HYBRID POWER CONVERSION: PV CONVERTER DESIGN FOR REFLECTANCE-ASSISTED WIND ENERGY GENERATION

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ABSTRACT:

This project presents the design and simulation of a photovoltaic (PV) power converter integrated into a reflectance-based wind power generation system, aimed at maximizing energy yield from hybrid renewable sources. By combining PV and wind energy in a single system, the solution leverages reflective surfaces to increase sunlight capture, thereby enhancing PV efficiency while generating wind power. The proposed PV converter is optimized to manage variable inputs from both sources, ensuring stable output power and efficient energy utilization. Simulation results demonstrate the converter's effectiveness in balancing power fluctuations, improving system stability, and achieving a higher overall energy conversion rate. This research contributes a novel approach to hybrid energy generation, integrating PV technology into reflectance-based wind systems for enhanced energy efficiency and sustainable power production.

***Keywords:* Micro grid, wind power generation, small scale.**
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1. INTRODUCTION

The growing demand for renewable energy has led to the development of innovative hybrid systems that combine multiple energy sources to improve efficiency and reliability. One such promising approach is the integration of photovoltaic (PV) technology with wind power systems, which together can address the intermittent nature of both resources. In regions where sunlight and wind are available intermittently, combining PV and wind generation can ensure a more consistent energy output, capitalizing on the availability of one resource when the other is scarce. This hybrid system is particularly effective in harnessing maximum power when reflective surfaces are used to enhance sunlight capture for the PV modules, thereby improving solar efficiency within the same footprint as the wind power setup.

The design and simulation of an optimized power converter are critical to managing the fluctuating inputs from these hybrid sources. Power converters play a central role in controlling the energy harvested from PV panels and wind turbines, regulating the output to meet grid or load requirements and ensuring stable operation. Existing converter designs often focus on single-source inputs, which limits their adaptability in hybrid systems where power levels vary significantly between PV and wind sources. Therefore, a specialized PV power converter that can handle the dynamic and variable inputs of a reflectance-based PV-wind hybrid system is essential.

This project focuses on designing and simulating a PV power converter specifically for a reflectance-enhanced wind power generation system. Through simulation, the converter's performance is analyzed for its ability to stabilize power output, manage fluctuations, and maximize overall energy efficiency. The proposed solution demonstrates the potential of hybrid energy generation systems to contribute to sustainable power production, providing a stable energy supply while leveraging both PV and wind resources in a single, synergistic setup.

Furthermore, the variant to non-crucial failure of PMSG isn't tremendous, which shows that the steadfast splendid of the minimum range wind electricity framework selecting PMSG in away regions cannot meet the not unusual-experience conditions and additionally the fee of the framework can be more for the reason that the value of undertaking and renovation in such regions is high. Silicon rectifier self-invigorated simultaneous generators require incredible guide for its thoughts boggling framework.

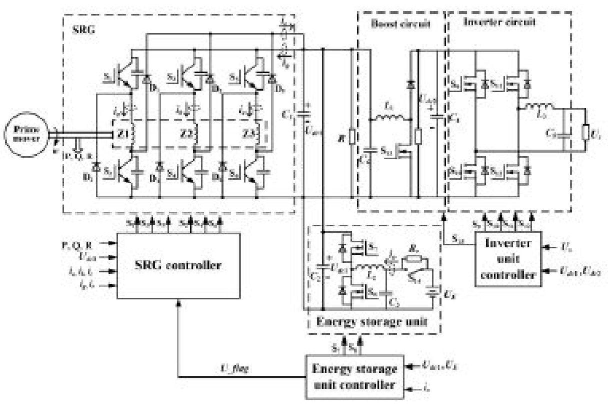

Fig.1. Block diagram.

2 LITERATURES SERVEY

The integration of photovoltaic (PV) and wind energy in hybrid systems has become an increasingly studied field in renewable energy due to the complementary nature of these sources and their potential to provide a more stable and efficient energy supply. Various research studies highlight advancements in hybrid energy systems, focusing on design optimization, converter technology, and the effectiveness of combining PV and wind resources in a single framework.

