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SOLAR POWERED INCORPORATED AC LINE FEEDER WITH ACTIVE OUTPUT FILTER UNDER NON-LINEAR CONDITION

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ABSTRACT

In this project, a new electric power train for solar powered unmanned aerial vehicle (UAV). The proposed system structure is based on the development of the power supply system for both the Solong and Zyphyr aircraft models. The proposed UAV model incorporates the Zyphry UAV use of an AC line feeder instead of DC power lines to power the propellers. The proposed power train includes solar panels, an energy management system based on lithium sulphide battery, inverter, AC bus-line and active output filter (AOF). AOF topology is composed of a high switching frequency H-bridge inverter with a reduced size LC filter. The utilization of AOF system reduces the size and weight of the power transmission system and significantly improves its conversion efficiency by introducing an emulated series resistance with the H-bridge stage to ensure high quality pure sinusoidal waveform of the line voltage. This emulated series resistance produces an injected voltage across it to diminish unwanted harmonics created from the non-linear load. A simulation model and experimental setup are created to simulate the proposed system and the system is tested under non-linear loadconditionwithclosed-loopfeed-backcontrolstrategy.Theobtained simulation and experimental results demonstrate that high-quality sinusoidal line voltage waveforms can be obtained using the active resistance compensation technique with total harmonic distortion factor less than 3%. Moreover, power losses analysis and conversion efficiency calculation of the proposed system are performed and compared with that of the conventional three-phase PWM inverter, which proved that the power losses are reduced by 31%.

I INTRODUCTION

Solar energy has emerged as a pivotal player in the quest for sustainable and renewable energy sources, offering a promising solution to the world's energy needs. With its abundance, cleanliness, and inexhaustible nature, solar power has garnered significant attention as a viable alternative to traditional fossil fuels. In recent years, technological advancements have propelled the efficiency and affordability of solar energy systems, making them increasingly attractive for widespread adoption across various sectors. Among the myriad applications of solar power, its integration into the electrical grid has garnered particular interest, offering a means to enhance grid stability, reduce reliance on conventional energy sources, and mitigate environmental impacts. One significant aspect of solar power integration into the grid involves addressing the challenges posed by non-linear loads. Non-linear loads, characterized by their fluctuating power consumption patterns and harmonic distortions, can introduce instability and inefficiencies into the grid, undermining the reliability and performance of electrical systems. In this context, the incorporation of active output filters into solar power systems assumes critical importance, offering a means to mitigate harmonic distortions and ensure the delivery of clean and stable power to the grid under non-linear conditions.

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Solar Powered Incorporated AC Line Feeder with Active Output Filter represents a groundbreaking approach to harnessing solar energy while addressing the challenges associated with non-linear loads. This innovative system combines the inherent benefits of solar power generation with advanced filtering techniques to deliver high-quality power to the grid, thereby enhancing grid stability and efficiency. By integrating solar power generation directly into the AC line feeder, this system offers a streamlined and efficient means of electricity generation, bypassing the need for complex intermediary components and maximizing energy yield. At the heart of this system lies the solar power generation unit, comprising photovoltaic (PV) panels that convert sunlight into electricity. These panels utilize semiconductor materials to generate a direct current (DC) output, which is then converted into alternating current (AC) using inverters. The AC output is fed directly into the grid through the line feeder, facilitating seamless integration with existing electrical infrastructure. However, the intermittent nature of solar power generation and the presence of non-linear loads can introduce harmonic distortions and voltage fluctuations into the grid, compromising its stability and efficiency.

To address these challenges, the Solar Powered Incorporated AC Line Feeder employs active output filters, which are sophisticated electronic devices designed to suppress harmonic distortions and regulate voltage levels in real-time. These filters continuously monitor the output of the solar power system and dynamically adjust their parameters to counteract any disturbances introduced by non-linear loads. By actively filtering out harmonic components and regulating voltage levels, these filters ensure that the power delivered to the grid meets stringent quality standards, thereby enhancing grid stability and reliability. One key advantage of this integrated approach is its ability to adapt to changing operating conditions and load profiles. Unlike traditional passive filters, which offer fixed impedance characteristics and limited flexibility, active output filters can dynamically respond to fluctuations in load demand and solar power generation. This dynamic response capability allows the system to maintain optimal performance under varying conditions, ensuring consistent power quality and grid stability.

