Solar Wireless Electric Vehicle Charging System

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***Abstract*—**The increasing adoption of Electrical Vehicles has changed the automotive industry, offering a cleaner and more environmentally friendly alternative to traditional fuel-powered vehicles. However, the adoption of electric vehicles is being interrupted by the limited availability of EV charging facilities. To address this challenge, this project proposes an innovative wireless EV charging system powered by solar energy, offering sustainable and convenient solutions for EV owners all around the world. The core of the proposed system is a wireless power transfer mechanism, enabling EV's to charge without any physical connectors. This technology not only eliminates the need for cables but also boosts the user's safety and accessibility. The usage of the solar energy further reduces the dependency on conventional sources of the power, making the charging more Eco- Friendly and also cost- effective. This approach provides numerous advantages over the traditional plug-in EV charging methods. The wireless charging eliminates the need for physicalconnections, improving the safety and convenience and solar power provides a sustainable and renewable energy source, minimizing the dependency on the power grid and impact on the environment and also the system's ability to charge EVs in motion further enhances userconvenience and decreases the discharge time. This project goal is to contribute to the development of the sustainable transport by providing an advanced solution that addresses the flaws of the traditional Electric Vehicle systems. The integration of wireless electric Vehicle charging system with solar not only advises eco-friendly energy adoption, but also supports development of a more adaptable and networked energy ecosystem, forging a way for greener and more efficient future in city transportation.

Keywords—MATLAB simulation, Solar energy, MPPT, Wireless charging system

I.INTRODUCTION

Solar wireless electric vehicle charging system is developed referring to different journals with the similar methods but a differentiator for every model. [1] Capacitive wireless power transfer uses coupling capacitors for power transfer instead of coils or magnets and AC voltage is applied to an H-bridge converter with power factor correction circuitry. High frequency AC generated by the H-bridge passes through coupling capacitors at the receiver side. Unlike regular inductive power transfer CWPT operates for both high voltage and low current.[2] Magnetic gear wireless power transfer is distinct from both CWPT and IPT, in MGWPT two synchronized permanent magnets (PM) are positioned side by side. The main power, acting as the current source, is applied totransmitter winding to produce mechanical torque on the primary (PM). The mechanical torque causes the primary PM to rotate, including torque on the secondary PM through mechanical interaction. The primary PM operates in generator mode. The secondary PM receives power and delivers it to the battery through a power converter and battery management system (BMS).[3] Resonant inductive power transfer is another method which is considered ad an advanced method than traditional IPT. Compensation networks in series and/or parallel configurations are added to both primary and secondary windings. These networks create the resonant case and reduce additional losses. Efficient power transfer is achieved when the resonant frequencies of the primary and secondary coils are matched. [4] The optimization problem of the PV array for the charging systems is reduced to the single objective problem applying the linear scalarization method and then it can be optimized through a genetic algorithm, the optimization framework can be applied to a case study to observe whether it reduces the annualized cost or not.[5] The previous studies are primarily focused on the EVs that can operate in a specific routes. A long-term mathematical model is presented for allocating and sizing of the dynamic wireless charging infrastructures. The optimization problem is solved using the mixed integer non-linear programming(MINLP). This model is used for the optimal sitting and sizing of the wireless EV charging infrastructures considering traffic systems and power distribution system. [6] The interest in wireless transmission of the power has emerged among people in the recent times with wireless charging support of some of the flagship mobile phones but there are also the implication from the WPT through RF radiations. [7] The simulation model developed in this paper is done referring to the above discussed aspects from different journals that are published. The solar wireless electric vehicle charging system can be analyzed well with the waveforms obtained at different stages of the system and it can only be possible by the simulation model of the system using Simulink. The solar energy captured by the PV array is fed to the boost converter since the energy obtained at PV array is unstable and at undesirable levels, boost converter then step-up the voltage obtained from the PV array to a level that it can chargea battery. A hf transformer with the inverter circuitry is then used to convert the DC power generated by the PV array into AC suitable for the wireless power transmission at transmitting and receiving coils. The diode bridge rectifier is then used at the receiving end to convert the AC power to DC so much so that it can charge a battery or energies the electric vehicle in this case. An LCD display is used for monitoring of the DC power obtained at the electric vehicle. The atmega controller shown in the blockdiagram is used in the prototype.