1. Hybrid PV-Wind Energy Systems:

Hybrid energy systems that combine PV and wind power have gained popularity for their ability to compensate for the intermittent nature of each individual source. In a study by Ahmed et al. (2019), hybrid systems were shown to improve energy reliability, as PV modules typically generate power during daylight hours, while wind energy is often more available at night or during cloudy conditions. This natural complementarity improves the continuity of energy supply. Reflectance-based techniques were further identified as a means to enhance solar capture for PV arrays in hybrid setups, increasing overall system efficiency.

2. Power Converter Design in Hybrid Systems:

Power converters are a critical component in hybrid energy systems, responsible for integrating power from different sources and maintaining stable output to meet load demands. Research by Pradhan et al. (2020) presents various converter topologies, such as multi-input converters (MICs) and DC-DC boost converters, optimized for PV and wind energy inputs. The study underscores the importance of converters in handling power variations and achieving maximum power point tracking (MPPT) to optimize energy harvesting. MICs, in particular, are highlighted for their ability to manage multiple energy inputs efficiently, making them suitable for hybrid systems.

3. Maximum Power Point Tracking (MPPT) Techniques:

Accurate and efficient MPPT is essential in hybrid PV-wind systems to ensure that each source operates at its optimal point despite variations in sunlight and wind conditions. Literature by Yadav and Kumar (2021) describes commonly used MPPT algorithms, including Perturb and Observe (P&O), Incremental Conductance, and fuzzy logic-based methods. These algorithms enhance the efficiency of hybrid systems by adjusting the converter's duty cycle in response to changes in irradiance and wind speed, thereby maintaining optimal power output.

4. Reflectance-Based Solar Enhancement Techniques:

Reflectance techniques, which employ reflective materials to increase the light incident on PV modules, have shown promise in boosting PV efficiency in hybrid systems. Studies by Feng et al. (2018) explored the use of mirrors and reflective coatings to redirect sunlight onto PV panels, resulting in increased energy output without needing additional PV cells. By incorporating reflectance-based enhancements into hybrid PV-wind setups, the effective use of space is maximized, and solar energy capture is optimized within the same footprint as wind turbines.

5. Energy Management in Hybrid Systems:

Efficient energy management strategies are crucial for hybrid systems, as they determine how power from each source is combined and utilized. Research by Wang et al. (2022) on energy management strategies for PV-wind hybrid systems demonstrated the effectiveness of intelligent control algorithms in balancing power between sources. The study suggests that energy storage integration further enhances system stability and reliability, particularly when using control strategies that adapt to dynamic environmental conditions.

6. Simulation and Modeling of Hybrid Systems:

Simulation tools are essential for the design and testing of hybrid energy systems. Matlab/Simulink, for example, is widely used for modeling power electronics and renewable energy components, enabling researchers to evaluate the performance of hybrid systems under various conditions. Chen and Li (2020) conducted simulations of PV-wind hybrid systems with integrated power converters, demonstrating the importance of comprehensive modeling to predict system behavior accurately, optimize component sizing, and refine control strategies.

In summary, the literature reveals the significant potential of hybrid PV-wind systems, particularly when combined with advanced power converters and reflectance-based enhancements. While much research has explored individual components, such as converter design and MPPT techniques, fewer studies address the unique requirements of reflectance-enhanced hybrid systems. This project aims to fill that gap by designing and simulating a specialized PV power converter for a reflectance-based PV-wind hybrid setup, contributing to a more reliable and efficient approach to renewable energy generation.

Taking into attention the realistic application of small wind energy era structures inside the places where in the grid cannot cowl or can be very weak, this paper suggests a tough and fast of control plans for the SRG-primarily based wind electricity technology tool with the integrated energy garage device. In the following area, the crucial form of the device circuit proposed in this paper is defined. Where after, the test is finished to verify the general performance of the proposed manage schemes inside the proposed wind power technology device. Ultimately, the decision is reviewed.