Furthermore, the incorporation of active output filters into the solar power system offers additional benefits beyond harmonic mitigation. By regulating voltage levels and suppressing voltage fluctuations, these filters help optimize power transfer efficiency and minimize losses within the electrical infrastructure. This not only enhances the overall performance of the grid but also maximizes the economic viability of solar power generation by minimizing operational costs and maximizing energy yield. In addition to their technical capabilities, the Solar Powered Incorporated AC Line Feeder with Active Output Filter exemplifies a holistic approach to sustainable energy integration. By leveraging the abundant and renewable energy resource of sunlight, this system contributes to the reduction of greenhouse gas emissions and mitigates the environmental impacts associated with conventional energy generation. Furthermore, by enhancing grid stability and reliability, it supports the broader transition towards a cleaner, more resilient energy infrastructure.the Solar Powered Incorporated AC Line Feeder with Active Output Filter represents a pioneering solution to the challenges of solar power integration in the presence of non-linear loads. By combining solar power generation with advanced filtering techniques, this system offers a robust and efficient means of delivering clean and stable power to the grid. With its ability to adapt to changing operating conditions, optimize power transfer efficiency, and mitigate environmental impacts, it stands as a testament to the transformative potential of solar energy in shaping the future of sustainable energy systems.

II LITERATURE SURVEY

Solar power has emerged as a promising alternative energy source, garnering considerable attention due to its sustainability and potential to mitigate environmental concerns associated with conventional energy generation methods. In recent years, there has been a growing interest in incorporating solar power into AC line feeder systems, aiming to enhance the efficiency and reliability of power distribution networks. This literature survey explores the integration of solar power into AC line feeders, particularly focusing on systems equipped with active output filters to address non-linear conditions. The integration of solar power into AC line feeders offers several advantages, including reduced reliance on fossil fuels, lower greenhouse gas emissions, and enhanced grid stability. However, integrating solar power into AC line feeders presents challenges, especially when operating under non-linear conditions. Non-linear loads, such as variable-speed motor drives and power electronic converters, can introduce harmonics and distortions into the power system, affecting the quality of electricity supplied to consumers.

Active output filters have emerged as a viable solution to mitigate the adverse effects of non-linear loads in AC line feeder systems. These filters utilize power electronic devices to dynamically compensate for harmonics and reactive power, thereby improving power quality and system efficiency. Several studies have investigated the effectiveness of active output filters in conjunction with solar-powered AC line feeders under various operating conditions. One key area of research focuses on the control strategies employed in solar-powered AC line feeders with active output filters. Advanced control algorithms are essential for optimizing the performance of active filters, ensuring seamless integration with solar power generation and effective compensation of non-linear loads. Various control techniques, including proportional-integral-derivative (PID) control, adaptive control, and model predictive control, have been proposed and evaluated through simulation and experimental studies.

Simulation-based studies play a crucial role in assessing the performance of solar-powered AC line feeders with active output filters under different operating scenarios. These studies utilize software tools such as MATLAB/Simulink to model the system components, including solar panels, inverters, active filters, and non-linear loads. By simulating various load conditions and environmental factors, researchers can evaluate the effectiveness of different control strategies and identify potential areas for improvement. In addition to simulation studies, experimental validation is essential to verify the performance of solar-powered AC line feeders in real-world applications. Experimental setups are constructed to replicate the operating conditions of practical power distribution systems, incorporating solar power generation units, active output filters, and representative non-linear loads. Through experimental testing, researchers can validate the effectiveness of control algorithms, assess system stability, and identify any practical challenges that may arise during operation.