II. BLOCK DIAGRAM

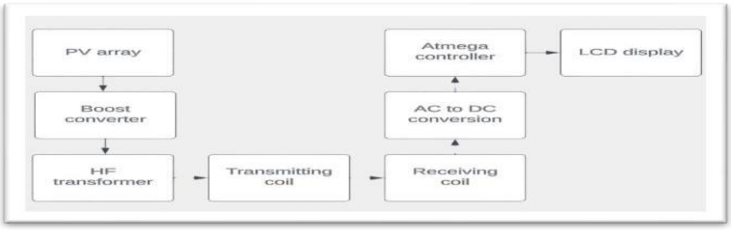

Fig. Block diagram

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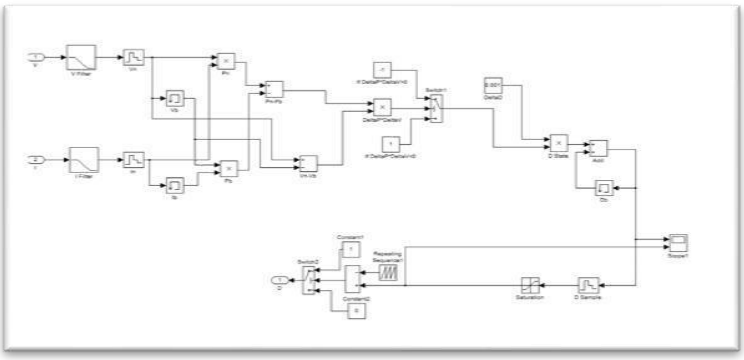


Fig. MPPT circuit using SimulinK

A maximum power point tracker, or MPPT, is basically an efficient DC to DC converter used to maximize the power output of a solar system. The first MPPT was invented by a small Australian company called AERL in 1985, and this technology is now used in virtually all grid -connect solar inverters and all MPPT solar charge controllers.

PERTURB AND OBSERVE ALGORITHM:

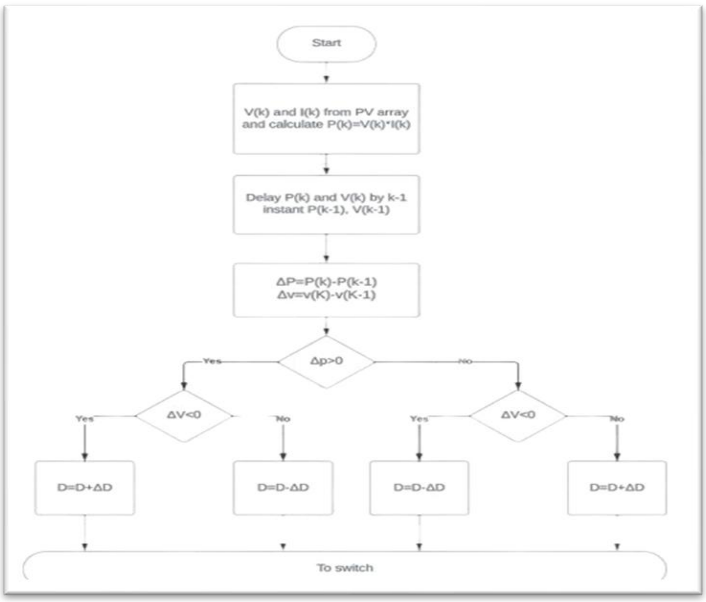


Fig. Flow Chart of P & O Algorithm

Maximum power point tracking(MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions, like changing solar irradiance, temperature and load.
Engineers developing solar inverters implement MPPT algorithms to maximize the power generated by PV systems. The algorithms control the voltage to ensure that the system operates at maximum power point or peak voltage on the power voltage curve.
The flow chart shows the steps of an algorithm that is used to calculate the value of a variable. The program starts by calculating the value of variable V(k) and a variable I(k) from a PV array. It then calculates the power P(X) as V(k) * I(k).
The program delays the power P(k) and the voltage V(k) by k-1. This means that the program stores the current values of P(k) and V(k) as P(k-1) and V(k-1).
The program now checks if a variable AV0 is set to Yes. If it is, then the program calculates the delta voltage ΔV(k) as V(k)-V(k-1). If AV0 is not set to Yes, then the program skips this step.
The program checks if the delta voltage ΔV(k) is greater than zero. If it is, then the program adds the absolute value of ΔV(k) to the duty cycle D. if ΔV(k) is less than zero, then the program subtracts the absolute value of ΔV(k) from the duty cycle D.If ΔV(k) is equal to zero, then the program does not change the duty cycle.

Detailed explanation of each step of the flow chart:

- This step calculates voltage and current from PV array and also power.

P(X)=V(k) * I(k)

- This step delays the power and voltage by k-1. It means the program stores the current values of P(k) and V(k) as P(k-1) and V(k-1).
- This step checks if a variable AV0 is set to Yes. If it is, then the program proceeds to the next step. If it is not, then the program skips to step 6.
- This step calculates the delta voltage ΔV(k) as V(k)-V(k-1).
- This step checks if the delta voltage ΔV(k) is greater than zero. If it is, then the program proceeds to the next step. If it is not,then the program skips to step 8.
- This step adds the absolute value of ΔV(k) to the duty cycle D.
- This step checks if the delta voltage ΔV(k) is less than zero. If it is, then the program proceeds to the next step. If it is not,then the program proceeds skip to step 9.
- This step subtracts the absolute value of ΔV(k) from the duty cycle D.
- This step goes to the switch.