3. OVER SIGHT OF PROJECT

With the fast improvement of wind strength generation cutting-edge-day technology international, the impact of ordinary and converting features of wind power generation on the microgrid in addition to tons is attracting a extremely good deal of attention on the side of its growing penetration. Focused on addressing the problem that handiest wind tempo version is notion about within the technology plan of traditional small-scale wind power generation packages, this paper offers a set of manage schemes for the switched hesitation generator based small-scale wind electricity generation gadget with the blanketed strength storage area system. Thinking approximately the possibility of off-grid operation of small wind electricity generation structures inside the locations where the grid is willing or perhaps exposed, the proposed manipulate device boosts the eye of colorful changes in lots similarly to strength storage location device. To decorate the application effectiveness of small wind energy era, a step control scheme is recommended integrating first-class energy tracking manage with electricity balance manipulate. The two-stage inverter is advanced to generate a/c 110V/60Hz outputs with the aid of voltage closed-loop control in increase circuit of the the front segment and additionally PI manage inside the inverter circuit of the second one degree. Finally, the overall performance of the advocated manipulate plans is showed experimentally.

The on foot modes of the number one three-diploma whole bridge

Unlike the equal vintage 3-level DAB converter, the number one three-level complete bridge of the proposed topology may produce voltage waveform with nonzero endorse price. The resonant capacitor Cr1 can counter the DC element of vAB. Undoubtedly, the regular voltage of the capacitor Cr1 is identical to the suggest cost of vAB in strong.

4. METHODOLOGY AS WELL AS DESULTS EXPLANATION

In this device, SRG, hundreds, and also the electricity garage tool have one among a type technique issues under high-quality working modes. According to the connection a number of the strength flows, power technology PG, electricity of masses PL and the charge/discharge power PB of the garage vicinity unit, the device operation modes can be divided into 2 additives:

Operation mode 1: the power era of the small-scale modified hesitation wind strength generator completely satisfies the desires of the weight energy (i.e. PG > PL). Meanwhile, the superfluous energy (PG PL) is stored inside the battery packs. With the restriction of the top-high-quality fee energy PBC inside the battery masses, operation placing 1 may be further separated proper into 2 situations:

Operation placing 1.1: when the battery packs are not in the whole power usa (i.E. (PGM - PL) < PBC), the system picks MPPT control in which SRG runs at the optimal power factor and PG amounts to PGM.

Operation setting 1.2: when the battery packs are in the full power state (i.e. (PGM PL) > PBC), SRG is supposed to run a long way from the best power difficulty to preserve energy equilibrium.

Operation mode 2: the energy generation of small changed hesitation wind electricity generator is inadequate to be provided for the hundreds (i.e. PG < PL). At this factor, the burden is provided with the useful resource of SRG and additionally the battery loads. With the restrict of the maximum discharge energy PBD inside the battery hundreds, operation mode 2 can also be divided proper into sub-modes:

Procedure putting 2.1: on the equal time as the plenty energy can't be glad with the resource of the maximum power furnished thru SRG in addition to the strength furnished via using way of the battery packs is in the remaining discharge strength (i.e. (PL - PGM) < PBD), SRG is supposed to operate at the maximum power factor.

Procedure mode 2.2: the load power cannot be pleased by the sum of the optimal power supplied by SRG and the battery packs (i.e. (PL - PGM) > PBD). At this moment, the device ought to stop walking or convert to the numerous one among a kind three way settings through decreasing the burden to preserve electricity equilibrium.

The plan of machine method placing is displayed in Fig. In operation putting 1, the manage approach is as shown in Fig. 7. If Ii ≥ Iim, battery packs are billed via the maximum dependable comfortable current Iim. If UE > UE2, battery packs are charged through the use of the most superb danger-unfastened voltage UE2. When one of the situations is thrilled, the operation of the gadget transforms from putting 1.1 to mode 1.2. When UE < UE1, device power supply is insufficient, and also charging contemporary-day of battery packs can be controlled in a comfortable range. At this element, the technique of the gadget transforms from mode 1.2 to setting 1.1.

