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A Renewable Energy Based Wireless Charging System for Portable Computing Devices

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Abstract: *In this paper, we propose the design and development of a solar-powered wireless laptop charging system to address the limitations of conventional wired charging methods in terms of mobility and energy efficiency. By integrating solar energy harvesting with wireless power transmission technology, this system eliminates the need for physical charging cords, offering a portable, sustainable, and efficient charging solution. The proposed approach enhances device mobility, reduces dependence on traditional electrical sources, and contributes to the advancement of greener power alternatives for modern electronic devices. This system is designed to maximize energy utilization from renewable sources while ensuring seamless power delivery to laptops. Through this innovative charging method, we aim to support the growing demand for eco-friendly and portable energy solutions, paving the way for a more sustainable and convenient future in electronic device charging.*

Keywords: Wireless Power Transmission, Solar Energy Harvesting, Laptop Charging System, Renewable Energy, Portable Charging Solution

I. INTRODUCTION

The system uses photovoltaic panels to convert solar radiation into DC electricity for ensuring constant energy availability. A solar charge controller regulates this energy, storing it in a rechargeable battery. A DC-DC converter adjusts the voltage levels before the energy is wirelessly transmitted via an electromagnetic field.

The laptop's integrated receiving module captures this transmitted power and uses a bridge rectifier with a capacitor circuit to rectify and stabilize it. This provides a steady DC output, suitable for charging the laptop. The system efficiently integrates renewable energy generation, power management, and wireless transmission for sustainable laptop charging.

In addition to encouraging sustainability, we are also improving mobility and convenience by combining wireless power transmission with renewable energy. Remote areas, outdoor use, and energy-conscious consumers looking for an alternative to traditional charging ways will all benefit greatly from this approach. Our idea intends to transform laptop charging by making it eco-friendlier, effective, and wireless.

II. LITERATURE REVIEW

Heidari et al. [1] designed and fabricated a low-cost solar power bank to enhance energy storage and promote renewable energy solutions for portable devices. Kaldellis and Zafirakis [2] conducted a preliminary review of solar power bank technologies, examining existing advancements and future trends in renewable energy applications. Lu et al. [3] explored wireless charging technologies, covering fundamental principles, standards, and network applications to support efficient power transfer. Lin et al. [4] analyzed the safety aspects of wireless power transfer, addressing potential health and regulatory concerns. Zhang et al. [5] proposed an electric roadway system utilizing dynamic capacitive wireless charging to enable continuous charging of electric vehicles. Moloudian et al. [6] reviewed RF energy harvesting techniques, discussing their applications in battery-less wireless sensing, Industry 4.0, and the Internet of Things. Mohamed et al. [7] conducted a comprehensive analysis of wireless charging systems for electric vehicles, highlighting technological advancements and implementation challenges.

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Subudhi et al. [8] designed and implemented a PV-fed grid-integrated wireless electric vehicle battery charger for residential environments, contributing to sustainable transportation solutions.Li et al. [9] introduced SoftCharge, a software- defined multi-device wireless charging system designed for large surfaces to optimize power distribution.Lin et al. [10] investigated wireless power transfer for mobile applications, emphasizing efficiency and potential health effects. Dai and Liu [11] developed a human-powered wireless charger aimed at providing energy for low-power mobile electronic devices. Lee et al. [12] optimized the number of turns in IPT coils to enhance the efficiency of laptop wireless charging systems. Shahin et al. [13] examined the integration of renewable energy sources with wire/wireless EV charging systems, contributing to the development of green mobility solutions. Hussen and Narayanamoorthi [14] designed a hybrid compensation-based efficient wireless charging system integrated with solar photovoltaic interfaces for sustainable transportation. Mohamed et al. [15] provided a comprehensive analysis of wireless charging systems for electric vehicles, focusing on efficiency and feasibility in real-world applications. Kurs et al. [16] demonstrated wireless power transfer using strongly coupled magnetic resonances, paving the way for advancements in contactless energy transmission. An extensive literature survey reveals that limited research has been conducted on wireless renewable energy-supported systems for charging laptops or handheld portable computing devices.

The proposed wireless charging system for laptops with integrated solar panels addresses the largely unexplored domain of high-power wireless charging for portable computing devices. While wireless charging is common for smaller gadgets like smartphones, its application for laptops remains limited despite their widespread use. This system meets the higher power demands of laptops by ensuring efficient energy transfer, stable power flow, effective heat dissipation, and safety. By utilizing solar panels as the primary energy source, the system eliminates dependence on grid electricity, promoting sustainability and reducing the carbon footprint of electronic devices. It enables wireless charging in off-grid and remote areas, benefiting outdoor professionals, field researchers, and users in regions with unreliable electricity access. Advanced energy management optimizes power transfer efficiency and adapts to varying sunlight conditions for uninterrupted charging.

