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Performance Analysis Of PI And PID Controllers For Multi-Port Renewable Energy Source Integration Using Buck- Boost Converter

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ABSTRACT: This conference paper delves into a simulation-based optimization of a Hybrid Renewable Energy System (HRES) that integrates photovoltaic (PV) and wind energy sources. Employing a Buck-Boost converter with Proportional-Integral (PI) and Proportional-Integral-Derivative (PID) controllers, the study aims to regulate and enhance system performance. The primary goal is to leverage synergies between PV and wind energy to achieve a stable DC output for critical loads. The research meticulously designs and simulates control strategies using MATLAB, emphasizing a comparative analysis of PI and PID controllers. Evaluation metrics include efficiency, response time, and overall system stability under varying environmental conditions. The simulation-based approach provides a detailed examination of the proposed system's efficacy, offering insights into its potential as a sustainable and reliable energy solution. The presented findings contribute to advancing greener and more resilient power grid technologies, with significant implications for the field of renewable energy. This research offers a promising avenue for the development of efficient and sustainable energy systems.

KEYWORDS: Hybrid Renewable Energy Systems (HRES), Photovoltaic (PV), Wind Energy, Buck-Boost Converter, Proportional-Integral (PI) Controller, Proportional-Integral-Derivative (PID) Controller, Control Strategies, Voltage and Current Stability, Efficiency, Response Time, Sustainable Energy, Resilient Power Grid, Renewable Energy Integration

I. INTRODUCTION

The global energy landscape is undergoing a transformative shift, compelled by the dual challenges of surging energy demand and the urgent need to combat climate change. This necessitates a radical transition towards sustainable and reliable power generation. Renewable energy sources, including photovoltaic (PV) and wind energy, play pivotal roles in this transition, providing clean alternatives to traditional fossil fuel-based power generation. However, the intermittent nature of these sources poses challenges to maintaining a consistent power supply, demanding innovative solutions.

Hybrid Renewable Energy Systems (HRES) have emerged as a practical approach to address the intermittency of renewable sources. This project focuses on integrating and controlling PV and wind energy sources within an HRES framework. A key element of this integration is the use of a Buck-Boost converter with Proportional-Integral (PI) and Proportional-Integral-Derivative (PID) controllers. The objective is to optimize power output from these sources, ensuring stability and reliability amidst fluctuating environmental conditions.

The complementary synergy between PV and wind energy, with peak production at different times, enhances the overall reliability of the HRES. PV systems generate electricity during daylight hours, while wind energy maintains a more consistent production throughout the day, mitigating the impact of weather variations and ensuring a steady power supply.

The integration of a Buck-Boost converter with PI and PID controllers adds a layer of control and adaptability to the system. These controllers dynamically adjust the converter's operation in response to changes in environmental factors and energy production, contributing to the stability and efficiency of the overall system.

This paper delves into the intricacies of integrating and controlling PV and wind energy within an HRES framework, exploring synergies and sophisticated control mechanisms. Through a comprehensive analysis, this research aims to provide valuable insights, contributing to enhanced strategies for addressing challenges associated with intermittent renewable energy sources. As we strive towards a sustainable energy future, the outcomes of this project have the potential to inform and influence the wider discourse on renewable energy integration and management.

II. WHY MULTIPLE INPUT?

- The ability to handle multiple input voltage levels makes the converter versatile and adaptable to a variety of applications. This flexibility is crucial in scenarios where the input power source may vary.
- A converter with a wide input voltage range provides robustness in the face of fluctuating input sources. It allows the system to operate over a broader range of conditions, accommodating variations in input voltage without sacrificing output stability.
- In renewable energy systems, such as solar or wind power, the energy harvested can vary based on environmental conditions. A buck-boost converter with multiple input capabilities can efficiently utilize the available energy by adapting to different voltage levels from the renewable sources.
- For battery-operated devices, the input voltage can change as the battery discharges. A converter capable of handling various input voltages ensures continuous and stable power delivery to the load throughout the battery's discharge cycle.
- Designing a power supply system with a converter that supports multiple input voltages can lead to a reduction in overall system complexity. This may result in a simplified design with fewer components, potentially reducing costs and improving reliability.
- Depending on the specific requirements and conditions, a multi-input buck-boost converter can be optimized for efficiency across a range of input voltages. This efficiency improvement can be crucial in applications where power consumption and energy efficiency are critical considerations.
- In environments where the input voltage is unpredictable or subject to rapid changes, a converter with multiple input capabilities ensures that the system remains operational, providing a stable output even when faced with unexpected voltage variations.