BOOST CONVERTER:

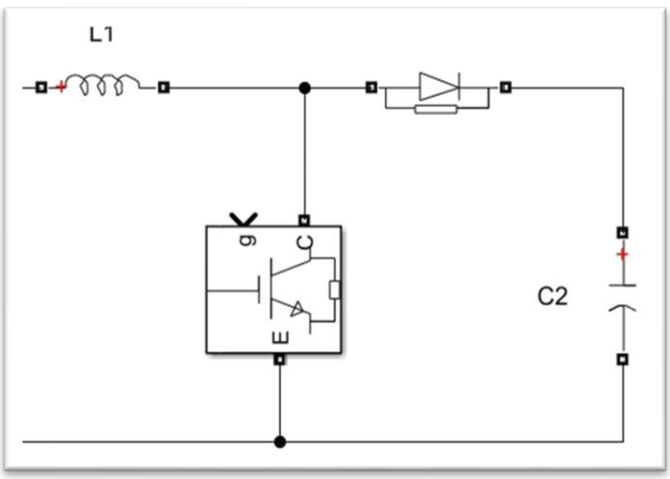


Fig. Boost converter

A boost converter is a type of DC-DC converter that steps up the input voltage from the PV array to a higher level. The boost converter can be used in the MPPT controller to adjust the voltage from the PV array and ensures that it operates at the maximum power point, this technique improves the efficiency of power conversion and maximizes the energy obtained from the PV array. Theboost converter serves for the battery charging where it steps up the voltage to the required level for effective battery charging. Due to the changes that occur in the environment the voltage from the PV array will fluctuate and boost converter can be used to help maintain a stable output voltage by compensating the fluctuations. Not in many cases does the voltage available from the PV array is sufficient to load requirements hence a boost converter can be used to step up the voltage to meet the voltage requirements of the load. The operation of the boost converter can be explained in a few phases.[1]During the switching phase the transistor is turned ON, connecting the input voltage. Then the inductor stores the energy in the form of magnetic field [2] The inductor doesn't allow any sudden changes in the current, so when the transistor is in OFF state the inductor releases its energy to the load [3] when the transistor is in off state the diode gets forward biased allowing the energy stored to capacitor and load [4] The output voltage acrossthe capacitor is higher than the input voltage due to the energy stored in the inductor during the switching phase. This is how the boost converter steps up the voltage.

HF TRANSFORMER AND INVERTER:

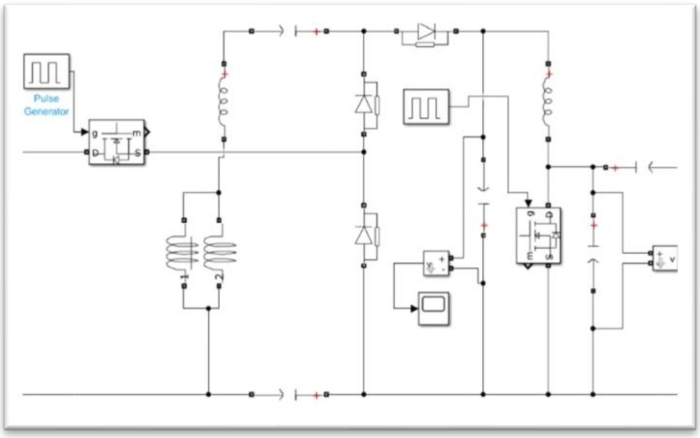


Fig. HF Transformer and Inverter

High frequency transformers are commonly employed with the inverters in the system. Inverters are commonly used for convertingthe DC from the PV array to AC. The simulation has both HF transformer and inverter connected which provide the AC power to the transmitting coil. HF transformers are also used for isolation purposes in certain PV system configurations. Isolation transformershelp to ensure the electrical safety and can be employed to provide galvanic isolation between different parts of the system, such asbetween the DC and AC sides. In certain cases transformers are used to match the voltage levels between PV array and other components like the inverter but it is more common only in the large-scale solar installations where optimizing the voltage for efficient power transmission is crucial transformers are employed in PV systems to boost or match the voltage levels to supply the high-voltage DC power generated by the PV array to the transmitting coil in this case whereas in other cases such as utility-scale solar installations it is used to supply the voltage efficiently to the grid. These transformers can be used to contribute to power conditioning. They help smooth out fluctuations in voltage and current improving the quality. It's worth noting that many modern grid-tied inverters use transformer less designs, leveraging high-frequency switching and capacitive coupling instead of traditional transformers. Transformer less designs aim to reduce size, weight, and cost while maintaining safety and efficiency.