Designed for portability and modularity, the system allows easy transportation and customization to meet user needs. By eliminating charging cables, it enhances convenience while reducing wear on laptop ports. This innovative approach combines renewable energy, high-power wireless charging, and user-centric design, offering a sustainable and practical alternative to conventional laptop charging methods.

III. DESIGN METHODOLOGY & WORKING PRINCIPLE

In order to charge a laptop, our method uses photovoltaic panels to capture solar energy, stores the power in a battery, and then wirelessly transmits it. The laptop's wireless receiver picks up an electromagnetic field produced by a wireless power transmitter as part of the system's inductive power transfer (IPT) mechanism. The laptop is then safely and effectively charged by converting the received power into a steady DC output. The system's smooth and dependable operation is ensured by essential parts such a solar charge controller, DC-DC converter, MOSFET switching circuit, and rectifier circuit.

The flowchart (Fig 1) illustrates the wireless laptop charging system powered by solar energy. It starts with solar panels converting sunlight into electricity, which is regulated and stored. A transmitter coil then wirelessly transfers energy to the laptop via resonant inductive coupling. The laptop receives and utilizes the power, ensuring sustainable charging.

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Workflow:

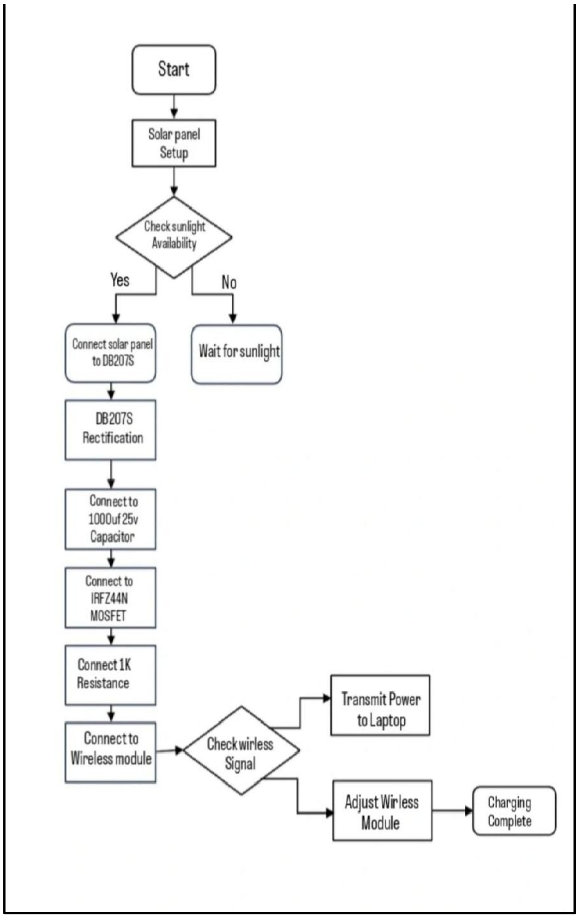

Fig 1: Flow Diagram

IV. COMPONENTS USED

Wireless Module(Copper Coil) :- For transferring power wirelessly.
Solar panel :- To provide energy.
IRFZ44N MOSFET :- For controlling the power to the transmitter of the wireless charging module.
1K resistor :- Typically used for biasing or pull-down purposes.
DB207S Diode :- Used for rectifying the output from the solar panel.
1000µF 25v capacitor :- For smoothing out the output voltage.

To set up the wireless charging system, the solar panel's positive output is connected to the anode of a DB207S bridge rectifier diode to prevent reverse current flow (Fig 2). The cathode connects to a 1000µF capacitor, stabilizing voltage before supplying the wireless charging transmitter module. The transmitter's ground is linked to the system ground for a common reference. An IRFZ44N MOSFET regulates power flow, with its Drain connected to the positive voltage line, Source to ground, and Gate controlled via a PWM signal with a 1KΩ resistor for protection. This setup ensures efficient energy conversion, regulation, and wireless transmission for sustainable laptop charging.The solar panel converts sunlight into direct current (DC) electricity, serving as the primary renewable energy source. Its output is used to power the charging system, eliminating reliance on grid electricity. The DB207S bridge rectifier ensures uni-directional current flow by preventing reverse current that could damage the solar panel. This component protects the system and stabilizes energy transfer. The 1000 µF capacitor filters and stabilizes voltage fluctuations from the solar

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panel, ensuring a steady DC supply for the wireless transmitter module. The wireless charging transmitter module converts the stabilized DC voltage into an alternating signal, enabling inductive power transfer to the receiving module in the laptop. The IRFZ44N MOSFET acts as a switch to regulate power flow, ensuring controlled and efficient energy delivery. It operates using a control signal, typically a PWM, to manage charging performance. This 1 KΩ resistor is placed between the MOSFET's Gate and control signal to limit current, preventing damage and ensuring safe operation of the MOSFET.