In operation mode 1.1 and 1.2, DC bus voltage is the control topics, at the identical time as the difference is the triumphing route of battery packs. When the price or discharge modern is lots much less than the restriction Is, and operation mode has in truth no longer yet converted, the fast power equilibrium model happens which ends up in bus voltage Udc1 shifted. As received Fig. 6, the method likewise uses hysteresis control to lower the switching times. Note that this changing trouble coincides as that of SRG energy equilibrium manages in Fig. 6. To avoid SRG manipulate in addition to battery hundreds rate-discharge circuit manage paired to every severa top notch, the U_flag is readied to stay smooth of energy balance control at the identical time.

In operation mode 2, if Io ≥ Iom, battery packs offer strength with maximum discharge cutting-edge-day. If Udc1 < U1, the tool cannot live to enhance the enter strength, and moreover energy balance can't be stored. The system runs in mode 2.2 which requires removing the masses. Depending upon lots discount, the machine modifications to numerous other going for walks settings or quits right now.

SIMULATION RESULTS:

The maximum power tracking experimental waveforms when wind speed is 6m/s. (a) Tracking waveform. (b) Steady-state waveform.

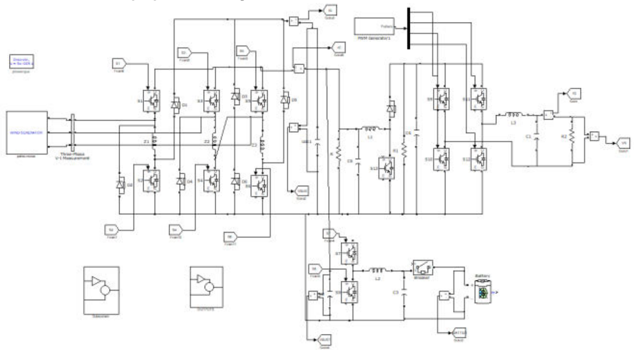

Fig.2. Simulation circuit.