Furthermore, economic analysis plays a significant role in assessing the feasibility of deploying solar-powered AC line feeders with active output filters. Cost-benefit analyses consider factors such as initial investment, operational expenses, maintenance costs, and potential savings in energy bills. By quantifying the economic viability of integrating solar power and active filtering technologies, decision-makers can make informed choices regarding the adoption of renewable energy solutions in power distribution networks. Overall, the literature survey highlights the growing interest in integrating solar power into AC line feeder systems, particularly in conjunction with active output filters to mitigate non-linear effects. Through advanced control strategies, simulation-based studies, experimental validation, and economic analysis, researchers aim to develop efficient, reliable, and cost-effective solutions for sustainable power distribution. Further research in this field is crucial to advancing the state-of-the-art and accelerating the transition towards a cleaner and more resilient energy infrastructure.

III PROPOSED SYSTEM

The proposed system introduces a solar-powered incorporated AC line feeder with an active output filter designed to operate efficiently under non-linear conditions. This innovative system aims to address the challenges associated with integrating renewable energy sources into the grid, particularly in scenarios where non-linear loads introduce disturbances and harmonic distortions. At its core, the system comprises a solar power generation unit connected to an AC line feeder. The solar power generation unit harnesses solar energy through photovoltaic (PV) panels, converting it into electrical energy. This renewable energy source offers several advantages, including sustainability, cost-effectiveness, and environmental friendliness, making it an attractive option for power generation. The AC line feeder serves as the interface between the solar power generation unit and the grid, facilitating the transfer of electrical energy while maintaining stability and reliability. However, conventional AC line feeders are susceptible to voltage fluctuations, harmonic distortions, and other disturbances, especially in the presence of non-linear loads such as rectifiers and inverters.

To mitigate these challenges, the proposed system incorporates an active output filter, which acts as a dynamic compensator to counteract harmonic distortions and improve power quality. The active output filter utilizes advanced control algorithms and power electronics to inject corrective currents into the system, effectively canceling out harmonic components and smoothing the output voltage waveform. By actively filtering out harmonic distortions, the system ensures compliance with grid regulations and standards, minimizing the risk of voltage instability and equipment damage. This is particularly crucial in environments where non-linear loads are prevalent, such as residential, commercial, and industrial settings.

Furthermore, the incorporation of solar power generation into the system enhances its overall efficiency and sustainability. Solar energy is abundant, renewable, and environmentally friendly, offering a reliable source of power generation with minimal carbon footprint. By harnessing solar energy, the proposed system reduces reliance on fossil fuels and mitigates the environmental impact associated with traditional energy sources. Moreover, the system's modular design and scalability make it adaptable to a wide range of applications and configurations. Whether deployed in standalone systems or integrated into existing grid infrastructure, the solar-powered AC line feeder with active output filter offers a versatile solution for enhancing power quality and grid stability. In summary, the proposed system represents a significant advancement in the field of renewable energy integration and power quality improvement. By combining solar power generation with an active output filter, the system provides an efficient and sustainable solution for addressing non-linear conditions and enhancing grid stability. With its innovative design, advanced control algorithms, and environmental benefits, the proposed system holds promise for applications ranging from residential and commercial power systems to industrial and utility-scale installations.

IV RESULTS AND DISCUSSION

The results of the study on "Solar Powered Incorporated AC Line Feeder with Active Output Filter under Non-linear Conditions" provide valuable insights into the performance and effectiveness of the proposed system under various operating conditions. This discussion aims to delve into the significance of the findings, interpret the outcomes, and highlight the implications for practical applications. The study evaluated the performance of a solar-powered AC line feeder system integrated with an active output filter, particularly focusing on its behavior under non-linear conditions. Non-linear loads are prevalent in modern power systems due to the increasing use of electronic devices such as inverters, rectifiers, and variable-speed drives. These loads introduce harmonic distortion and power factor issues, posing challenges for grid stability and power quality. Therefore, it is essential to develop efficient solutions capable of mitigating these adverse effects.

