Solar Roadways for Wireless Charging of Electric Vehicles

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ABSTRACT

Since the most feasible mode of transportation is road transportation, it has significantly increased during the past few years. So, there is a rapid increase in energy consumption and oil dominates among the various energies. But due to the huge carbon emission, it contributes to air pollution and climate change. Due to the higher energy efficiency and less carbon emission, electricity is more preferred but there are limitations for this too. By shifting from conventional to electric vehicles, carbon emissions in the transportation sector can be reduced. Solar energy is the most widely used renewable energy source, and it can be used to produce electricity, power electric vehicles, and provide power for electric infrastructure. Consequently, using solar energy to power roads is a viable strategy for sustainable transportation. This solar powered road will charge the electric vehicle by a mechanism such that when the vehicle moves over the road, it will automatically charge. The solar panels will charge the battery, and this is inverted to the wireless coils mounted inside the roads which are the transmitter coils. It actually has two parts - transmitter part and receiver part. The transmitter part is the coils mounted inside the roads and the receiver coils are placed under the vehicle. Once the vehicle starts moving over the road, it will charge automatically.

Keywords: Wireless Power Transfer (WPT), Renewable Energy-Solar Energy, E-Vehicles

1 Introduction

Electric vehicles are becoming more prevalent, and it is anticipated that 10% of all vehicles will be fully driverless by 2030 [1]. Soon, cars will be able to drive themselves and charge themselves. These electric cars are subject to a number of limitations. They should be at rest during charging periods. Typically, EV batteries should last for 8 years before they need to be replaced. The limited distance between charges is another issue. Additionally, they need to be directly linked to a socket or charging station. An electric vehicle offers a clean, energy efficient, and silent mode of transportation in contrast to fuel-powered automobiles.

Solar energy is a good example of a dc to ac sustainable energy source that may be used to charge electric cars efficiently. More people can use renewable energy sources like solar energy as a result of falling solar panel prices. The amount of solar energy that the world absorbs is roughly many times greater than the total amount of non-conventional energy that the earth is now using. Due to concerns about lack of energy and global warming, renewable energy sources, such as wind and solar energy, now contribute to the generation of electrical energy. There may be a way to end humanity's reliance on fossil fuels. However, just 18% of the total electricity produced worldwide comes from renewable sources, which is still a very tiny percentage. As a result, energy generated by renewable resources is wasted.

We will employ solar energy for magnetic induction wireless power transfer (WPT) in highways to charge electric cars (EVs). WPT Technology, which is used for wireless charging, offers the advantages of safe operation, lessened emissions, and reasonably priced maintenance. Thanks to WPT Technology, there is no need for a physical connection between the charging station and the vehicle. As a result, the dangers and drawbacks associated with conventional charging techniques will be diminished.

2 System Design

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2.1 Proposed System

For electric car charging applications, wireless power transfer (WPT) method is used. The suggested method for implementing wireless power charging for electric cars uses an ARDUINO microcontroller. This system is composed of an ARDUINO microprocessor, inductive coils, and a vehicle prototype module. The inverter circuit (Bug Converter), which was used to transmit electricity to the primary coil, connects the solar panel to the battery. The input voltage can then be driven into the rectifier circuit because it is a result of the inverter's design and operation. A common voltage for smaller consumer and business inverters is 12 VDC, which is supplied by rechargeable 12 V lead acid batteries.

Because of its large inductance capacity, the coil can transmit electricity at very high frequencies. The transmitter coil sup- plies electricity to the receiving coil in the receiver block. The power is then fed into the rectifier circuit and driven to the regulator circuit, battery, and other connected devices in order for the Arduino Nano to perceive the energy transfer from ac to dc for the rectifier circuit [2]. For the purpose of a rectifier, we used a bridge rectifier, which contains four distinct diodes, of which we used two. The bridge rectifier uses three volts altogether, or 1.7 volts per diode. The controlled power is then transferred to the controller to drive the vehicle's motor.