Input Control Method

controlling a multiport buck-boost DC-DC converter using PID or PI module present in the MATLAB environment.

- The PID controller is designed to leverage three key components: Proportional (P), Integral (I), and Derivative (D) terms. The MATLAB environment provides a conducive platform for the simulation of PID controllers. The control algorithm is coded, and the dynamic response of the multiport buck-boost DC-DC converter is analysed under varying conditions. The proportional, integral, and derivative gains (K_p , K_i , K_d) are tuned to optimize the controller's performance, ensuring a rapid response to setpoint changes while minimizing overshoot and oscillations.
- For scenarios where a simplified control approach is preferred, a Proportional-Integral (PI) controller can be employed. The integral term assists in eliminating steady-state errors, enhancing the converter's accuracy. The PI controller parameters (K_p and K_i) are tuned to achieve optimal performance in the MATLAB simulation environment.

Tuning strategy:

- I. Proportional (P) Term:
The proportional term is based on the current error, which is the difference between the set point (desired value) and the process variable (actual value).

The controller output is directly proportional to this error. Mathematically, it can be represented as: $P = K_p * e(t)$, where K_p is the proportional gain, and $e(t)$ is the error at time t .

$$\text{OutputP} = K_p * (\text{Setpoint} - \text{Process Variable})$$

II. Integral (I) Term:

The integral term considers the cumulative sum of past errors over time. This helps in eliminating any steady-state error that may be present in the system.

It is calculated as the integral of the error over time: $I = K_i * \int e(t) dt$, where K_i is the integral gain.

$$\text{OutputI} = K_p * (\text{Setpoint} - \text{Process Variable}) + K_i * \int (\text{Setpoint} - \text{Process Variable}) dt$$

III. Derivative (D) Term:

The derivative term anticipates future behaviour by considering the rate of change of the error. It helps in damping oscillations and improving the system's response time.

Mathematically, the derivative term is given by: $D = K_d * \{de(t)/dt\}$, where K_d is the derivative gain, and $\{de(t)/dt\}$ is the rate of change of the error with respect to time.

$$\text{OutputD} = K_p * (\text{Setpoint} - \text{Process Variable}) + K_i * \int (\text{Setpoint} - \text{Process Variable}) dt + K_d * d/dt(\text{Setpoint} - \text{Process Variable})$$

Were,

Output - the control output (in your case, the voltage).

Setpoint - (15V in your case). Process Variable - the current value of the system output (45V in your case).

K_p , K_i , and K_d are the proportional, integral, and derivative constants, respectively, which need to be tuned to achieve the desired control performance.

Now, combining all three terms, the output of the PID controller is given by:

$$\text{Output}(t) = P + I + D$$

This output is then used to adjust the control variable of the system, influencing the process variable towards the set point.

III. PROPOSED SYSTEM

The block diagram illustrates a Hybrid Renewable Energy System (HRES) comprising a photovoltaic (PV) source and a windmill integrated to enhance overall energy generation. The PV source is connected to a buck-boost converter, a versatile power electronics device capable of adjusting the voltage level as needed. Simultaneously, the windmill output is rectified and fed into the same buck-boost converter. This converter acts as a central hub for combining the energy generated from both sources, optimizing the overall power output.

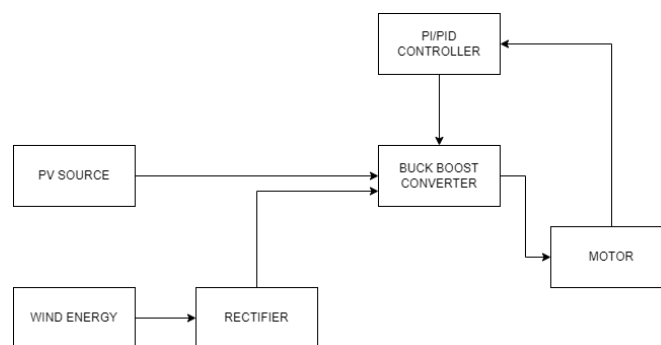


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-1. Block Diagram

The output from the buck-boost converter is then directed to a load, represented by a motor in this scenario, which utilizes the combined energy for various applications. To ensure a stable and controlled energy flow, a closed-loop control system is implemented. The voltage feedback from the output is fed into a Proportional-Integral-Derivative (PID) controller. The PID controller processes this feedback to generate precise control signals for the buck-boost converter. This closed-loop control mechanism helps regulate the voltage levels and maintain the stability of the system under varying load conditions.