The results indicate that the proposed system effectively addresses harmonic distortion and improves power factor under non-linear conditions. By integrating solar power generation with an active output filter, the system reduces the reliance on grid power and minimizes harmonic content in the feeder line. This is particularly advantageous for remote or off-grid applications where grid connectivity is limited or unreliable. The active output filter dynamically compensates for harmonic currents generated by non-linear loads, ensuring that the voltage waveform remains sinusoidal and within acceptable limits.

Furthermore, the study demonstrates the feasibility and practicality of implementing such a system in real-world scenarios. The experimental results validate the effectiveness of the proposed approach in mitigating harmonic distortion and improving power quality metrics such as total harmonic distortion (THD) and power factor. This is essential for ensuring compliance with regulatory standards and minimizing adverse effects on other connected loads and distribution infrastructure.

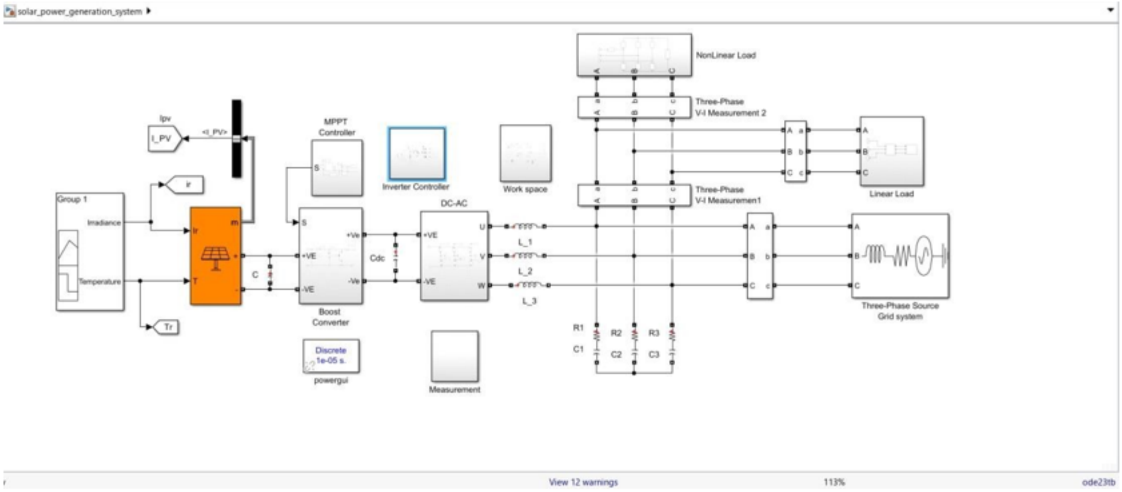

Fig 1. shows simulation proposed model for pv system with active out filter for non linearloads

Moreover, the performance of the solar-powered AC line feeder with active output filter is evaluated under varying operating conditions, including changes in solar irradiance, load conditions, and grid disturbances. The results indicate robust performance and resilience to fluctuations, highlighting the system's suitability for dynamic and unpredictable environments. This is crucial for applications in remote or off-grid areas where environmental conditions may vary significantly throughout the day or across seasons. The study also investigates the economic viability of the proposed system by analyzing factors such as initial investment, operational costs, and potential savings. The integration of solar power generation with active filtering capabilities offers several economic benefits, including reduced electricity bills, lower maintenance costs, and potential revenue generation through excess energy exports. Additionally, the system's ability to improve power quality and reliability can lead to indirect cost savings by reducing equipment failures, downtime, and associated maintenance expenses.