TRANSMITTING AND RECEIVING COILS:

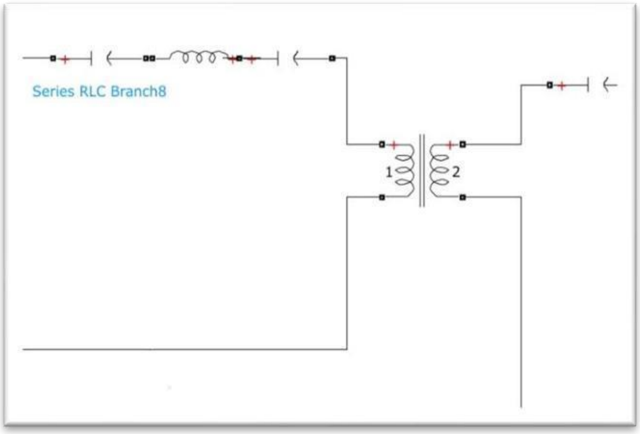


Fig. Transmitting and Receiving Coils

The transmitting coil is energized by the alternating magnetic field when connected to a power source. Typically embedded in thecharging pads on the ground. The receiving coil inside the EV is coupled with the transmitting coil on the charging pads on the ground. Satisfying the principles of electromagnetic induction, the rapidly changing magnetic field induces an electric current in the receiving coil which is then converted into DC using a full bridge rectifier to charge EV battery. This inductive transfer of the power to charge the EV eliminates the need of any kind of wires to connect the EV with an energy source to charge it offering EVowners to continue their journey without worrying about the battery charge and also reduces the wear and tear effect often occur otherwise on the charging infrastructure. When this system is energized by solar instead of the conventional methods that involves large amount of pollution to obtain the energy reduces the carbon emission into the environment.

BRIDGE RECTIFIER:

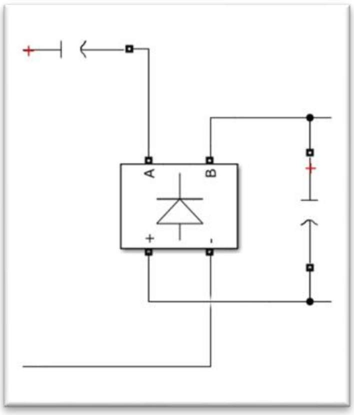


Fig. Bridge rectifier

To convert the AC power obtained from the receiving coil to the DC in order to store that in the EV's battery we use the bridge rectifier which is mostly made of diode only. In this simulation we used the universal bridge to do the job. The bridge rectifier is a circuitry responsible for the conversion of the AC power into DC. This typically consists of 4 diodes connected forming a bridge,as the current flows through this bridge it undergoes the conversion process where the negative half cycles are converted into positive half cycles resulting in a unidirectional flow of electric current. This rectified DC output is then smoothed using the capacitors to improve the waveform providing more stable DV voltage for proper charging of the battery present in the electric vehicle. The bridge rectifier is wholly responsible for the conversion of the fluctuating AC power induced in receiving coil to consistent DC power for efficient charging.

LOAD:

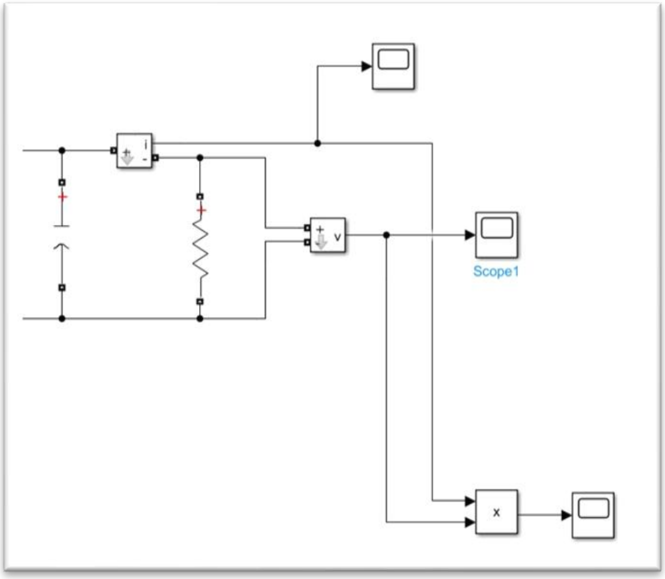
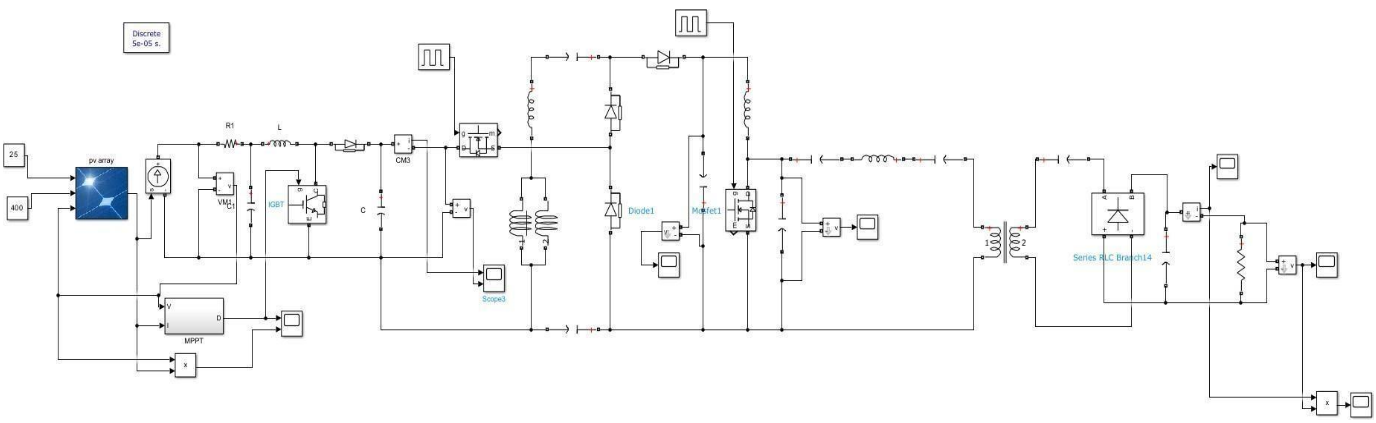


Fig. Load

In this system the load represents the battery inside the electric vehicle with the whole aim to charge it wirelessly. In this context theload is assumed to be purely resistive. The resistor in the simulation indicates the resistive elements in the electric vehicle, including the charging circuit and other resistive losses. This resistive load plays a crucial role in determining the power dissipationand efficiency of the wireless charging process, influencing factors such as charging speed and overall energy transfer effectiveness. Characterization of the load as resistive is essential for optimization of the wireless charging system's performance and for better efficient utilization of the DC power transferred in the charging of the EV's battery. The charging circuit present inside the EV manages the incoming DC power, regulates the charging voltage to ensure safe and efficient charging of the battery. It includes components like voltage regulators, current limiters, and safety features to protect the battery. load also consists of energy storage elements, such as capacitors which help to stabilize the DC voltage. These capacitors help to smoothen the voltage fluctuations ensuring more reliable power supply to the EV's battery. Due to the dynamic nature of the load in the EV charging system its electrical characteristics may change during charging process and upon some time the load resistance my vary due to battery charging which impacts in the overall efficiency of power transfer.

RESULT:

Simulation:



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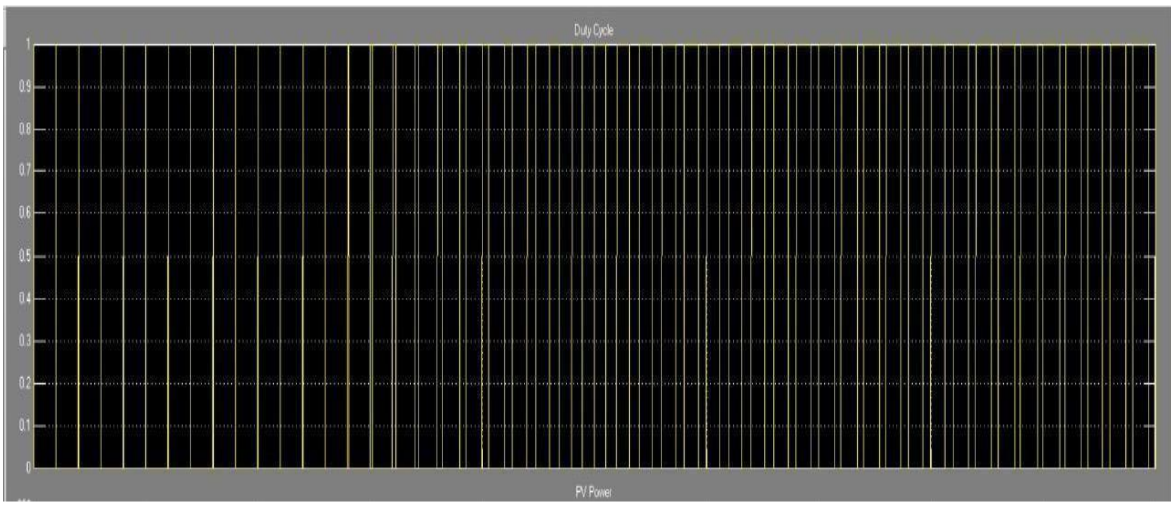
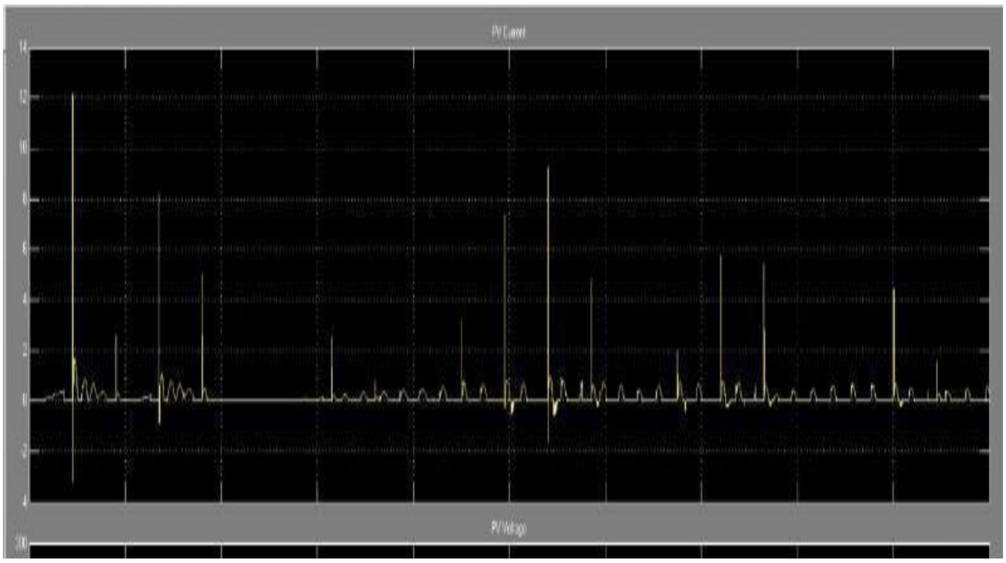
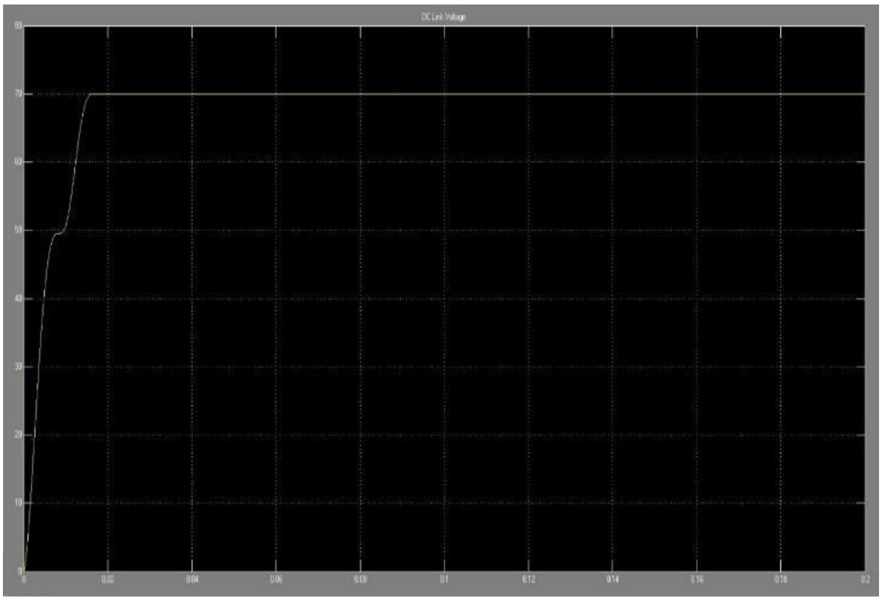
Duty cycle from the MPPT controller circuit



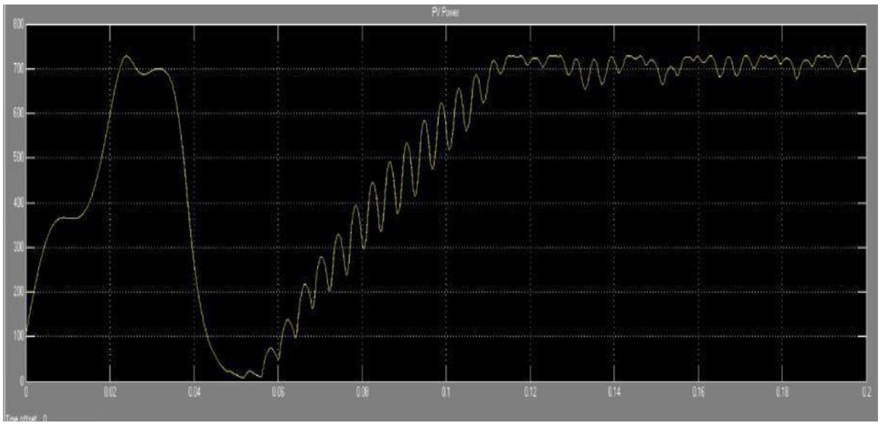
Unstabilized current obtained from the PV array.