2.2 Block Diagram

The circuits that are used sequentially are described in the block diagram. Here, a charging circuit, an inverter circuit, WPT coils, a rectifier circuit, and a load have all been employed. Block diagram of the proposed system is given below. The charging mechanism that is being proposed uses two separate circuits [3].

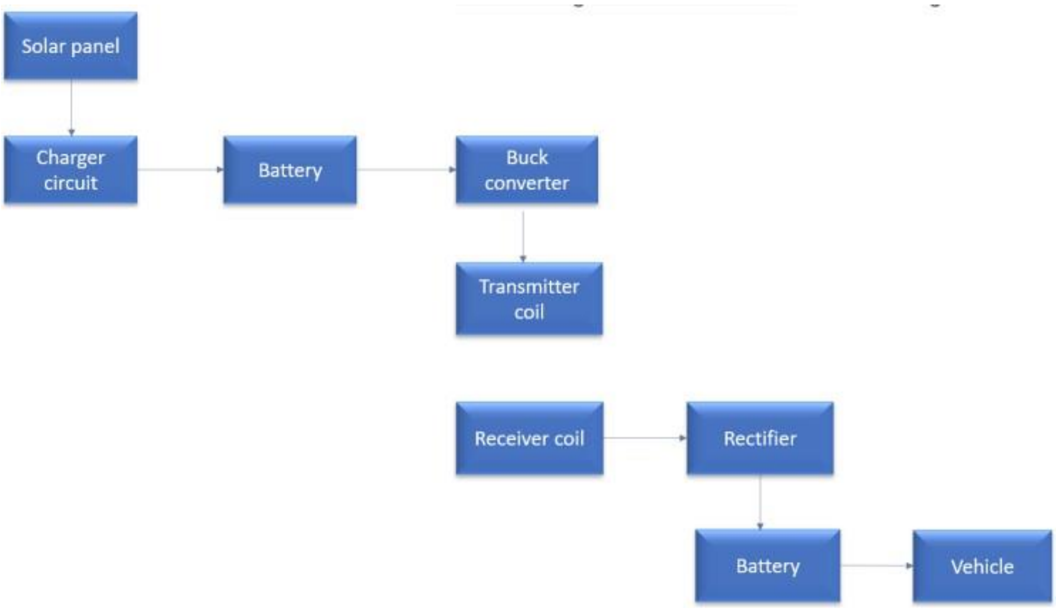

Figure 1: *Block Diagram*

- The primary circuit which charges the base inductively.
- The secondary circuit which charges the battery of the vehicle.

The primary circuit comprises the DC main supply which is the source. The supplied power is converted into AC and fed to the Inductor, thus charging the surface inductively. When the vehicle consisting of the secondary circuit travels over the inductively charged surface, the inductive power is utilized by the secondary circuit. The vehicle's battery is then charged after being converted to DC [4].

3 Methodology

The difficulties with charging and upkeep are a major factor in the low adoption of electric vehicles. Due of these

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problems, long-distance travel in electric vehicles is virtually prohibited. In order to solve the issues with everyday traditional technologies, this project suggests using wireless power transmission to construct a solar-powered charging station for electric automobiles. A wireless power transfer system is used to transport solar energy from the Photo-Voltaic (PV) cell to the battery in the electric car. To minimise its reliance on traditional energy sources, a freestanding power station that uses solar panels is being proposed for construction.

Utilizing the light energy that the sun emits; solar panels create electrical energy. The power generated by the PV cell is transferred from the panel to a battery using a solar charge controller, which raises the PV cell's power output. The transmitter circuit converts the source side batteries' DC supply into a high-frequency AC output, which is then sent to the load side as electromagnetic (EM) waves with the help of a transmitting coil. A receiving coil installed inside the car is used by the receiver circuit to decode the received wave and provide a corresponding DC output for charging the battery.