The pulse signals generated by the PID controller are then applied to the buck-boost converter, adjusting its operation to match the requirements of the connected load. This closed-loop control ensures efficient utilization of energy from both the PV source and the windmill, contributing to a reliable and optimized Hybrid Renewable Energy System. The integration of multiple renewable sources and closed-loop control reflects a sophisticated approach towards harnessing clean energy in a sustainable and effective manner.

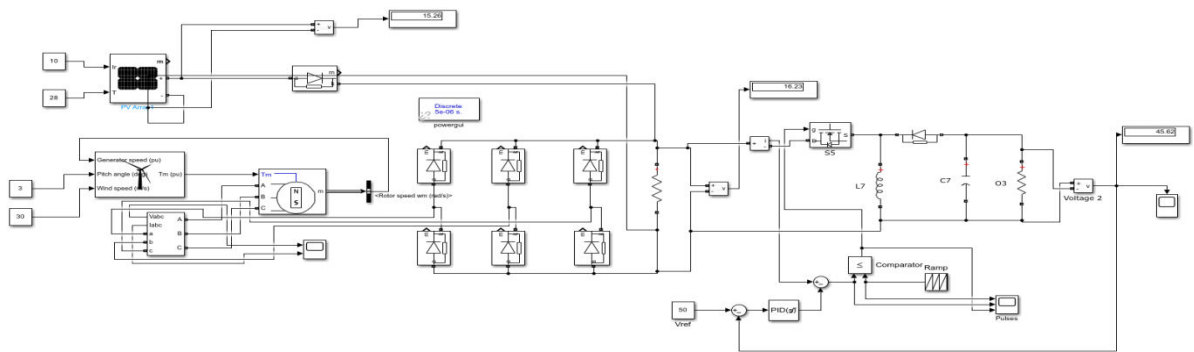


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-2. showing circuit design done on MATLAB

Approach

In the proposed Hybrid Renewable Energy System (HRES), a Photovoltaic (PV) source and a windmill are strategically integrated to harness energy efficiently. The PV source is connected to a buck-boost converter, while the windmill output is rectified and also fed into the same converter. This converter serves as a pivotal component for regulating the energy flow and ensuring compatibility with the load, represented by a motor in this case.

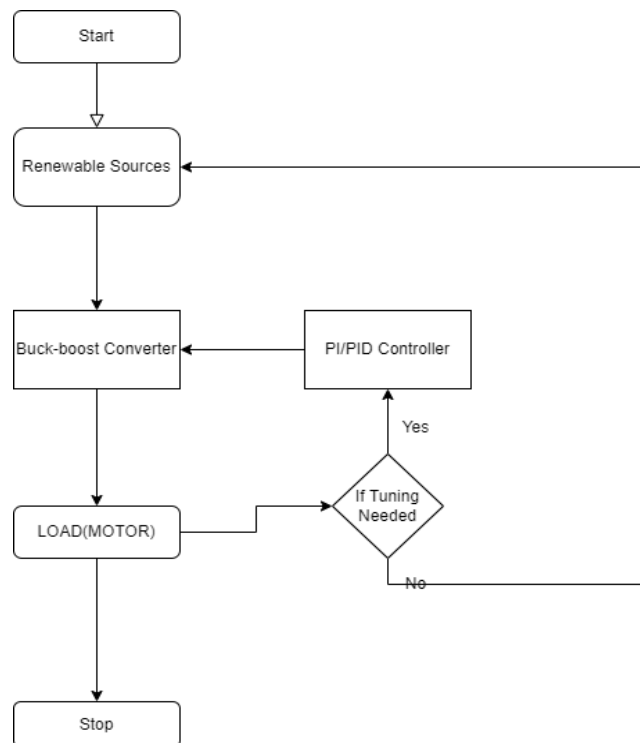


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-3. Algorithmic Approach



The energy conversion process is facilitated by a closed-loop control system, where a Proportional-Integral (PI) or Proportional-Integral-Derivative (PID) controller plays a crucial role. The controller receives feedback in the form of voltage information, comparing it with a reference voltage to maintain a desired output. This closed-loop control mechanism optimizes the efficiency of the buck-boost converter, thereby regulating the energy supplied to the load.

