



**ISSN: 2454-9940**



**INTERNATIONAL JOURNAL OF APPLIED  
SCIENCE ENGINEERING AND MANAGEMENT**

**E-Mail :**  
**editor.ijasem@gmail.com**  
**editor@ijasem.org**

**[www.ijasem.org](http://www.ijasem.org)**

# SMART ROADS WITH WIRELESS E V CHARGING AND RENEWABLE ENERGY INTEGRATION

K.Shiva Kumar, K.Niharika, K. Jyothi, K.Bunny

GUIDE: Mrs. P. Tejaswini

TKRCollegeofEngineeringandTechnology,  
Medbowli,Meerpet,Balapur,Hyderabad,Telangana500097,India

**Abstract**—More environmental deterioration is occurring in the contemporary era due to the over exploitation of petroleum resources, which is having an impact on the weather. Therefore, an alternative solution is required to reduce dependency on such non-sustainable assets. The promotion of an alternative highway design called "Solar Freeways" is one example of such an effort in the transportation industry. Optimal road design has the ability to improve solar power generation efficiency, pave the way for national programs like Smart Cities, and make room for the electric vehicles that will supplant their petroleum-powered predecessors. This study introduces a new method for charging renewable energy cars and buses, one that takes use of the plentiful clean energy that can be harnessed from roadways. To do this, it employs state-of-the-art power electronics and power system analytical methods, incorporates revolutionary nanotechnology, and makes use of highways.

Our group put the ingenious inductive charging method through its paces with a little prototype. By optimizing the use of the pre-installed solar panels, our project team enhanced the model's functionality and tailored it to our unique vision. In order to charge an electric vehicle (EV) while it is in motion, special coils are installed. It is in this report that you will find the detailed proposal overview

## 1.INTRODUCTION

Roads are essential to transportation systems, enabling efficient movement of people and goods while supporting economic growth. Recent research focuses on developing smart road infrastructure that enhances traffic efficiency, reduces environmental impact, and supports emerging technologies such as autonomous vehicles.

Electric vehicles (EVs) are a key component of sustainable transportation due to their lower energy consumption and reduced emissions of greenhouse gases and pollutants such as PM and NO<sub>x</sub>. However, their widespread adoption is limited by challenges associated with battery technology, including low energy density (89–110 Wh/kg compared to 12,000 Wh/kg for gasoline), limited driving range, high cost, long charging times, and reduced lifespan.

To overcome these limitations, advanced charging solutions are being explored. Conventional EV charging includes Level 1 (slow charging using 120 V AC), Level 2 (moderate charging at 198–260 V), and Level 3 or DC fast charging, which can charge up to 80% in 20–30 minutes. In addition, emerging technologies such as wireless power transfer (WPT) and solar-powered EVs aim to provide more flexible and sustainable charging options. WPT uses magnetic resonance coupling to transfer energy without physical connections, though it is currently limited by cost and efficiency. Solar-based charging offers renewable energy benefits but is constrained by low efficiency and dependence on sunlight. Overall, integrating innovative charging technologies with smart road infrastructure is essential to address current limitations and enable the future of sustainable and efficient transportation systems.

## 2. BACKGROUND AND REALATED WORK

### 2.1 Electric Vehicle Charging Stations

Electric vehicles (EVs) are charged by connecting them to a power outlet through a charger. There are three primary types of EV charging stations: Type 1, Type 2, and Type 3 (Quick Chargers).

**Type 1 chargers** are plug-in devices that operate on 120 V AC power and can be connected to a conventional electrical grid without requiring additional installation equipment. They typically provide a driving range of 3–6 miles per hour of charging. Despite being the slowest option, they are commonly used by homeowners for overnight charging. Companies such as Orion, Aero-Vironment, Duosida, and Leviton manufacture Type 1 chargers.

**Type 2 chargers** are widely available in both public and private settings. They require a dedicated outlet capable of handling 240 V (residential) or 210 V (commercial) power, and installation must be carried out by a professional electrician. Some

Type 2 stations are integrated with solar panels. These chargers offer a charging range of 9–58 miles per hour and can fully charge a vehicle battery in under three hours. They are suitable for both homes and businesses. Not all EV manufacturers use the same Type 2 charging

system; Nissan is one example. Manufacturers include Siemens, JuiceBox, ClipperCreek, and ChargePoint.

