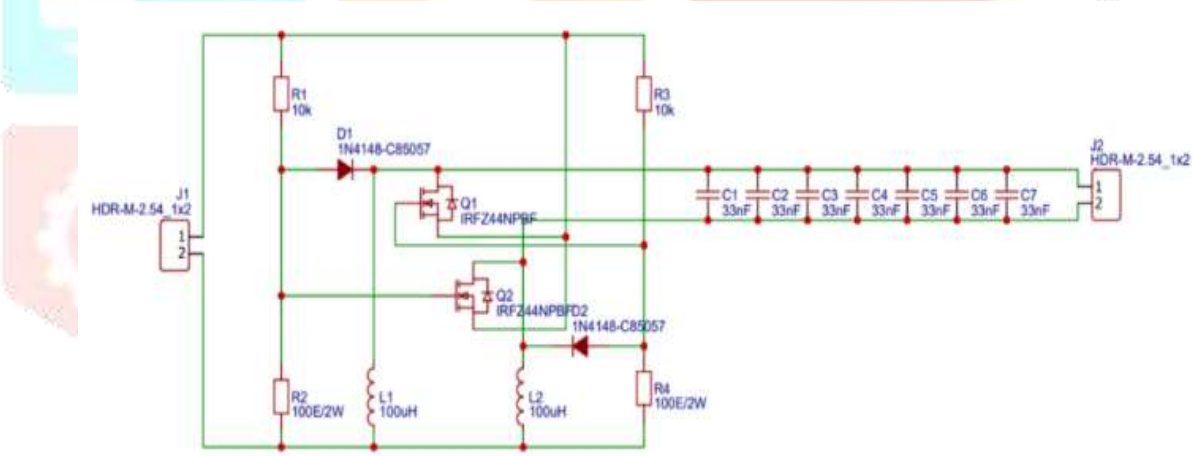

Fig 3: Wireless Power Transmitter

The wireless power transmitter functions based on the principle of electromagnetic induction. It includes a primary coil, connected to a power source, and a secondary coil, linked to the receiver or base station. When an alternating current passes through the primary coil, it creates a fluctuating magnetic field. This magnetic field generates a voltage in the secondary coil, which can then supply power to the base station.

The effectiveness of power transfer is influenced by factors such as the spacing between the coils, their alignment, and the system's design. Enhancing these aspects is crucial for achieving efficient and reliable wireless power transmission. This innovative technology has the potential to transform how we charge devices and distribute power across various applications.

VIII. Wireless Power Receiver Wireless Power Receiver

The wireless power receiver circuit is mounted on the vehicle to enable efficient energy transfer from the road infrastructure to the vehicle's onboard battery. Designed specifically for this purpose, the circuit captures wirelessly transmitted energy from the solar-powered road and converts it into usable electrical energy. It uses a coil or antenna as a receiving element to intercept the oscillating magnetic field generated by the transmitter embedded in the road. This process, based on electromagnetic induction, induces a voltage in the receiver coil.

Since the induced voltage is in the form of alternating current (AC), a rectifier circuit is used to convert it into direct current (DC), which is suitable for charging the vehicle's battery. To ensure a stable and consistent energy flow, capacitors are integrated into the circuit to smooth out any voltage fluctuations. The circuit's efficiency is vital for the success of solar roadways, as it minimizes energy losses during transfer and maximizes the power stored in the battery. Key factors influencing its performance include the alignment between the road's transmitter and the vehicle's receiver, as well as the use of high-quality components. With this technology, vehicles can wirelessly charge their batteries both while stationary and in motion, eliminating the need for conventional charging stations and making solar-powered infrastructure more practical and sustainable.