The algorithm governing this system involves the initial harvesting of energy from both the PV source and the windmill. The combined energy output is then converted to a reference voltage, serving as the basis for the closed-loop control. The PI/PID controller fine-tunes the converter's operation based on the feedback, ensuring that the energy supplied to the load is precisely controlled and meets the required specifications.

This innovative HRES design not only maximizes energy harvesting from diverse sources but also guarantees an optimized and stable performance through the closed-loop control strategy.

IV. SIMULATION RESULTS

In this study, we use the MATLAB tool to run simulations, enabling us to observe the voltage and current profiles and evaluate the energy efficiency of the system. The simulation results show that the Hybrid Renewable Energy System (HRES) effectively manages energy, resulting in a significant improvement in overall performance and energy efficiency. Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-1 presents a comprehensive depiction of the dynamic behaviour of voltage over time. The x-axis meticulously charts the progression of time, while the y-axis elegantly captures the voltage in volts. The waveform portrayed in the graph mirrors the intricate dance of fluctuations and variations, showcasing the PV board's response towards temporal changes. Notably, the graph peaks at an impressive maximum voltage of approximately 17 volts, marking a pivotal point in the system's electrical activity.

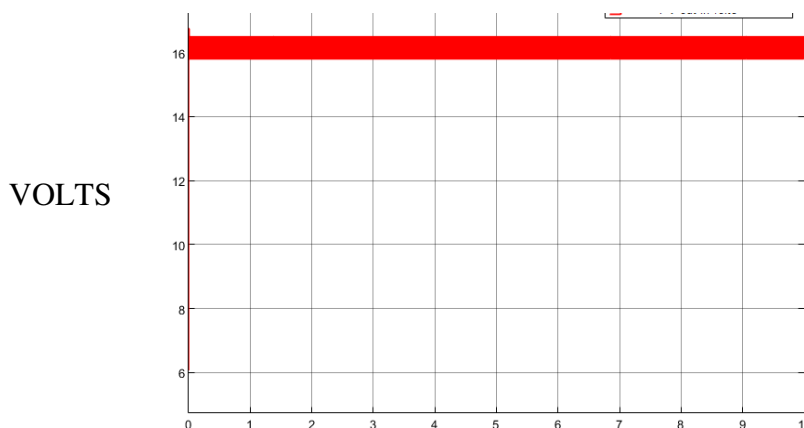


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-1: PV Results

Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-2 offers an enhanced, closer view of the dynamic voltage behavior over time, building upon the insights presented in Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-1

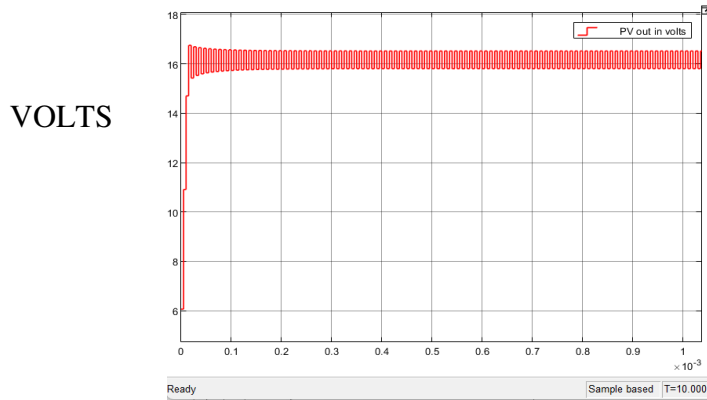


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-2 PV Results in a close view

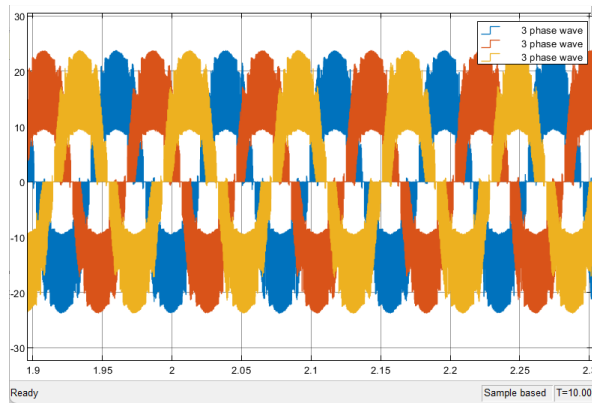


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-3: AC Wave from windmill

The graph in Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-3 displays the voltage output of a three-phase windmill with an RMS voltage of about 20 volts and a 50Hz sinusoidal waveform peaking at 27 volts. This variation illustrates how wind speed and turbine efficiency affect the dynamics of wind energy. Disturbance in the wave created from the dynamo movement