**Type 3 chargers**, also known as DC fast chargers or Quick Chargers, are high-power systems primarily used in commercial and industrial applications due to their complex installation and maintenance requirements. They can extend an EV's range by approximately 50–95 miles in just 20 minutes. However, most plug-in hybrid vehicles do not support DC fast charging. Fully electric vehicles such as the Nissan Leaf and the Mitsubishi i-MiEV are compatible with these chargers.

### 2.1 Electrified Vehicles' Utilization of Wireless Power Transmission

Wireless power transmission (WPT) for electric vehicles (EVs) enables charging without physical connectors by using magnetic resonance coupling between a ground-based coil and a copper coil mounted beneath the vehicle. A landmark demonstration by researchers at Massachusetts Institute of Technology in 2007 successfully transmitted 60 W of power over a distance of 1.8 meters using coupled magnetic resonance, establishing a foundation for modern WPT systems.

Advancements in this field include the development of optimized circuitry and ground-level control systems. The use of aluminum shielding to confine magnetic flux and ferrite materials to guide it allows WPT systems to achieve resonance frequencies of up to 90 kHz.

### 2.2 Solar-Powered Streets

One kind of energy collection equipment is solar pavement, as seen in Figure 1.3. One of the several potential uses for the energy harvested by the solar panels is to power various infrastructure, such as vehicles, parking spaces, sidewalks, etc. Houses and businesses may put the collected energy to use, or it can be utilized to construct charging stations for electric vehicles (EVs). To construct a solar pavement, you will need the following three materials: First, the solar cells receive light from the sun via the upper surface.

2) A small micro controller chip in the electrical layer helps the panels' heating element; this makes them useful for things like snow removal.

3) Solar panels are installed on a base plate layer that collects solar energy and distributes it to surrounding households and businesses.

### 2.3 Positioning of Solar Collectors

When the phrase "solar road" is brought up, asphalt sun collectors (ASCs) are often the first items that come to mind. Solar water heating might be a viable use for the collected energy from these pavements. We developed the first ASC system in 1978. A system of concealed pipes is used to transport fluid during the construction of an ASC. Because of the temperature difference between the fluid

and the asphalt's surface, the fluid's temperature rises as it travels through the pipes, a phenomenon known as thermal conductivity. Electricity generation, local heating and cooling of buildings, and de-icing of road surfaces are all advantages of this temperature rise.

## 3.SYSTEM DESIGN AND METHODOLOGY

### 3.1 System Architecture

Using the solar panel unit to charge the electric vehicle module is shown in the block diagram below:

- Charging will begin after you adjust the solar panel to the correct angle; a beep will signal when charging is complete.

It is the controller that is responsible for sending the charge

- The converter changes the DC charges into AC charges, which are different from one another. As the vehicle travels, charged batteries are wirelessly transferred to the transmitting coils, which in turn produce an electromagnetic field that the receiving

### 3.2 Field Induced by a magnet

For the circuit to function optimally when a higher-frequency alternating-current signal is sent into the transmitting portion of

the coil, the secondary and transmitter must occupy the resonance configurations in their entirety. A common electric car battery charger serves as the foundation for the proposed method. Afterwards, the maximum energy may be delivered at a medium distance of around 30 cm and a coupling value of 1.01.

wireless power transfer (WPT) is achieved through magnetic coupling between two coils. WPT techniques are broadly classified into radiative and non-radiative methods; this study focuses on a non-radiative, loosely coupled magnetic approach. The efficiency of power transfer depends on coil parameters such as diameter, number of turns, conductivity, and spacing between turns, as these determine the mutual inductance. Maximum efficiency is achieved when the transmitter and receiver coils are of similar size and properly aligned, enabling the generation of a strong magnetic field with high current and flux linkage.

