Wireless Power Transfer from A Hybrid Renewable Energy to Grid & Charging Stations Using IoT

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Abstract — Efficient and clean energy charging infrastructures are necessary due to the rising demand for sustainable energy solutions and the fast expansion of electric cars (EVs). A smart hybrid renewable energy based wireless power transfer (WPT) system that uses wind and solar photovoltaic (PV) to power the grid and electric vehicle charging stations is proposed in this project. Through the integration of various renewable energy sources, the system guarantees a consistent and dependable energy supply, lessens the impact of intermittent power production, and decreases reliance on traditional electricity generated from fossil fuels. In addition to offering a secure and hassle-free way for electric vehicles to charge wirelessly, the system is engineered to maximize energy consumption via smart energy management. A hybrid renewable energy generating unit, energy storage components, power conditioning units, and a resonance WPT module for electric vehicles make up the suggested system. Solar panels, wind turbines, battery storage, and WPT transmitters all contribute to a constant stream of real-time data that is collected by an Internet of Things (IoT) control and monitoring platform. Integration with grid demand response systems, remote monitoring, fault detection, adaptive load management, predictive charging schedules, and the Internet of Things (IoT) system are all made possible. To maximize system efficiency and minimize energy losses, this link guarantees that renewable energy is routed effectively between grid support and EV charging. The topic of wireless energy is the focus of this study. What we call "wireless power transfer" or "wireless energy transmission" really refers to the movement of electrical current from a generator to an appliance or other device that uses it, all without the need of physical wires. Power transmission methods that employ time-varying electro-magnets are collectively referred to by this name. When running cables between devices is too much of a hassle, too risky, or just not an option, wireless transmission is a lifesaver. One equipment, known as a transmitter, is linked to a power source—the mains power line, solar panels, or wind turbines—and uses electromagnetic fields to send electricity over space to another device, or devices, that can convert it back into electric power.

Keywords: Wireless Power Transfer (WPT); Hybrid Renewable Energy System; Electric Vehicle Charging; Solar and Wind Energy Integration; Internet of Things (IoT); Smart Energy Management;

I. INTRODUCTION

Wireless charging, or inductive charging, is a method of transferring energy between devices that make use of an electromagnetic field. The use of a charging station is commonplace for this purpose. An electrical gadget may charge its batteries or power itself by receiving energy via an inductive connection. Charge your battery using an induction charger by using a charging base to generate an alternating electromagnetic field. Then, a second induction coil in the portable device will receive the power from the field and convert it back into electric current. An electrical transformer is formed when two induction coils that are close together join. The inductive charging system may reach greater distances between the transmitter and receiver coils by using resonant inductive coupling. A mobile transmission coil (one that may be installed on an elevating platform or arm) and different materials for the reception coil, such as silver-plated copper or sometimes aluminum, have been used to reduce resistance caused by the skin effect and save weight in recent enhancements to this resonant system. Creating an electromagnetic field that allows energy to be transmitted from one coil to another without the need of conducting wires is the topic of this incredible project effort. It is essential that the power transmitting and receiving coils be set at a certain distance in parallel with each other. An expanded power transmission range of up to four or five centimeters is possible, depending on the power source. You don't need to run wires to use these free wireless energy sources. Range will be less than 3.5 to 4 cm's since it is a prototype module and a low power transmitter is developed.

Demand for efficient and environmentally friendly charging systems is on the rise due to the worldwide trend toward renewable energy and electric transportation. Problems including cable deterioration, charging inconveniently, energy transmission losses, and utility grid overload result from the current EV charging infrastructure's heavy reliance on wired transfer and grid supplies. Solar and wind power may help meet energy demands, but they aren't always reliable because of their intermittent nature, which makes it hard to run continuously. A smart hybrid renewable energy based wireless power transfer (WPT) system that can integrate numerous renewable sources, intelligently manage power, and wirelessly deliver energy for EV and grid applications is necessary to overcome these issues. The project's overarching goal is to promote smart power distribution and environmentally friendly mobility while simultaneously decreasing reliance on the grid and making charging more convenient.

II. LITERATURE REVIEW

Looking Back at the History of Wireless Energy In 1891 and 1892, Nikola Tesla demonstrated the feasibility of wireless power transmission by lighting evacuated tubes without wires using high-tension oscillatory transformers. A major step forward in wind turbine technology was achieved when Denmark, in the midst of the 1973 oil crisis, built the world's first steel windmills designed only for power generation. In the past, renewable energy sources were impeded by the availability of cheap fossil fuels.