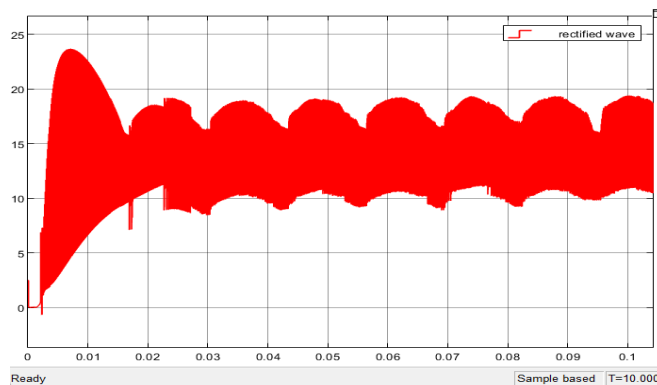


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-4: AC after rectification

Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-4 shows the rectified output from the rectifier

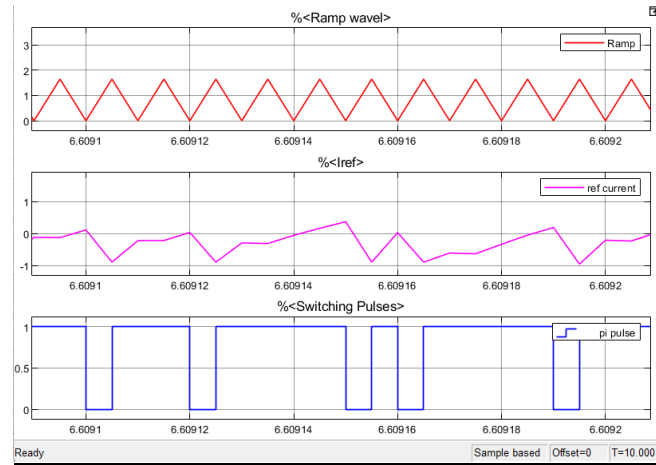


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-5 : (a)Ramp Sig (b) Ref Current (c)Switching Pulse Of PI

The above Figure *Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-5* has divisions(a,b,c) shows ramp signal produced by the ramp generator this generated signal is compared by comparator with current produced shown by Figure *Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-5(b)*, and the resulting pulse produced is used for switching similar Figure *Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-6* gives same but for PI controller whereas Figure *Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-5* depicts function done by PID controller

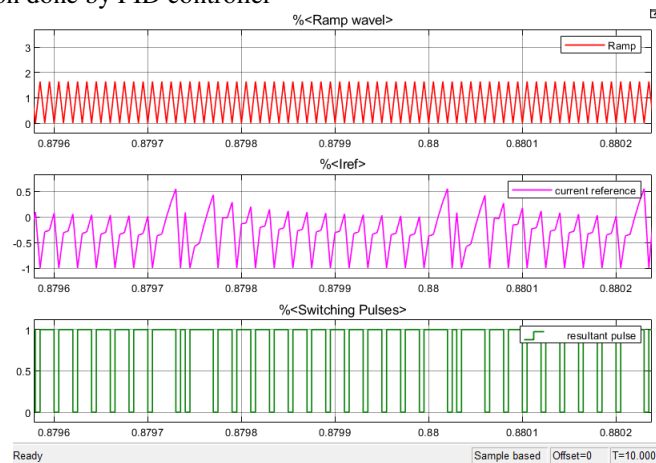


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-6 : (a)Ramp Sig (b) Ref Current (c)Switching Pulse Of PID

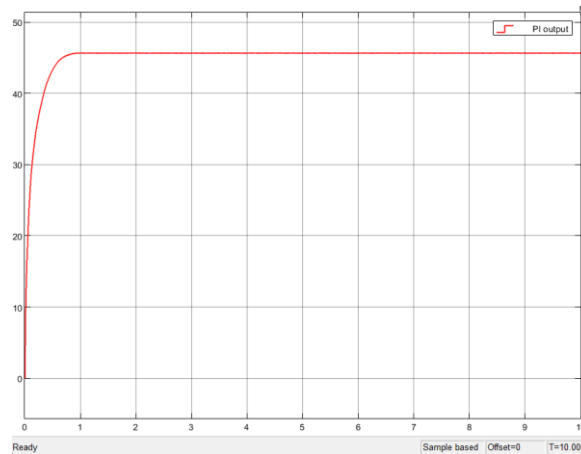


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-7: PI Output

The final voltage required is depicted in Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-7** and Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-8**