### 3.3 Arduino nano controlling factor

At its core, an Arduino small circuit board houses the ATmega328 microprocessor. In addition to a power connection, an ICSP header, a reset button, a USB port, and six analogue inputs, this component also has fourteen digital I/O pins, six of which are PWM outputs, and a ceramic resonator running at 16 MHz. Just plug it into a USB port, use an AC-to-DC converter, or insert a battery to power the microcontroller. Everything else is already included. The omission of the FTDI USB-to-serial driver

chip distinguishes the nano from its predecessors. The true star here is the USB-to-serial converter Atmega16U2 (or Atmega8U2 up to R2). The third iteration of the board has the following improved features:

In addition to the AREF pin, the 1.0 pinout includes two more pins: the IOREF, which allows the shields to adapt to the board's voltage, and the SDA and SCL, which are situated next to it. They want to make shields that work with AVR and Arduino boards down the road. In order to function, it needs 3.3V. One is associated with the other, while the other is reserved for future use. The next model up is the Atmega 16U2.

### 3.4 DC Boost converter

The XL6009 module is a non-isolated step-up boost voltage converter that allows you to alter the output voltage and has great efficiency. This apparatus converts a DC input voltage of 5-32V into an AC value of 4-38V.

### 3.5 Liquid crystal displays used in electronics

An LCD panel is an electronic display module that has several uses. A 16x2 LCD screen is an essential and often used part of many electronic gadgets and circuits. These modules outperform multi-segment LEDs with seven segments. In addition to being cheap and easy to program, LCDs can show anything, including animations, special characters, and unique segments (unlike seven segments). Each of the two lines of a 16x2 LCD can show sixteen characters. A 5x7 pixel matrix displays each character on this LCD. "Command" and "Data" refer to the two windows on this LCD.

To direct the LCD, one must first access the command register. A number of operations, including self-initialization, screen cleaning, pointer position setting, display management, and more, may be programmed into the LCD. The information that will be shown on the LCD is stored in the data register. The ASCII value of the character is shown on the LCD.

### 3.6 Rechargeable batteries

During charging, the positive active material is oxidized to produce electrons, while the negative material is reduced to consume them. Electricity travels across the external circuit in the form of these individual electrons. In lead-acid cells (Transmitter battery), the electrolyte is an active component of the electrochemical reaction; in nickel-cadmium and lithium-ion cells ( Receiver batteries), it only acts as a buffer for the internal ion movement between the electrodes.

## 4. IMPLEMENTATION

### 4.1 Development Environment

The firmware was written in C++ using Arduino IDE 2.3 on a Windows 10 workstation. No GPU hardware is

required; all computation executes on the ATmega328P CPU.

### 4.2 Hardware Configuration

The proposed Smart road system is implemented using a combination of renewable energy sources, wireless power transfer components and control units. The system is designed to efficient generate , store, and transfer energy to electric vehicle

The primary energy source is a solar panel, Which converts solar energy into electrical energy. This energy is stored in a rechargeable battery to ensure continuous operation even during low sun light conditions. A voltage regulator is used to maintain

a stable power supply to the system components. Wireless power transfer is achieved using inductive coils.

The transmitter coil is embedded within the road surface, While the receiver coil is mounted on the electric vehicle. When the vehicle passes over the transmitter coil, Power is transferred through electromagnetic induction. An Arduino micro controller is used to control the system operation.

### 4.3 Hardware configuration table

S. No	Component	Specification	Specification
1	Solar panel	12V, 10W - 20W	12V, 10W
2	Rechargeable battery	12V lead-acid/Li-ion	12V lead-acid
3	Arduino uno	ATmega328P	ATmega328P
4	Transmitter coil	Copper coil	Copper Coil
5	Receiver Coil	Copper coil	Copper Coil
6	Rectifier Circuit	Bridge rectifier	Bridge rectifier
7	Voltage Regulators	7805/7812	7805/7812
8	Capacitors	100mF,1000mF	100mf,1000
9	Connectiong wires	Standard	standard
10	LED Indicators	5VLEDS	

## 5. RESULTS AND ANALYSIS

### 5.1 Result

The proposed smart road system with wireless EV charging was tested under different operating conditions to evaluate its performance and efficiency. The system successfully demonstrated wireless power transfer using inductive coupling between the transmitter and receiver coils.