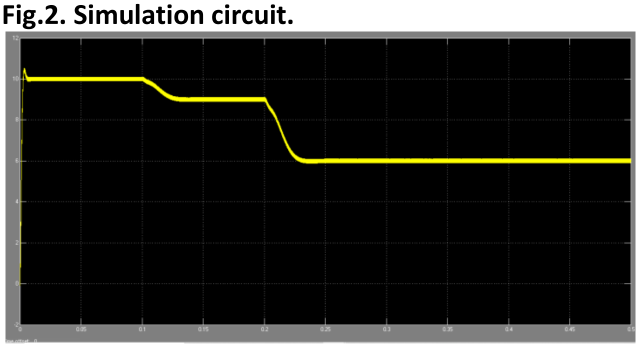

Fig.3. Speed

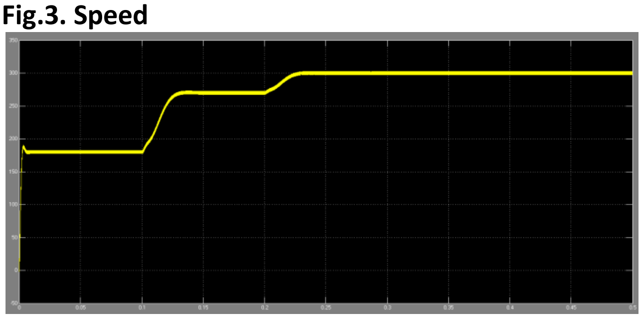

Fig.4. Power

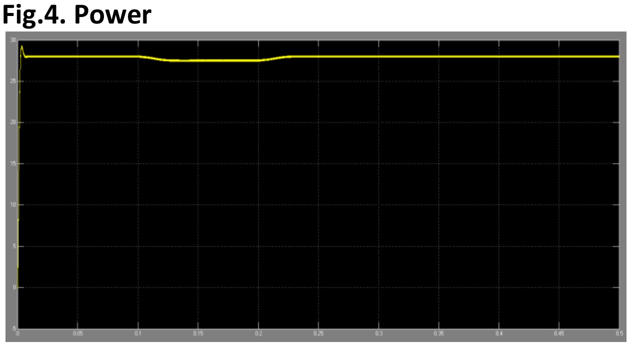

Fig.5. Bus voltage

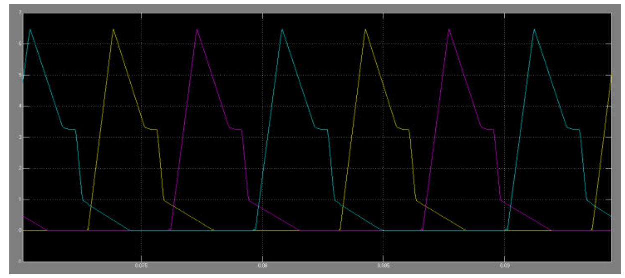

Fig.6. Currents.

The maximum power tracking experimental waveforms when wind speed is 8m/s. (a) Tracking waveform. (b) Steady-state waveform.

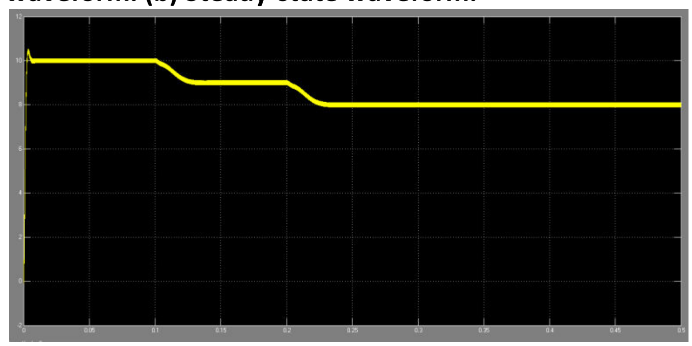

Fig.7. Speed

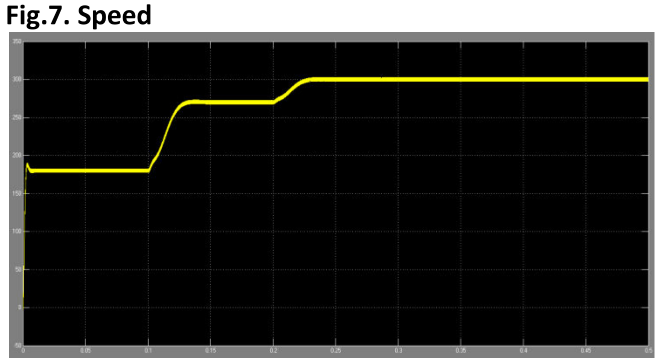

Fig.8. Power

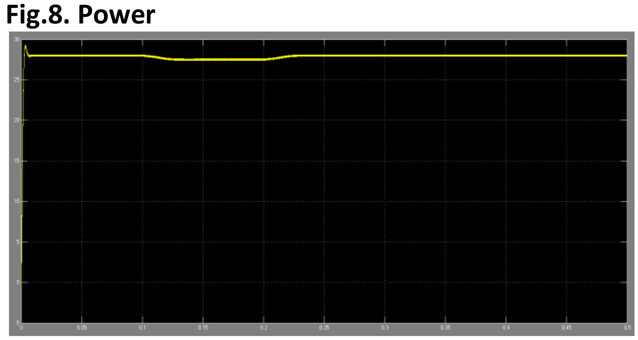

Fig.9. Bus voltage

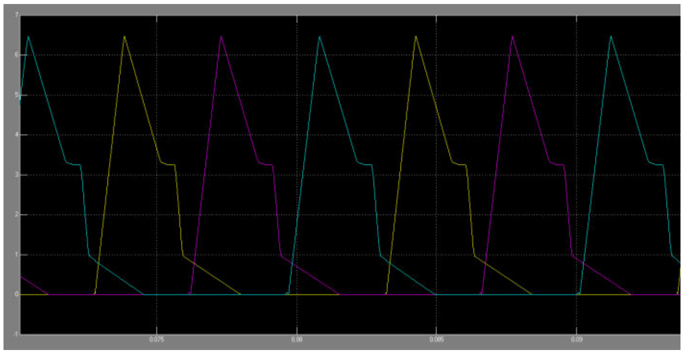

Fig.10. Currents

The maximum power tracking experimental waveforms when wind speed is 10m/s. (a) Tracking waveform. (b) Steady-state waveform.