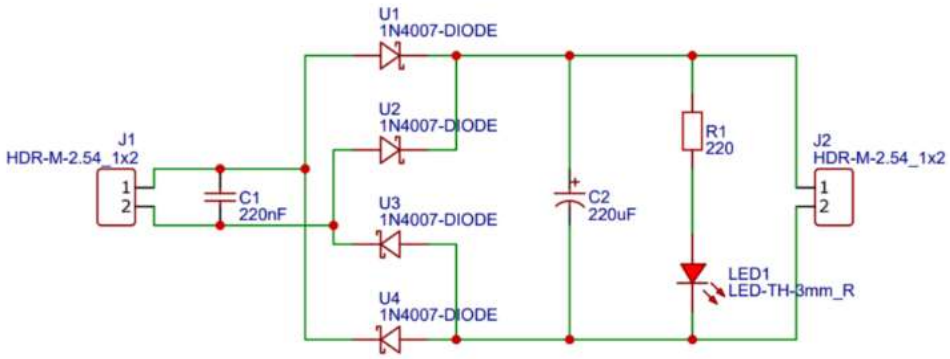

Fig 4: Wireless Power Receiver

IX. Solar Power Li-ion Battery Charger Circuit

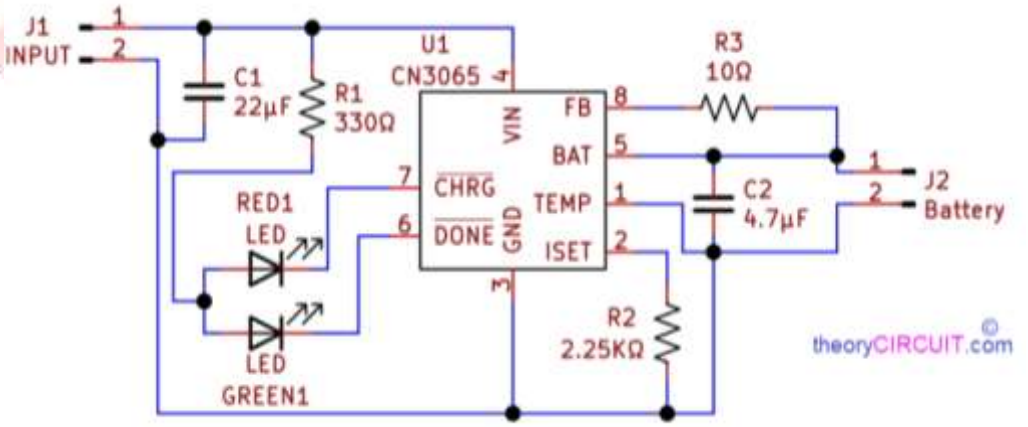

Fig 5: Solar Power Li-ion Battery Charger Circuit

The energy produced by the solar roads is probably stored in Li-ion batteries so that it may be wirelessly sent to the base station. This contributes to having an effective and sustainable power supply. 1. Li-ion batteries are essential to the concept known as wireless power transfer using solar roads and a base station. Because of their high energy density—that is, their ability to store a significant quantity of energy in a tiny package—these batteries are widely employed. 2. The electrolyte, anode, and cathode are the three main components of Li-ion batteries. Usually, the cathode is made of lithium iron phosphate or cobalt oxide, whereas the anode is made of graphite. An organic solvent containing dissolved lithium salt serves as the electrolyte, allowing lithium ions to move freely. 3. During charging, lithium ions are moved from the cathode to the anode, where they are stored, via the electrolyte. When the battery discharges, the lithium ions return to the cathode, releasing the

stored energy.4. Li-ion batteries are favoured in part because of their great energy efficiency. They are able to maintain their charge for extended periods of time because to their low self-discharge rate. In addition, their lifespan is longer than that of other battery kinds. 5. It is crucial to remember that Li-ion batteries can experience thermal runaway and that they need to be properly managed due to their sensitivity to high temperatures. Because of their chemical makeup, careful handling and appropriate disposal are also required.

X. Advantages

The advantages of the proposed system can be summarized as follow:

[1] Clean and Renewable Energy: Solar highways produce power by harnessing solar radiation. By using solar energy, we can reduce carbon emissions and our dependency on fossil-fuels.

[2] Efficient Power Generation: Long-distance transmission lines are not necessary since solar roads can produce electricity exactly where it is required. As a result, there is less energy lost during gearbox, increasing system efficiency.

[3] Infrastructure Integration: Solar highways can effectively use the available area by integrating into the current road infrastructure. This implies that we can produce electricity without occupying more space or changing the natural environment. 4.Decentralised

[4] Power Generation: Without the use of conventional power cables, electricity may be sent straight from the solar roadways to the base station using wireless power transmission. By using a decentralised strategy, the power grid's resilience can be increased and the likelihood of power outages decreased.

[5] Sustainability: By utilising solar energy, solar highways offer a sustainable means of producing electricity. As a result, there is less need on non-renewable energy sources, aiding in the shift to a more sustainable and greener future.

[6] Cost Savings: Wireless power transmission via solar highways may result in long-term cost savings by producing electricity locally and lowering the requirement for substantial power infrastructure.

[7] Sustainability: By utilising solar energy, solar highways offer a sustainable means of producing electricity. As a result, there is less need on non-renewable energy sources, aiding in the shift to a more sustainable and greener future.