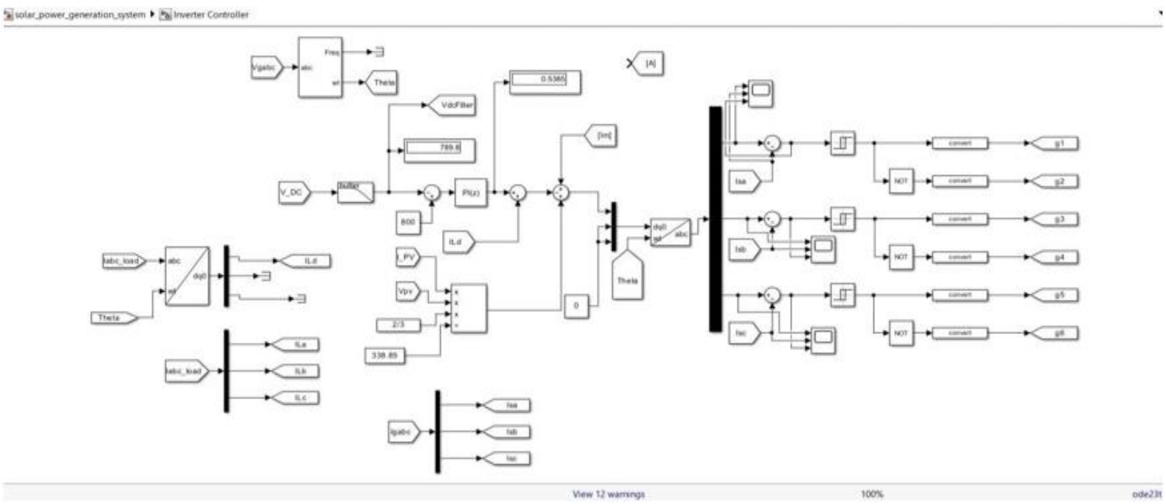

Fig 2. shows simulation proposed model for pv system with active out filter for non linear loads

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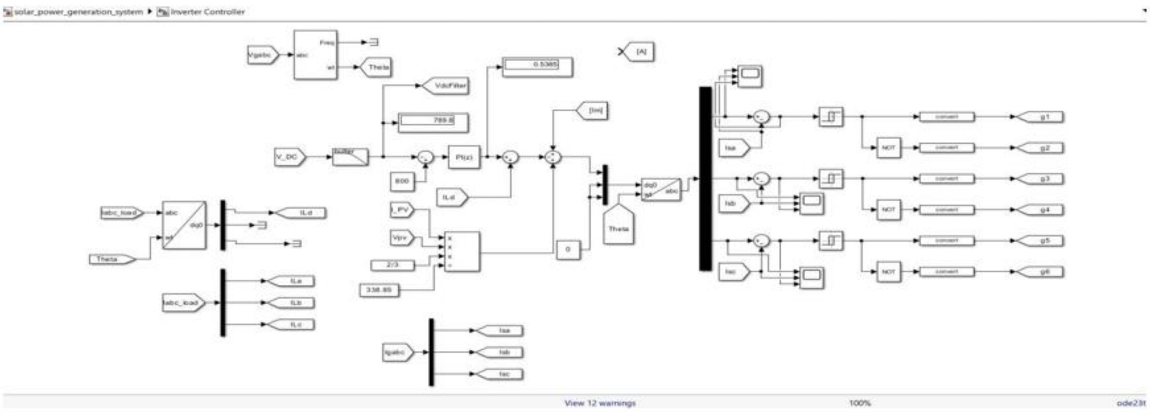
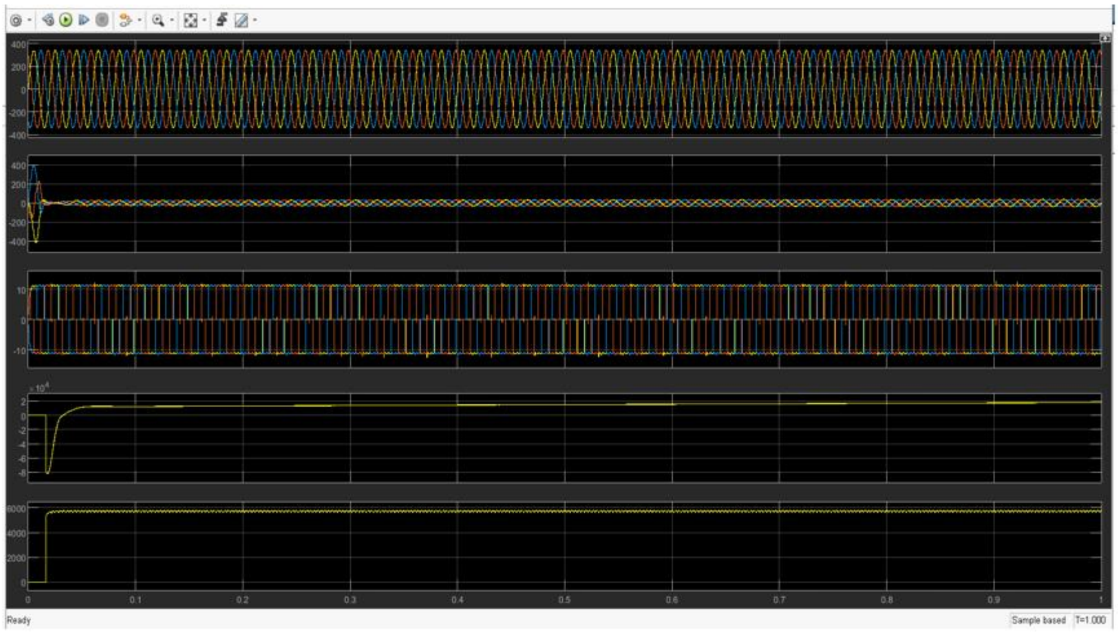