A. WPT (Wireless Power Transfer) Built on

Without the need of artificial conductors, WPT transfers electrical energy from a power source to a load using time-varying electromagnetic fields. In terms of distance, the two main categories of current WPT technology are: It is near-field (non-radiative) because it uses electric or magnetic fields to function at small distances. The three types of coupling mentioned here are inductive, capacitive, and resonant. Using electromagnetic radiation, such as microwave or laser power transmission, allows far-field radiation to travel longer distances.

B. Principles of Renowned Inductive Complement (RIC)

The RIC method is the most used one for mid-range wireless charging. The procedure involves a transmitter and a receiver, which are elements of LC (inductor-capacitor) circuits that have been tuned to resonate at the same frequency. Instead of using tight flux linkages and metallic cores, which are used in conventional transformers, electric field induction converters (RICs) leverage the high quality (Q) factor of resonators to transmit energy via evanescent waves. This method reduces the likelihood of coil misalignment while simultaneously substantially increasing the transmission distance.

C. Electric Vehicle Infrastructure

The move toward contactless charging for EVs aims to improve user convenience by doing away with the requirement for physical connections. At the moment, there are primarily two approaches to studying implementation: You may use a static charger to charge the vehicle while it's parked. These days' systems are only about 1% to 2% less efficient than the old-fashioned wired stations. Dynamic Charging (DWPT) is a method of charging automobiles while they are in motion; it may let them run for longer and reduce the size of the battery packs required aboard.

D. Combining Renewable Energy Sources

A continuous flow of power might be achieved by combining solar photovoltaic (PV) with wind energy, which reduces the intermittency that is associated with using a single power source. In regional settings like as Telangana, there has been a significant increase in solar capacity, with over 5,400 MW harnessed, providing a decentralized green power base for sustainable charging infrastructure.

III. METHODOLOGY

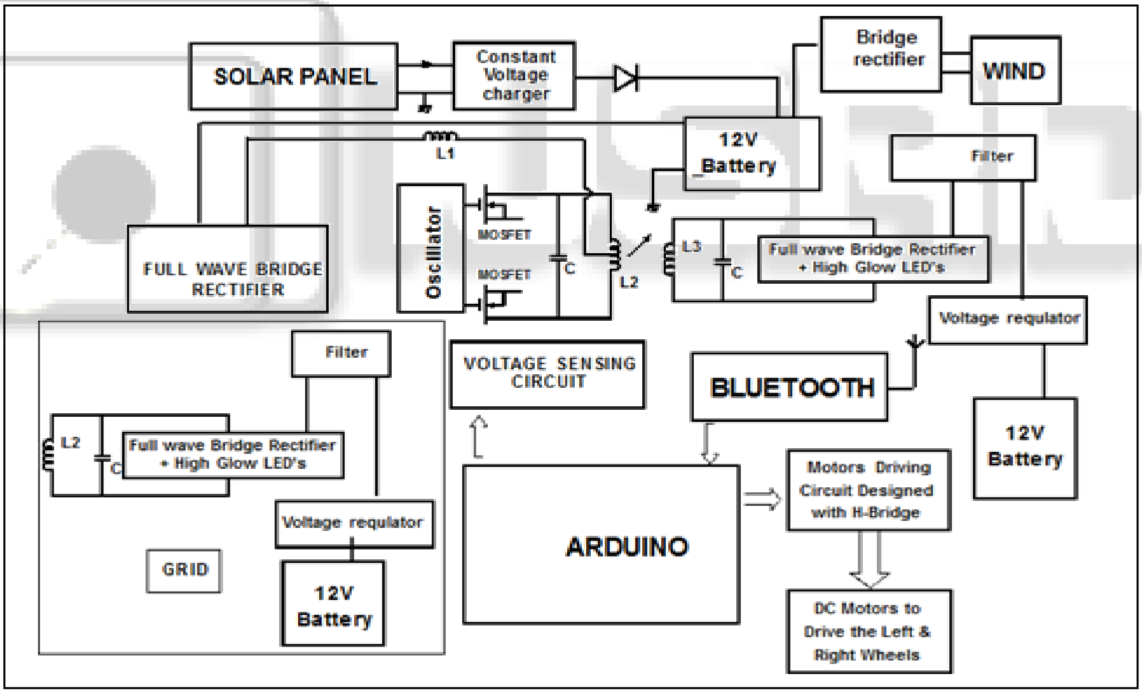

Fig. 1: Block diagram

In order to build a working electric vehicle (EV) prototype, this project's methodology adheres to a structured strategy that incorporates renewable energy collection, sophisticated power electronics, and wireless power transfer (WPT). Solar panels and wind turbines are the principal energy harvesters in the Power Source Integration and Storage phase, which starts the process. The outputs of these sources are transformed into a stable DC format by use of bridge rectifiers due to the fact that their power is erratic. The 12V battery is charged effectively and protected from overcharging by a continual charging circuit, which manages this energy.