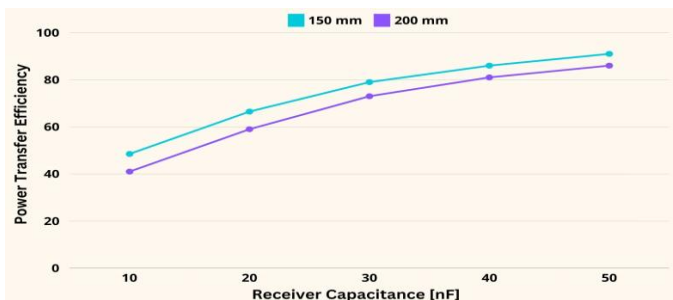
The performance of the system mainly depends on factors such as the distance between coils, alignment, and input power supply. Experimental observations indicate that the efficiency of power transfer decreases as the distance between the transmitter and receiver coils increases.

The integration of solar energy provides a sustainable power source for the system. The stored energy in the battery ensures continuous operation even in the absence of sunlight. The system was able to charge low-power loads efficiently, validating the feasibility of dynamic wireless charging.

Overall, the results confirm that the proposed system is capable of reducing charging time, improving energy efficiency, and supporting sustainable transportation.

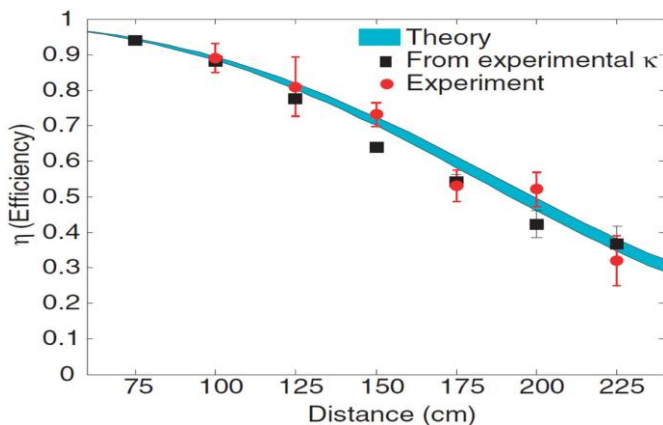
### 5.2 Efficiency Vs Capacitance

X - Axis = Capacitance  
Y - Axis = Efficiency



### 5.3 Efficiency Vs Distance

X - Axis = Distance(cm)  
Y - Axis = Efficiency



### 5.4 Limitations

The installation cost of embedding coils and solar panels into road infrastructure is relatively high, making large-scale deployment challenging. Additionally, maintenance of embedded components may be difficult due to environmental conditions such as dust, water, and physical wear.

The system currently supports only low-power applications and is not yet suitable for high-power electric vehicles without further optimization. Scaling the system for real-world highways would require significant improvements in coil design and power handling capacity.

## CONCLUSION

According to the research, a novel smart charging method may have potential applications for electric vehicles. Using the solar board to charge it from a distance is an innovative part of the course. An enrollment loop is no longer necessary. Since discovering a new energy source will lessen the quantity of pollutants produced by fossil fuels, it is attractive from the perspective of public transportation. One potential solution to the pollution caused by fossil fuels is the rise of electric automobiles as an alternative to gas-powered vehicles. In terms of innovation, usefulness, and difficulties, a remote charging framework might significantly enhance the electric vehicle charging arrangement. At full recurrence coordination, the results of the simulation show that the air hole transmits a distant Force

Although the switch to solar roads will be expensive, they will replace conventional highways in due time. The development of the solar-powered road might be less costly as it produces more electricity without destroying any existing structures. On well-kept older highways, the sun-facing highway design may work. Plans to renovate the airport's main building and parking lot are subject to alter at any moment. Solar roadways should be accessible and safeguarded when financial restrictions are the main driver.