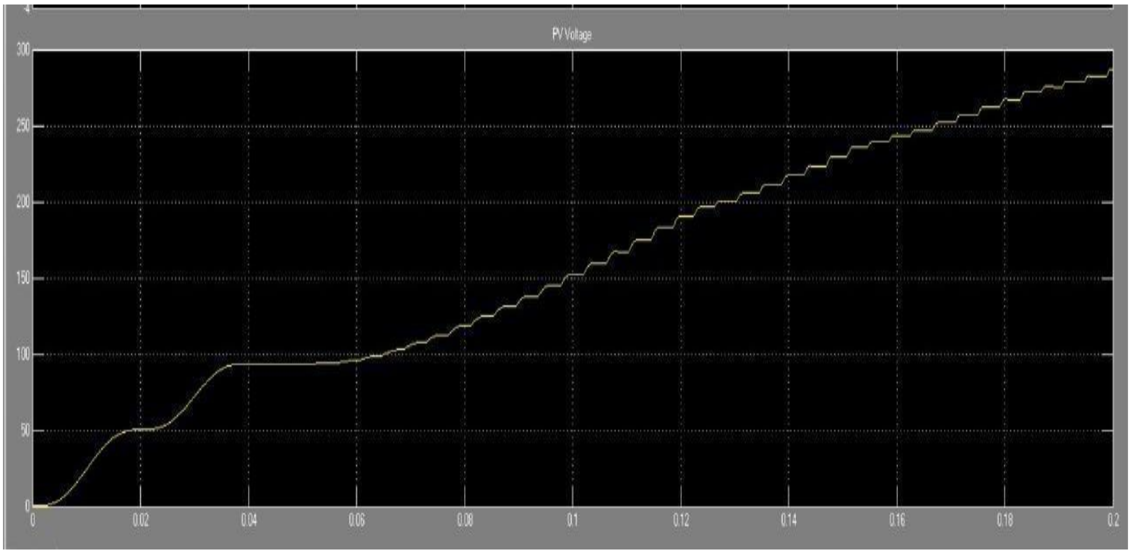
DC link voltage



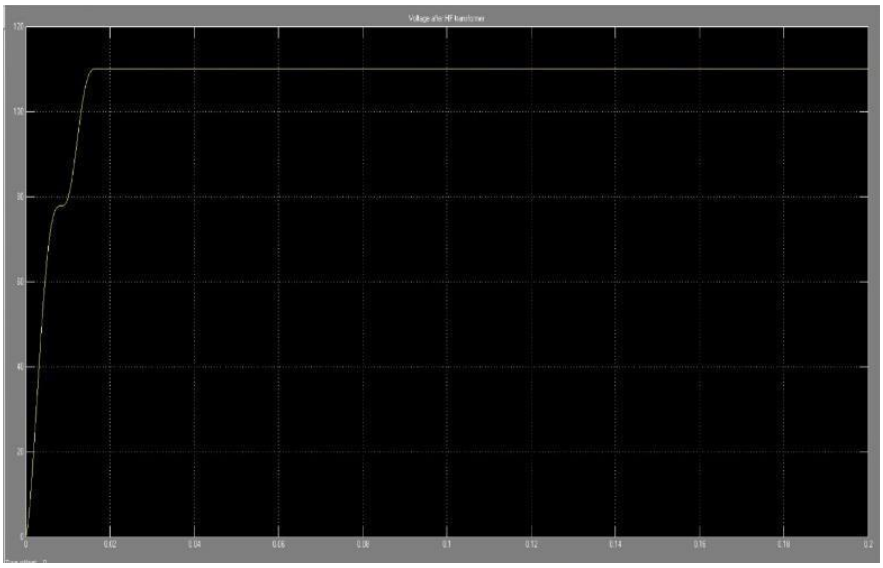
Unstabilized DC power obtained from PV array.