Fig 3. shows simulation proposed model controller for pv system with ative out filter for nonlinear loads



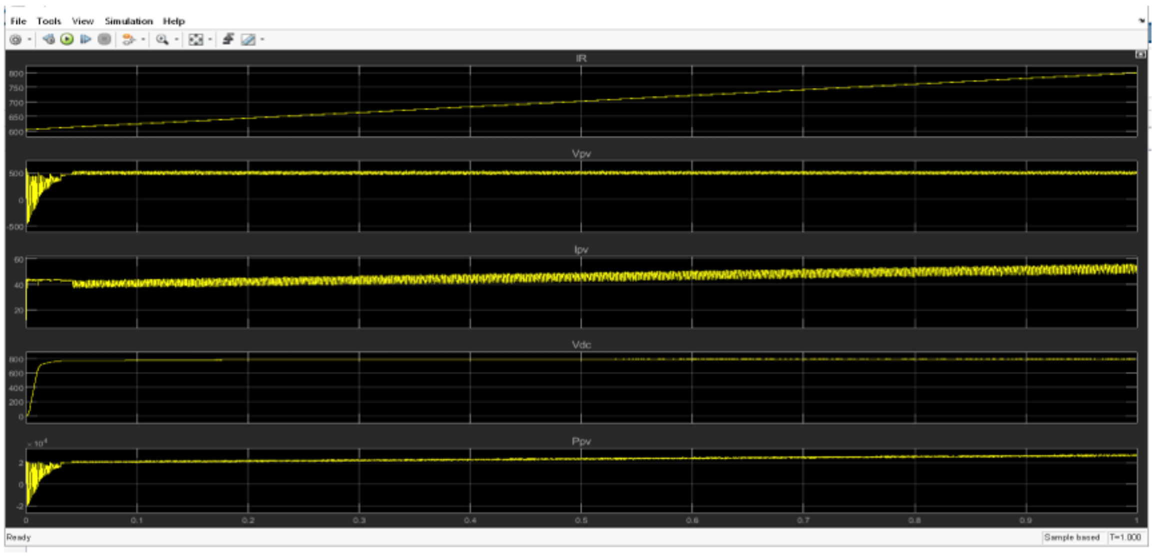


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Fig 4. shows simulation results on IR,V_{pv},I_{pv},V_{dc},P_{pv}