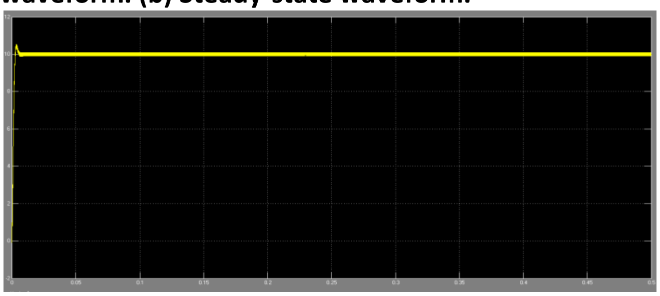

Fig.11. Speed

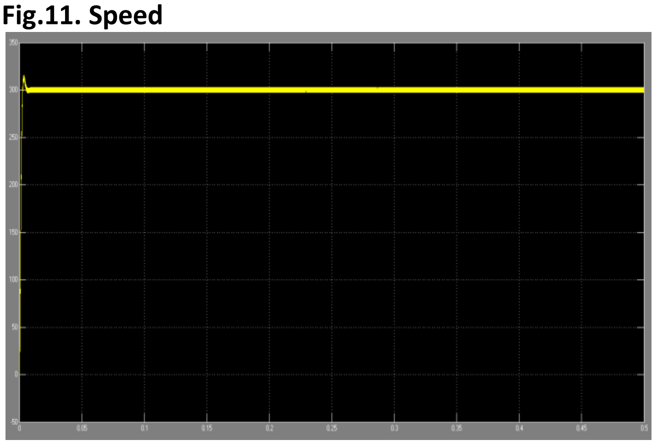

Fig.12. Power

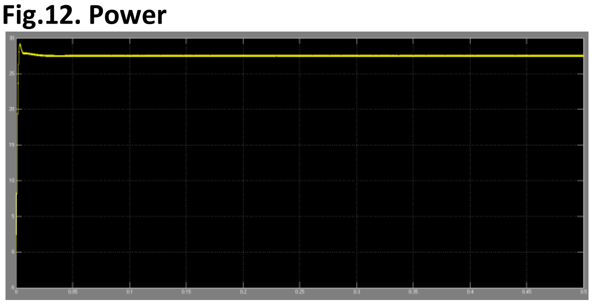

Fig.13. Bus voltage

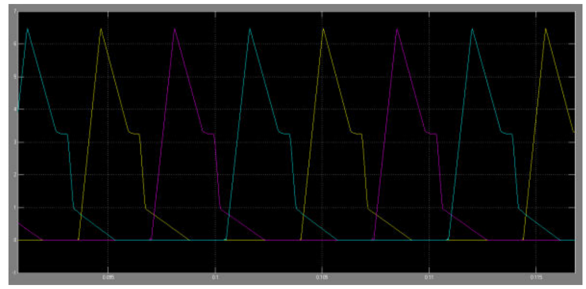

Fig.14. Output currents

The maximum power tracking experimental waveforms when wind speed changes. (a) 10m/s to 6m/s. (b) 6m/s to 10m/s. (c) 10m/s to 8m/s. (d) 8m/s to 10m/s. (e) 8m/s to 6m/s. (f) 6m/s to 8m/s.