3.1 Wireless Power Transfer

Wireless Technology has been employed in various sectors ranging from Telephone to satellite communication. The use of such technology in power transfer can have a significant positive impact on society. We can transport power without using wires by employing a wireless power transmission system. Wireless communication is advantageous when running wires between devices would be difficult, dangerous, or impossible. The most extensively utilized wireless technology is inductive coupling.

The suggested EV dynamic charging system is verified by the Wireless Power Transfer (WPT) of 50 W power across a distance of 200 mm, which highlights the advantages of continual energization, variable power control, and cost savings [5]. Electrons in nearby coils vibrate and produce electricity as a result of the electromagnetic field created by the current flowing through the wires during wireless transmission. This power can be utilised to dynamically charge electric automobiles.

In WPT inductive, there are two sections to the inductor that are used for charging. The primary winding of the transformer is made up of one half of the inductor, and the secondary winding is made up of the other half. The charger's function is to transform low-frequency AC electricity into high-frequency AC power. The battery pack is provided with DC power after the secondary side of the charger receives the high frequency AC transmission.

3.2 Working

The project consists of two parts; one is the transmitter part, and another is the receiver part [Fig 1]. In the transmitter section, a solar panel of 9W 12V 500mA is used. From the solar panel a charging circuit is connected. This charging circuit is connected to the battery. From the solar panel the charge is regulated, and it will be connected to the battery. Here a 12V battery is used but the transmitter coil receives only 3.7V, so a buck converter is used. Therefore, the purpose of the buck converter is to reduce voltage from 12V to 3.7V. From the buck converter, the energy is given to the transmitter coil. Transmitter coil acts on the electromagnetic effect. Due to this effect, it produces energy around the transmitter coil. So, whenever receiver coil comes into the radius, it will get energized and receiver coils receives the energy. The received energy will be in ac form. All the batteries used are dc, so a rectifier circuit is used to convert ac to dc. From that dc voltage is given to a battery. The battery at receiver side is 6V, from which will be charging a vehicle setup.

3.2.1 Solar Roads

A variety of eco-solutions are provided by Solar Roadways, which is a significant contribution. This creative idea will produce abundant, safe, affordable, non-polluting, and sustainable electrical energy. It is also an effective and creative invention. Furthermore, this concept might make it possible for nations to continuously deliver electricity through their highways. Building solar roadways has a significant upfront cost, but it also requires very little maintenance and is an innovative, cost-effective technique. Solar roads are durable for up to 21 years. With the help of this technology, we can generate electricity and recover our investment.

3.2.2 Solar panels

Solar panels are devices which generate electricity or heat by absorbing sunlight. A solar panel consists of an assembly of solar (or photovoltaic) cells that can produce power or electricity with the help of photovoltaic effect. Here too, it takes in solar energy and transforms it into electricity that will be stored in a battery.

3.2.3 Battery

Electrical appliances like flashlights, cell phones, and electric vehicles are all powered by batteries. A battery is a device composed of several electrochemical cells connected to specific external components. Direct current is used by DC batteries. Lead-acid batteries typically power electric vehicles and only flow in only one direction. DC generates a constant current that is readily dissipated. Although it can be recovered, the power loss is substantial. Batteries exhibit this phenomenon over time; they gradually lose power until they stop functioning.

3.2.4 Buck Converter

A DC-DC converter, often known as a "buck converter," is one that steps up current while stepping down voltage. A buck converter is an SMPS's most essential part. To transform a greater input voltage into a lower output voltage, it is frequently employed in industrial settings. When the DC output voltage must be less than the DC input voltage in SMPS circuits, the Buck Converter is employed.

3.2.5 WPT Coils

Most of it is made up of a transmitter coil and a receiver coil. The transmitter coil is driven by an AC current, which creates a magnetic field that causes a voltage to be induced in the reception coil. The fundamental component of wireless power transmission is the inductive energy that can be transferred from a transmitter coil to a receiver coil via an emf. A power source's DC current is transformed into high frequency AC current using specially designed electronics that are integrated into the transmitter. A copper wire in the transmitter part experiences an increase in AC current, which induces an emf. The receiver coil may experience an AC current flowing through it if it comes in the radius of the emf. Electrons in the receiver part convert the AC current to DC current.