There are no compensatory components that can hinder the growth of black-top, unlike rival kinds. In its next stage, the ITS program seems to be aiming for a concept that is readily implementable. If our country constructed streets facing the sun, we might perhaps address our garbage, coal, energy, pollution, and transportation subsidy problems.

This innovative method of charging electric cars remotely will, in any event, significantly cut down on CO<sub>2</sub> emissions. Electric vehicles cut annual CO<sub>2</sub> emissions from gas-powered cars in half, from 60 to 30 metric tons. There will be less environmental change and more positive evolution as a result of this.

## REFERENCES

1. Gerssen-Gondelach, S., and Faaij, A. (2012) Performance of batteries for electric vehicles on short and longer term, *Journal of Power Sources*, pp. 111.
2. Etacheri, V., Marom, R., Elazari, Salitra, R. and Aurbach, D. (2011) Challenges in the development of advanced Li-ion batteries: A review, *Energy Environmental Science* 4, pp. 3243.
3. S. Li et. al. (2015) Wireless Power Transfer for Electric Vehicle Applications, *IEEE Journal of Emerging and Selected Topics in Power Electronics*, pp.
4. Will electric cars soon have solar roofs? Toyota and Tesla say yes, [ThinkProgress.org](http://ThinkProgress.org),
5. Kurs, A., Moffatt, R., Joannopoulos, J., Fisher, P. and M. Soljacic (2007) Wireless power transfer via strongly coupled magnetic resonances, *Science*, pp. 83–86.
6. Sample, A., Meyer, D. and Smith, J. (2011) Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer, *IEEE Trans. Ind. Electron.*, pp. 544–554.
7. Cannon, B., Hoburg, J., Stancil, D. and Goldstein, S. (2009) Magnetic resonant coupling as a potential means for wireless power transfer to multiple small receivers, *IEEE Transactions on Power Electronics*, pp. 1819–1825.
8. Kurs, A., Moffatt, R., and Soljacic, M. (2010) Simultaneous mid-range power transfer to multiple devices, *Applied Physics Letters*, pp. 044102-1–044102-3.
9. Sanghoon, C., Yong-Hae, K., Kang, S.-Y., Myung-Lae, L., Jong-Moo, L. and Zyung, T. (2011) Circuit-model-based analysis of a wireless energy transfer system via coupled magnetic resonances, *IEEE Trans. Ind. Electron.*, pp. 2906–2914.
10. Kainan, C., and Zhengming, Z. (2013) Analysis of the double-layer printed spiral coil for wireless power transfer, *IEEE J. Emerg. Sel. Topics Power Electron.*, pp. 114–121.
11. Yiming, Z., Zhengming, Z. and Kainan, C. (2014) Frequency decrease analysis of resonant wireless power transfer, *IEEE Trans. Power Electron.*, pp. 1058–1063.
12. Kavimandan, U. et al, (2019) Analysis of Dead-Time in a Single Phase Wireless Power Transfer System, 2019 IEEE Transportation Electrification Conference and Expo (ITEC), Detroit, MI, USA, pp. 1-8. Bai, T. et al, (2019) Machine Learning-Assisted Wireless Power Transfer based on Magnetic Resonance, in *IEEE Access*.
13. Chu, S. and Avestruz, A. (2019) A New Calibration Strategy for Transfer-Power Measurement of Wireless Charging of Electric Vehicles, 2019 IEEE Transportation Electrification Conference and Expo (ITEC), Detroit, MI, USA, pp. 1-5.
14. Mohammad, M. et al., (2019) Sensitivity Analysis of an LCC-LCC Compensated 20-kW Bidirectional Wireless Charging System for Medium-Duty Vehicles, 2019 IEEE Transportation Electrification Conference and Expo (ITEC), Detroit, MI, USA, 2019, pp. 1-7.
15. Ayachit, A., Abdul-Hak, M. and Kazimierczuk, M. (2019) Transfer Functions of Wireless Power Transfer Systems with Series and Series-Parallel Compensation Schemes, 2019 IEEE Transportation Electrification Conference and Expo (ITEC), Detroit, MI, USA, 2019, pp.