[8] Flexibility and Scalability: Since wireless power transmission may be integrated into a variety of items, including wearable technology, automobiles, and infrastructure, it provides flexibility in the placement of power-receiving devices. Opportunities for wider adoption and utilisation are created by this scalability.

[9] Lessened Environmental Impact: The overall environmental impact is lessened by using wireless transmission and solar energy. This entails cutting back on carbon emissions, relying less on conventional power plants, and protecting the environment's natural resources.

[10] Safety and Convenience: By doing away with physical connections and wires, wireless power transmission lowers the possibility of mishaps like electrical shocks or tripping hazards. It also provides the ease of charging gadgets without the trouble of constantly connecting and unplugging cords.

[11] Energy Independence: Wireless power transmission and solar highways can help people and communities become more self-sufficient and producing their own electricity. When typical power sources are unavailable, such as in distant places or during natural catastrophes, this can be quite-helpful.

[12] Less Maintenance: Compared to conventional roads, solar roadways are made to last a long time and need less upkeep. As a result, there may be financial savings and reduced interference with traffic during maintenance tasks.

[13] Innovation and Technical Progress: The creation and application of solar roads for wireless power transfer necessitates technological and engineering breakthroughs. This encourages creativity and creates opportunities for breakthroughs in infrastructure and renewable energy in the future.

[14] Increased Safety: By including elements like LED lighting and sensors, solar roadways can increase road safety and visibility. Furthermore, since wireless power transfer does not require overhead power lines, there is a lower chance of mishaps or damage from falling cables.

XI. Applications

the proposed system can be employed at variety of applications such as :

1. Electric Vehicle Charging: On solar highways, electric vehicles can be charged while operating thanks to wireless power transmission. This makes it possible to conveniently and continuously charge while on the go, doing away with the need for frequent pauses at charging stations.
2. Smart Infrastructure: By integrating sensors and data transmission technology, solar highways can be made part of a smart infrastructure. This makes it possible to monitor traffic patterns, road conditions, and even the weather in real time, which improves transportation systems.
3. Public Transportation: By lowering the dependency on fossil fuels and increasing environmental friendliness, wireless power transfer can be utilised to charge electric buses or trams.
4. Outdoor Lighting: Wirelessly powered LED lights can be included into solar highways. This can improve safety and visibility by providing effective and environmentally friendly illumination for walkways, highways, and other outdoor spaces.
5. Charging of Mobile Devices: Tablets and smartphones can be charged via wireless power transmission. This implies that you won't need wires or charging stations to keep your gadgets charged as long as you're travelling on a solar roadway.

XII. Results

Fig 6: Top View

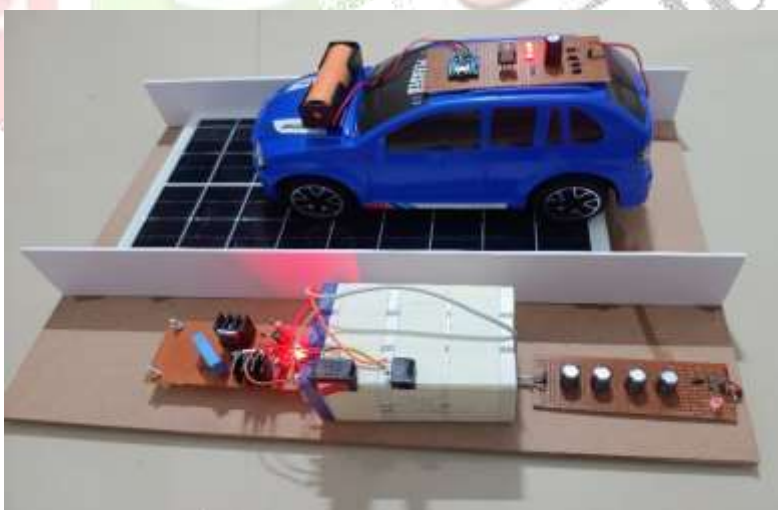

Fig 7: Side View

XIII. Conclusion

In the quest for sustainable energy solutions, the initiative represents a critical turning point. Through the integration of cutting-edge technologies such as wireless power transmission and solar highways, we have made progress toward building an energy infrastructure that is more intelligent, resilient, and cleaner. We have proven during this project that it is feasible and even possible to directly harvest solar energy from road surfaces and wirelessly transport it to neighboring locations in an efficient manner. By lowering pollution and carbon emissions, this strategy not only lessens our dependency on finite fossil fuels but also lessens its negative effects on the environment. The system's adaptability and scalability are further increased by the incorporation of base stations as energy distribution centers, enabling the use of renewable energy even in isolated or underserved locations.

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