3.2.6 Solar Charge Controller

This design is aimed for small- and medium-power solar charger solutions and is based on the TI MSP430F5132 MCU [6]. It can operate on solar modules with voltages between 15 and 60 volts and batteries with a voltage range of 12 to 48 volts while producing up to 20 A of output current. The maximum current can be raised to 40A by substituting the MOSFETs used in this design for TO- 220 package variants. More than 96 percent of the design's components are operationally efficient and track maximum power using the perturb-and-observe technique.

4 Results and Discussions

The suggested infrastructure consists of solar-powered roads, roadways, and paths. The generated energy is sent to the systems that supply homes, businesses, and stationary electric vehicles with both wired and wireless charging. This concept involves wirelessly charging electric automobiles in a dynamic manner, or while they are moving along the road. Therefore, there is no need to wait or waste time when charging. It is a more effective strategy with very little power loss [Fig 4].

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4.1 Simulation Results

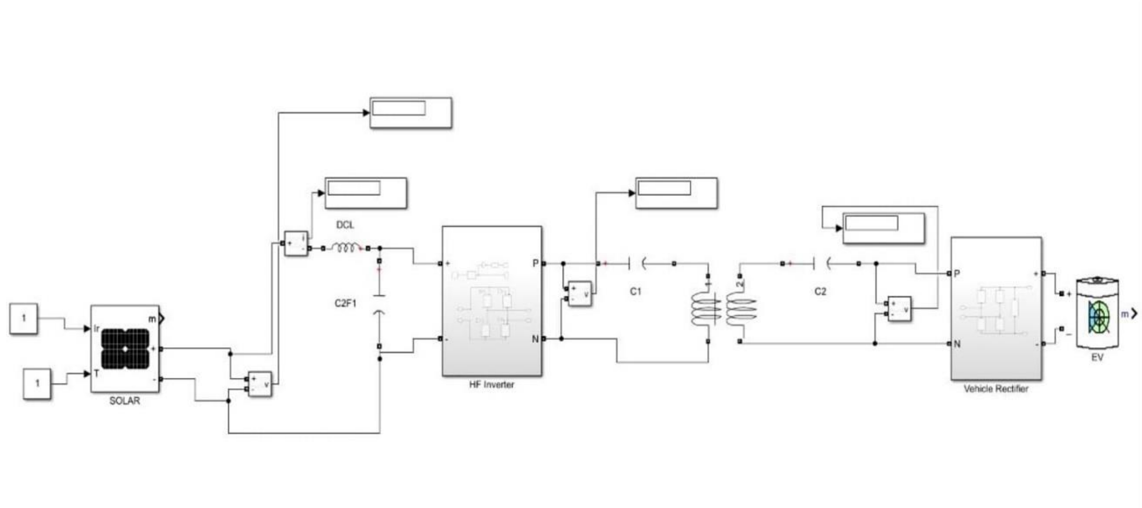

Figure 2: *Circuit Diagram*

A transmitter and a receiver make up both pieces. Irradiance, which is a constant value, and temperature, which can range from 0 to 40 degree Celsius, are the two inputs to the solar panel. The LCD display shows the resultant voltage and current. The output voltage is then presented after it has been converted to AC current by a high frequency converter [Fig 2]. Pure DC is created by combining an inductor and capacitor to decrease noise. The transistor component is composed of this [7]. Mutual inductance allows the emf to be wirelessly transferred to the receiver component, where it is then converted back into dc with the aid of a bridge rectifier. As a result, the vehicle's battery gets charged [Fig 3].