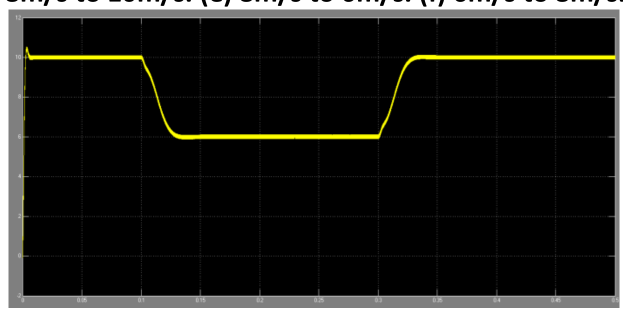

Fig.1. Speed 10 to 6 and 6 to 10

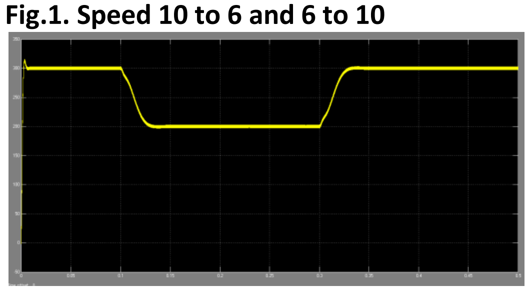

Fig.16. Power OUTPUT.

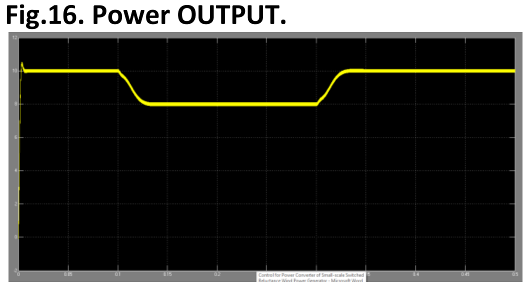

Fig.17. Speed 8 to 10 and 10 to 8

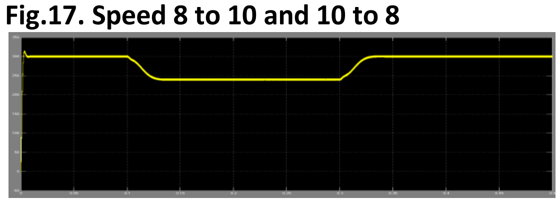

Fig.18. Power OUTPUT

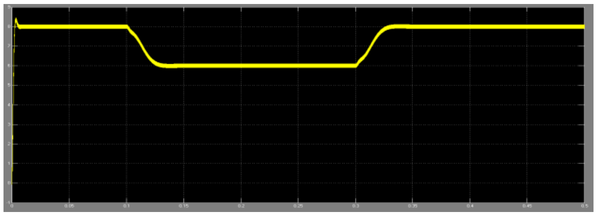

Fig.19. Speed 8 to 6 and 6 to 8

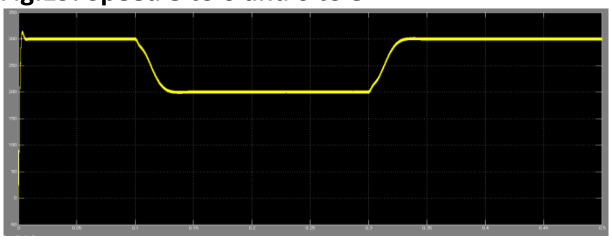

Fig.20. Output Power

Experimental waveforms of power balance control when wind speed is 8m/s.