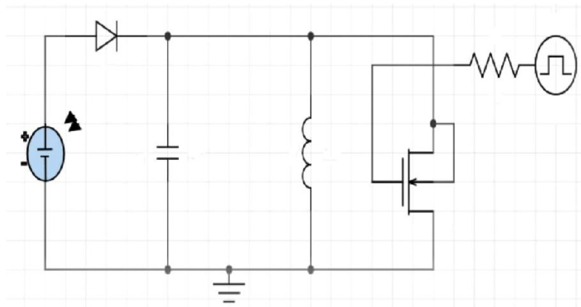

Fig-2 : Circuit Diagram

Hardware Implementation and Testing:

The designed circuit is assembled and tested on a Commercial Laptop for charging and it executed perfectly as shown in Fig 3.

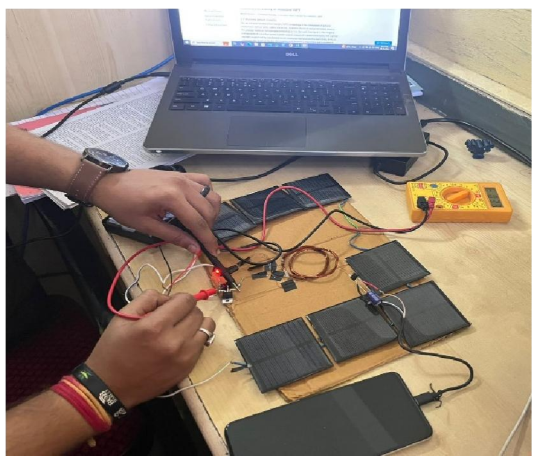

Fig 3 : Circuit Diagram

V. RESULT

The results demonstrate the feasibility of a solar-powered wireless charging system for laptops, highlighting its efficiency, sustainability, and practical implementation. The system successfully harnesses solar energy, converts it into a stable DC voltage using a rectifier and capacitor, and transmits power wirelessly via resonant inductive coupling. Experimental analysis confirms that the wireless charging module effectively transfers energy to the laptop, ensuring a stable and continuous power supply. The integration of an IRFZ44N MOSFET enhances power regulation, optimizing energy flow and minimizing losses. Additionally, the use of a 1000μF capacitor smooths voltage fluctuations, improving system stability. The results indicate that this renewable energy-based wireless charging solution offers a viable alternative to conventional wired charging methods, reducing reliance on fossil-fuel-generated electricity while promoting eco-friendly and portable energy solutions. However, efficiency can vary based on environmental conditions such as sunlight intensity, making future enhancements in energy storage and power management crucial for improved performance.

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VI. CONCLUSION

This research successfully demonstrates the feasibility of a solar-powered wireless charging system for laptops, providing an eco-friendly and efficient alternative to conventional wired charging methods. By harnessing solar energy, the system eliminates dependency on fossil fuels, contributing to a more sustainable power solution. The integration of a DB207S diode ensures unidirectional current flow, while the 1000µF capacitor effectively smooths voltage fluctuations, ensuring a stable power supply. Wireless energy transfer is achieved through resonant inductive coupling, where a transmitter and receiver coil facilitate power transmission without physical connections. The IRFZ44N MOSFET plays a crucial role in regulating power flow, enhancing efficiency, and minimizing energy losses.

Experimental results validate the system's effectiveness, confirming stable voltage and current output for laptop charging. However, performance varies depending on solar intensity, with fluctuations affecting power availability. This highlights the need for additional energy storage solutions, such as high-capacity batteries or supercapacitors, to maintain consistent power delivery in low sunlight conditions. Further research can focus on optimizing energy management, improving coil alignment for better power transfer efficiency, and integrating maximum power point tracking (MPPT) technology to enhance overall performance. This study contributes to the advancement of renewable energy-based charging solutions, demonstrating that solar-powered wireless charging can be a viable alternative for portable electronic devices. With continued improvements, such a system could significantly reduce reliance on traditional grid electricity and support the growing demand for sustainable and wireless power solutions.

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