The Wireless Power Transfer Transmitter Design becomes the center of attention after the energy is stored. In order to make inductive coupling easier, high-speed MOSFETs are used to provide DC power into a non-oscillator circuit. Transforming the low-frequency DC into high-frequency AC is the crucial function of this circuit. Next, the energy is prepared for air-core transmission by driving the high-frequency current through a main transmitter coil (L_1), which nearby produces an electromagnetic field that varies with time.

The third phase is conditioning and receiving power. Within the electromagnetic field, there is a secondary receiver coil that uses inductive coupling to collect the energy. In order to stabilize the resultant AC voltage, it is immediately processed via a full-wave rectifier and a filtering step. Load devices, such LEDs or supplemental batteries, are driven by this controlled power, and the control logic and communication modules get the voltage they need. Lastly, an EV Motor Drive is linked with the system's Control and Monitoring Section. A voltage-sensing circuit reports back to an Arduino micro controller on the status of the battery and the efficiency of the power sources in real time. In order to facilitate remote monitoring, the Arduino controls power flow and source switching via communication with a Bluetooth module. A H-Bridge motor driver receives signals from the Arduino and uses them to operate the DC motors on the electric vehicle prototype's wheels, therefore translating them into actual movement.

New technological advancements were brought forth by the 19th-century Industrial Revolution. Inventions surged throughout that century in ways never seen before. Natural resources like coal and oil were used in some of these innovations. Neither the creators of the succeeding generations gave a second consideration to the environmental harm that may result from overusing these resources or the fact that they are infinitely renewable. Renewable energy sources include things like wind, sun, water, sea, and biomass, in addition to the waste products produced every day. In addition to being endless and untapped, these sources do not contribute to pollution, making them clean energy options.

There has been a significant rise in power output in India, reaching almost 5.24 lakh MW. In Telangana, the total installed capacity has reached around 19,500 MW. All of the state's villages and outlying settlements are connected to the grid via a modernized system of transmission and distribution lines. Due to industrialization and agricultural demands, the demand for electricity in Telangana is expanding quickly and has reached record high. The rapidly declining fossil fuel reserves, unpredictable coal quality, high raw material prices, and growing transportation costs all contribute to this challenge. The most important reason to switch to "clean and green energy" is the environmental destruction that traditional energy sources cause.

In light of these facts, renewable energy sources that are less harmful to the environment have become an essential option. Renewable and endless, these power sources harness the power of the sun, wind, and biomass. With the successful harnessing of over 5,000 MW, the emphasis in Telangana has turned mostly toward solar power. The state has an estimated 4,200 MW of wind potential, although only about 128 MW of that has been harnessed so far, mostly due to investments made by private companies. In addition, the state's green energy grid is now using around 160 MW of capacity, and there is an estimated potential of 500 MW in the biomass and waste-to-energy sector.

IV. IMPLEMENTATION

The presentation is on the design and execution of a cost-effective wireless power transmission system, and the low power transmitter circuit is created utilizing power MOSFETs, as befits a prototype module. To feed more current into the main coil, two Mosfets are configured to operate in push-pull mode. By powering the Mosfets in a certain sequence or using a feedback mode diode, you may avoid having them conduct at the same time. After being constructed as a tapped center, the main coil will be divided into two parts and activated by separate Mosfets. In the same way that an energized top Mosfet may cause a de-energized bottom, the reverse is also true. The fast recovery diodes in the feedback loop dictate the switching frequency in this switching approach.

The Application of Hybrid Renewable Energy Systems Continuous power production is guaranteed by the system's combination of solar and wind energy sources. Module for Solar Energy: Panels that use the Photovoltaic Effect to turn sunlight into electricity are known as photovoltaics, or PVs. A tiny wind turbine converts the force of the wind into usable electricity in a wind module. Through charge controllers, both sources are linked to a shared DC bus. This combination method guarantees that energy will be available regardless of the time of day or the amount of wind speed.

A. Design of DC Buses and Power Conditioning

Renewable energy sources like wind and solar power need conditioning since their outputs are unpredictable. In order to control voltage levels, DC-DC converters are used.