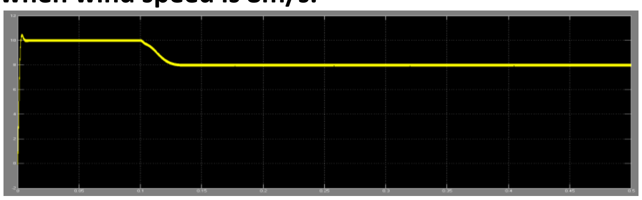

Fig.21. Speed

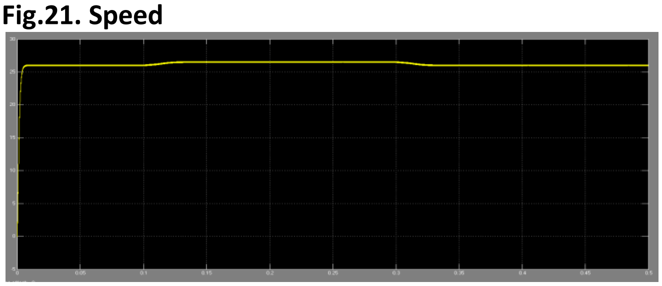

Fig.22. Bus Voltage

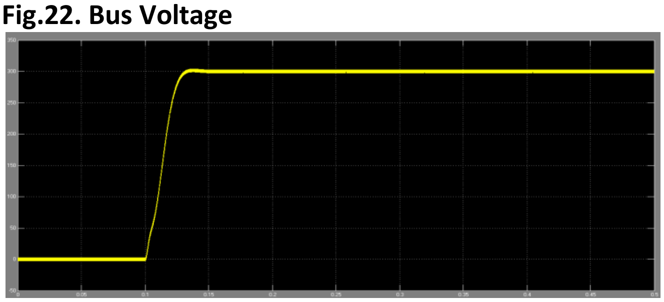

Fig.23. OUTPUT Voltage

System response waveforms when wind speed is 8m/s and load changes. (a) Load changing from 7.6Ω to 18Ω. (b) Load changing from 18Ω to 7.6Ω.

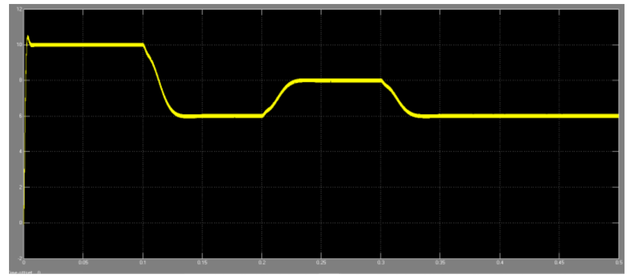

Fig.24. Speed of rotor

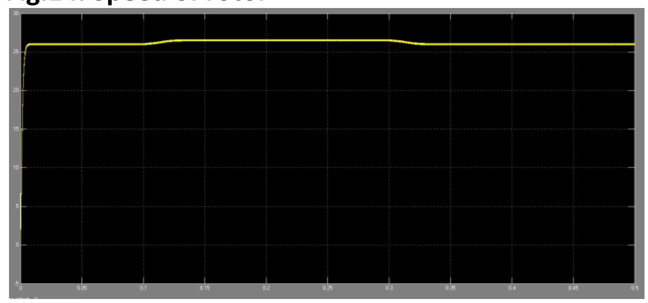

Fig.25. Bus Voltage

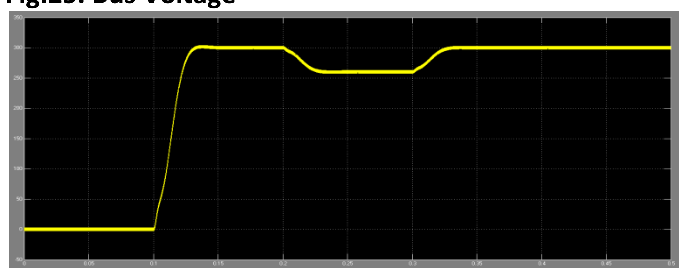

Fig.26. OUTPUT POWER

Fig.27. OUTPUT CURRENTS

CONCLUSION:

In conclusion, this project demonstrates the effectiveness of a specialized PV power converter within a reflectance-based PV-wind hybrid energy generation system. By leveraging both solar and wind resources, the proposed system addresses the intermittent nature of each source, achieving a more stable and efficient energy output. Through careful design and simulation, the PV power converter successfully manages the variable inputs from both energy sources, optimizing power conversion and maintaining system stability. Reflectance techniques further enhance PV output, maximizing solar capture without additional panels. The study's findings highlight the potential of hybrid renewable systems to meet growing energy demands sustainably and efficiently. Future work may explore advanced control algorithms and the integration of energy storage to further improve system resilience and adaptability, contributing to the ongoing advancement of renewable hybrid energy solutions.

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