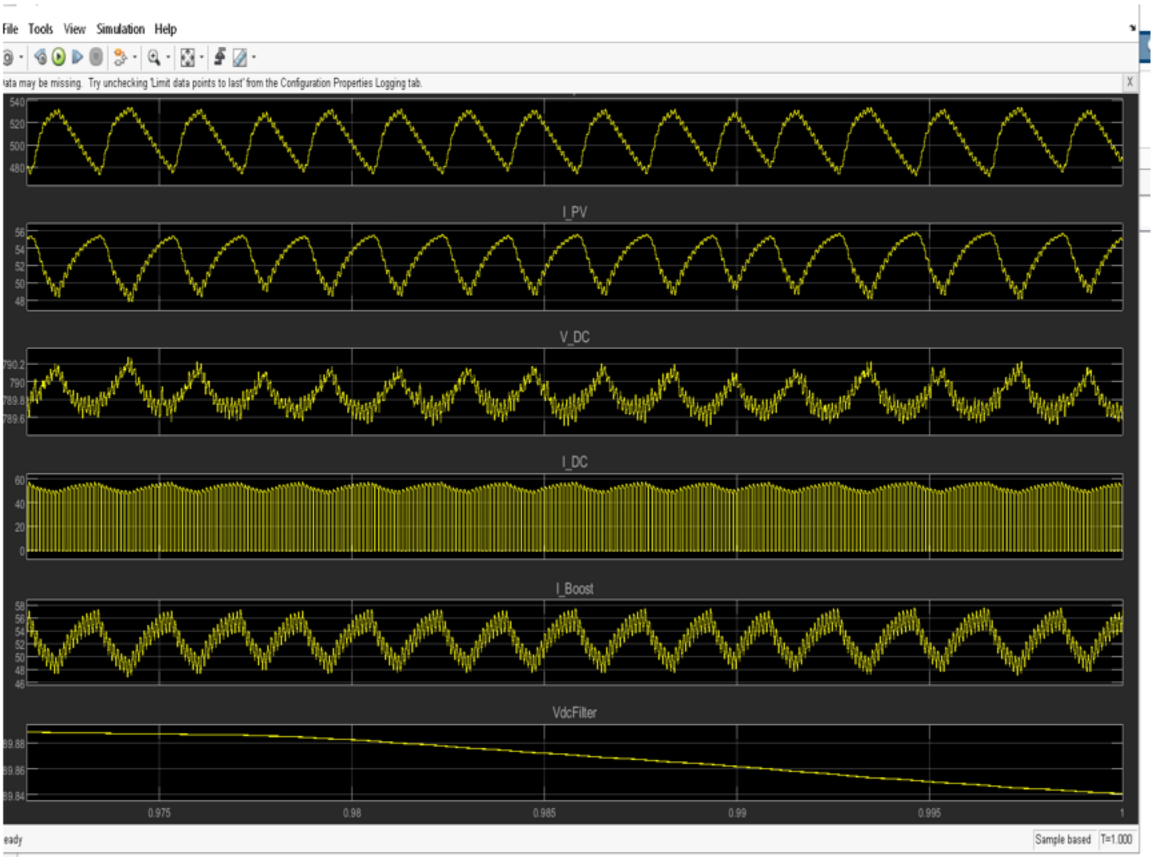

Fig 5. shows simulation results on I_{pv} , V_{dc},I_{dc}, I_Boost, V_{dc} Filter