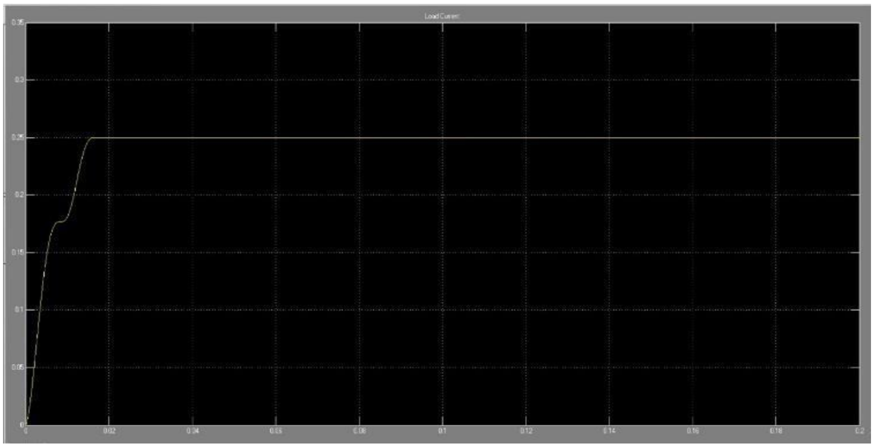
Unstabilized PV voltage reaching values of 300V.



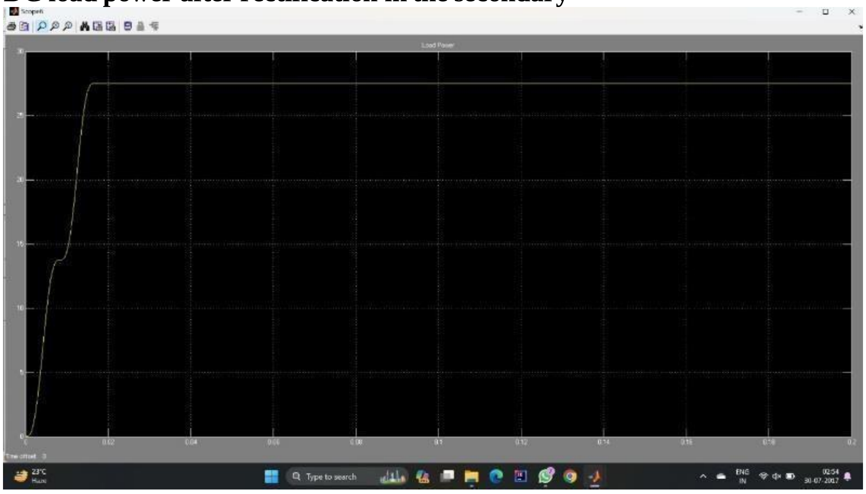
High frequency AC voltage converted for the transmitting coil to induce increased from 70V to 110V.



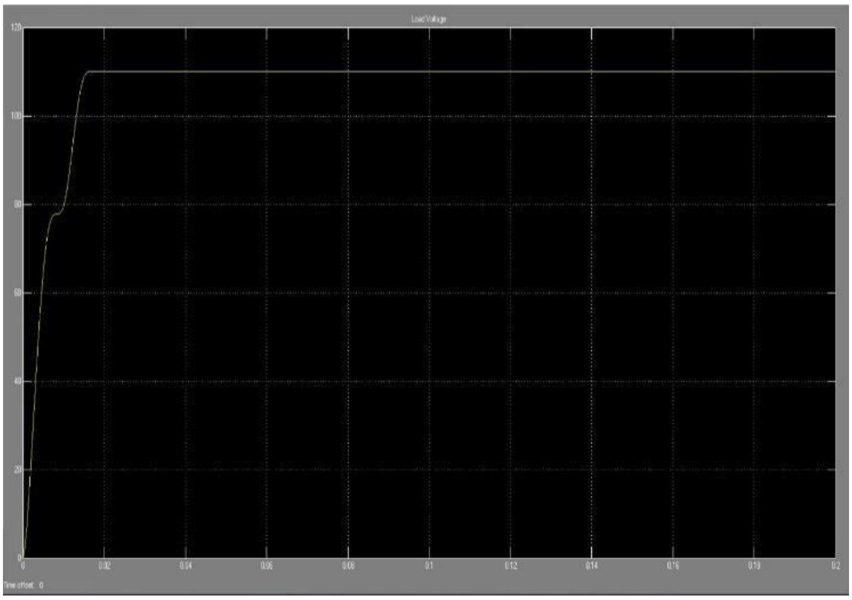
DC load current after rectification in the secondary



DC load power after rectification in the secondary



DC load voltage after rectification in the secondary



CONCLUSION:

In conclusion, the proposed wireless EV charging system powered by solar energy presents a transformative solution to the challenges hindering the widespread adoption of electric vehicles. By eliminating the need for physical connectors and integrating renewable solar power, this innovative approach not only enhances user safety and accessibility but also significantly contributes to environmental sustainability. The project's emphasis on reducing dependency on conventional power sources aligns with the broader goal of creating a more eco-friendly and cost-effective transportation ecosystem. Furthermore, the system's capability to charge EVs in motion marks a leap forward in user convenience and efficiency. Overall, this project represents a significant step towards fostering a greener and more adaptable future in city transportation, supporting the development of a networked and sustainable energy ecosystem.

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