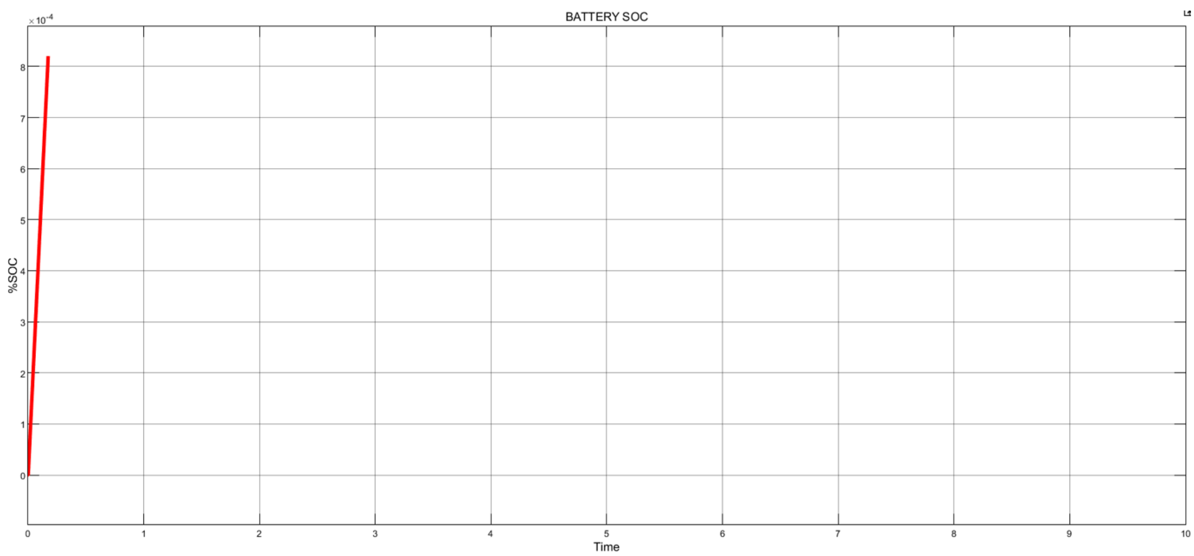

Figure 3: *Battery SOC (1)*

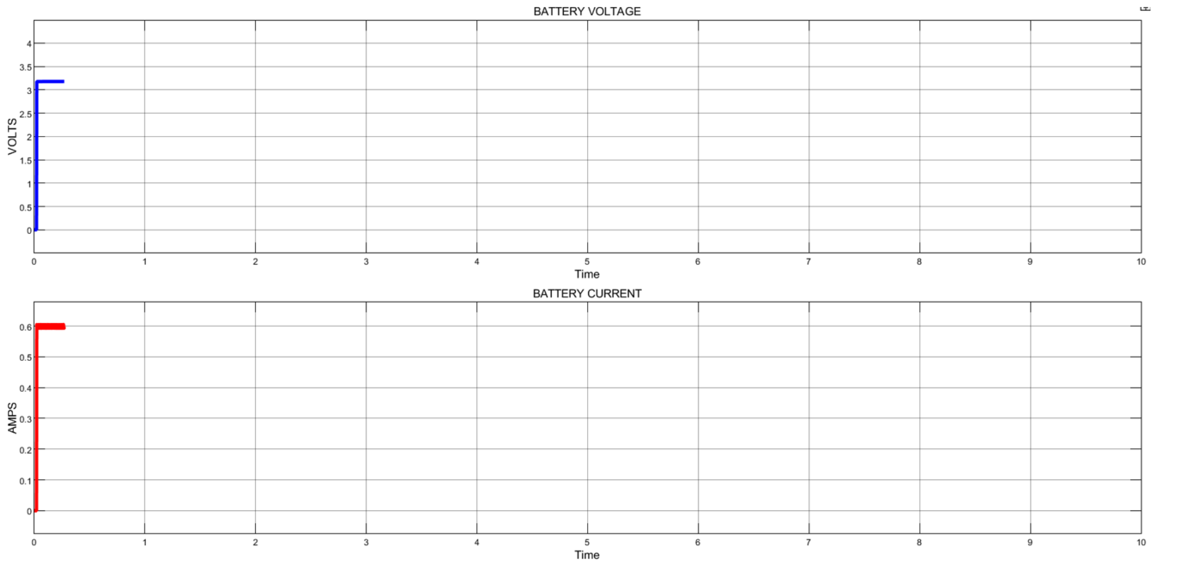

Figure 4: *Battery voltage and current level*

5 Conclusions

Electric vehicles (EVs) are a new class of automobiles that use wireless charging and inductive charging to remotely recharge their batteries. The wireless charging EVs do not require a power cable connection to charge, in contrast to traditional plug-in EVs. Electricity needed to charge an e- vehicle is generated from solar energy. The e-vehicle will automatically charge while in motion and does not need to be idling thanks to Wireless Power Transfer (WPT) Technology that has been adapted to charge the vehicle. As a result, the risks and inconveniences caused by traditional charging methods will be reduced. This process is quicker. The barrier is implemented to prevent pointless charges. Although the project's initial costs will be high, the long-term advantages may outweigh those costs [Fig 5].

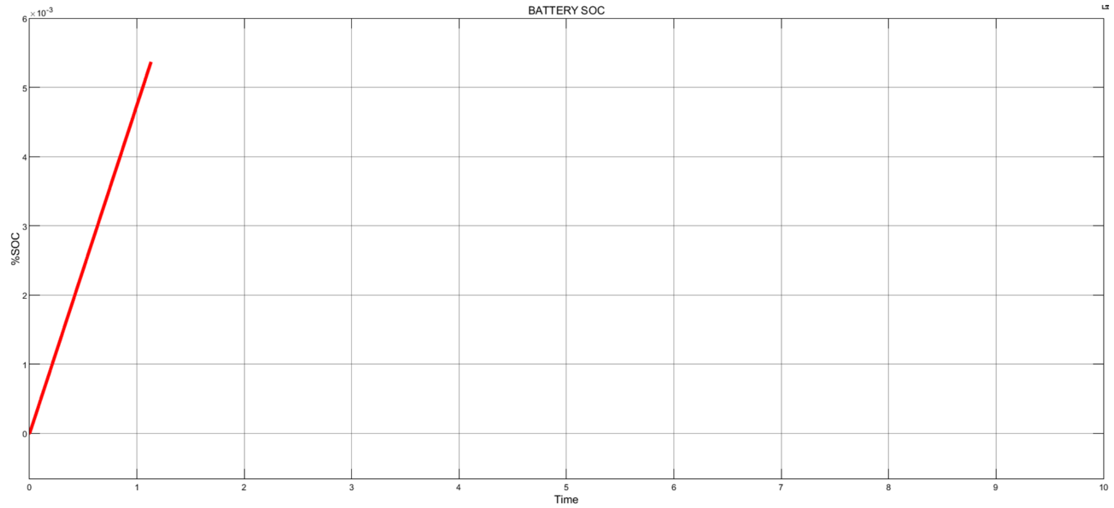

Figure 5: *Battery SOC (2)*

According to the research, 10 percent of all vehicles worldwide will be electric by 2030. Therefore, we have concentrated on an efficient charging method that lowers the cost of fuel. Additionally, the vehicles' batteries would last up to 8 to 10 years, making maintenance unnecessary. The charge received from the solar roadways can be stored in these batteries. Therefore, the vehicles can safely travel on regular roads until the charge is finished.

A 1.6-kilometre stretch of road in Sweden has been converted into a wireless energy charging dock capable of powering buses using the induction process as part of a test project on the vacation island of Gotland [8]. According to the studies, the most efficient highways are those that are conductive at ground level. After launching an

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experimental shuttle service in 2009, Korea was the first to introduce an induction-based public electric road with a commercial bus line in 2013. These are the real-life examples which inspired to experiment this project "Solar Roadways for Wireless Charging of Electric Vehicles".

6 Publisher's Note

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