- The optimization of solar power systems makes use of Maximum Power Point Tracking (MPPT).
- Wind turbines employ rectifiers to get AC power. A steady DC bus is formed by combining the regulated outputs; this bus is the primary distribution line for power transmission and storage.
- Putting WPT into Practice By using inductive coupling, wireless power transmission may be accomplished. Communication End To convert DC current into AC current, a high-frequency inverter is used.
- An alternating magnetic field is produced by the transmitting coil.
- Side of the receiver Magnetic energy is collected by the receiving coil.
- An electronic device that changes current from AC to DC is known as a rectifier. Regulator of voltage maintains consistent output
- Electromagnetic induction, a method of transferring power without the need for physical connections, is the basis of the system's operation.

B. Design of a Resonant Inductive Coupling

Efficiency is enhanced by using resonant coupling. Both the transmitter and the receiver use capacitors in their coils. Resonance frequencies of the two circuits are identical. This allows for more efficient transmission of electricity over a relatively short distance. Resonance in this instance is:

$$F = \frac{1}{2\pi\sqrt{LC}}$$

Where:

- off = resonant frequency
- LLL = inductance
- CCC = capacitance

V. Grid Integration Implementation

The electricity that has been received is sent to Power distribution system (via inverter) in the area station for electric vehicles to make AC electricity that is in sync with the grid's frequency, a grid-tie inverter transforms DC power. Ensuring safe operation is the job of protection circuits, which include:

This setup is compatible with both wired and wireless EV charging: Module for DC rapid charging Energy storage device (BMS) Controller for charging Inductive coupling is not just used for electric vehicles; it can also be used to wireless charging stations. By allowing for intelligent energy management, remote control, and real-time monitoring, the wireless power transfer system is enhanced via the Internet of Things (IoT) application. In order to monitor power production, transmission efficiency, and load circumstances in real-time, the system incorporates sensors, micro controllers, communication modules, and cloud platforms. Hybrid renewable energy sources are maximized and system dependability is enhanced via this smart connection.

VI. Conclusion

A lot of people become very excited about wireless power transfer while they are building the project. Improving the area of wireless electrical energy transfer between two magnetically connected coils requires extensive experimentation. We have experimented with various gauge wires, turn ratios, coil sizes, and kinds of magnetic coils in our trail runs. We have finished winding one set of coils using 21 SWG wire and an 8" ring size; the main and secondary coils each contain six turns. When compared with other coils, we discovered that the range increased marginally with them. We found that the battery was charging at around 300ma when the distance was less than 30mm, and at 50mm we found that the battery was charging at a lower current.

Due to the limited power supply on the main side, the prototype module's low power transmitter is built. While cost-effectiveness is an important consideration, we are certain that we can construct a transmitter with sufficient power and extend its range as needed thanks to our extensive testing. Resonant circuit tuning, including inductance and capacitance, is the meat and potatoes of this project. An additional critical factor is the pace at which these devices are functioning efficiently; the outcome is dependent on these two devices. In order to know precisely, we learned that formulae aren't very effective. The only thing to do is to undertake a lot of trial runs with a lot of patience. In order for the resonant circuits on each side of the coils to resonate at the same frequency, they must be fine-tuned. In this case, two identical LC circuits must be connected in parallel; one device's transmitter coil sends electric power into space, while another device's reception coil receives and transmits electric energy. While this technology is primarily being developed to power and charge portable gadgets like as mobile phones, it has a wide range of potential uses. This technique is used to charge the battery in this case.

VII. Results

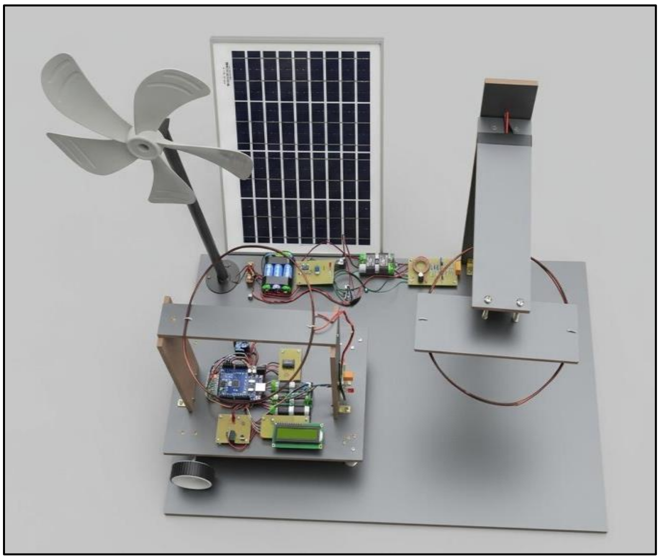

Fig. 2: Hardware setup

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