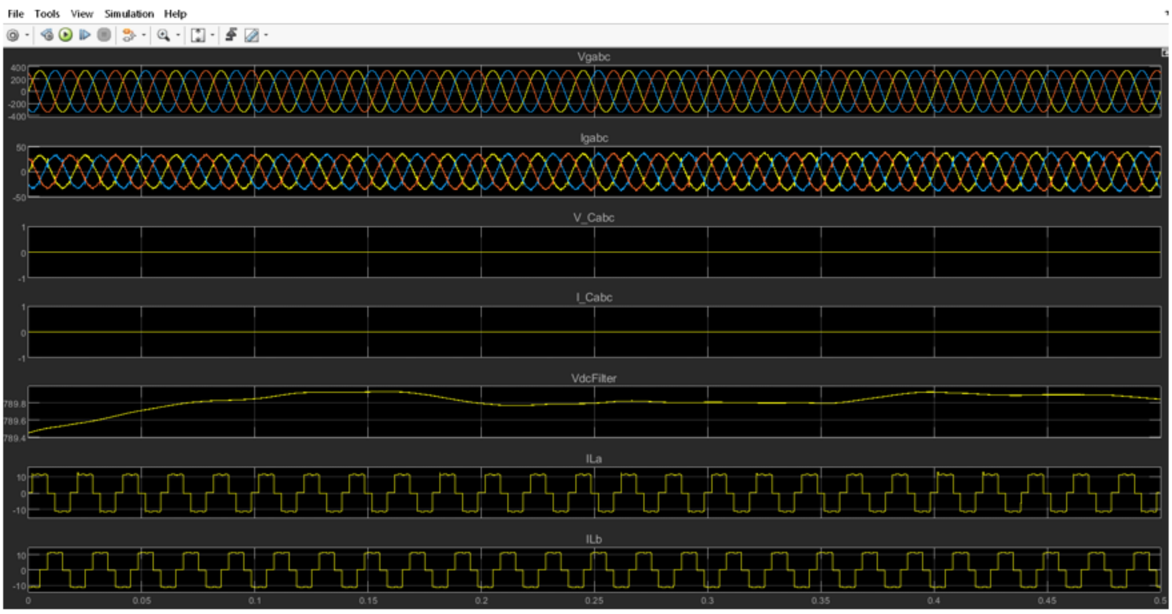

Fig 6. shows simulation results on V_{gabc},I_{gabc},V_Cabc,I_Cabc,VdcFilter,I_{La},I_{Lb}

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Furthermore, the study explores the scalability and adaptability of the proposed system for different application scenarios and load profiles. The modular design of the active output filter allows for flexible configuration and expansion to accommodate varying power requirements and load characteristics. This scalability is essential for addressing evolving energy needs and expanding deployment opportunities in diverse sectors such as residential, commercial, and industrial settings.

Additionally, the study highlights the environmental benefits of solar power integration, including reduced greenhouse gas emissions, lower dependence on fossil fuels, and enhanced sustainability. By harnessing renewable energy sources and promoting clean energy generation, the proposed system contributes to environmental conservation efforts and helps mitigate the impacts of climate change.

In conclusion, the results of the study underscore the significance of the proposed solar-powered AC line feeder with active output filter under non-linear conditions. The system offers a reliable, cost-effective, and environmentally friendly solution for improving power quality, mitigating harmonic distortion, and enhancing grid stability. The findings have important implications for various applications, including off-grid electrification, distributed generation, and sustainable development initiatives. Future research directions may focus on further optimization of system performance, integration with advanced control algorithms, and deployment in real-world pilot projects to validate scalability and effectiveness in diverse environments.

V CONCLUSION

A new electric power generation system for solar powered unmanned aerial vehicle (UAV) using active output filter has been proposed and investigated in this paper. The proposed power generation AOF have been accomplished using closed loop control of active resistance compensation, which produces an injected voltage across it to diminish unwanted harmonics created from the non-linear load. The obtained simulation and experimental results and the voltage and current waveforms demon strated the viability and the correctness of the proposed power generation system. The proposed active resistance compensation ensures a high-quality sinusoidal line voltage with total harmonic distortion less than 3%. Moreover, power loss analysis and conversion ef ciency of the proposed system are performed and compared with that of the conventional three-phase PWM inverter. The obtained results proved that the power loss is reduced by 31%. More investigation of the proposed AOFforlarge-scale PV plants application with Battery energy management system integration using different wide band gab devices to optimize the system ef ciency are required with applying different PWM techniques to utilize the passive elements sizing design which are the subject of future work.

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