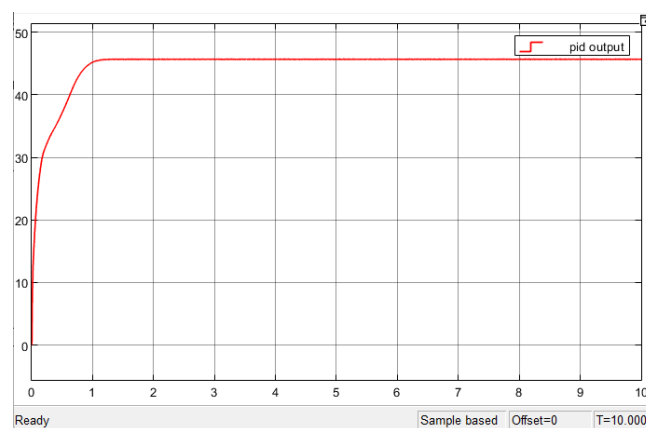


Figure Fehler! Kein Text mit angegebener Formatvorlage im Dokument.-8 : PID Output

V. CONCLUSION

W In conclusion, this project successfully demonstrated the integration of photovoltaic (PV) and wind energy sources through a Buck-Boost converter controlled by both Proportional-Integral (PI) and Proportional-Integral-Derivative (PID) controllers in software level. The results highlighted the effectiveness of the system in maintaining stable DC power output for critical loads under varying environmental conditions, with the PID controller showcasing superior performance in terms of response time and overall efficiency. This research contributes to the development of robust and efficient Hybrid Renewable Energy Systems (HRES), offering a promising solution for sustainable and reliable power generation in a rapidly evolving energy landscape.

REFERENCES

- [1] N. Dalarsson, "The buck-boost DC/DC converterINTELEC - Twentieth International Telecommunications Energy Conference (Cat. No.98CH36263).



- [2] Sairatun Nesa Soheli, Golam Sarowar, Md. Ashraful Hoque, Md Saidul Hasan, "Design and Analysis of a DC -DC Buck Boost Converter to Achieve High Efficiency and Low Voltage Gain by using Buck Boost Topology into Buck Topology 2018 International Conference on Advancement in Electrical and Electronic Engineering (ICAEEE)
- [3] Dong-Kurl Kwak, Seung-Ho Lee, Do-Young Jung, "A new buck-boost dc/dc converter of high efficiency by soft switching technique 2009 IEEE 6th International Power Electronics and Motion Control Conference.
- [4] B. Ram Kiran, G. A. Ezhilarasi, "Design and analysis of soft-switched Buck-Boost Converter for PV applications 2015 Annual IEEE India Conference (INDICON).
- [5] Bassem Saleh, Ahmed Teirelbar, Amr Wasfi, "A DC/DC buck-boost converter control using sliding surface mode controller and adaptive PID controller 2020 22nd European Conference on Power Electronics and Applications (EPE20 ECCE Europe).
- [6] V. Fernu00e3o Pires, Daniel Foito, Armando Cordeiro, J. Fernando Silva, "A Single-Switch DC/DC Buck-Boost Converter with Extended Output Voltage 2018 7th International Conference on Renewable Energy Research and Applications (ICRERA)
- [7] Arash A. Boora, Firuz Zare, Gerard Ledwich, Arindam Ghosh, "Bidirectional positive buck-boost converter 2008 13th International Power Electronics and Motion Control Conference.
- [8] Neng Zhang, Danny Sutanto, Kashem M. Muttaqi, "A buck-boost converter based multi-input DC-DC/AC converter 2016 IEEE International Conference on Power System Technology (POWERCON)
- [9] Mohammad Saleh Khan, Soumya Shubhra Nag, Anandarup Das, Changwoo Yoon, "A Novel Buck-Boost Type DC-DC Converter Topology for Electric Vehicle Applications 2021 IEEE Energy Conversion Congress and Exposition (ECCE)
- [10] "Extended Switching-Capacitor-Based Buck Boost Converter IEEE Journal of Emerging and Selected Topics in Industrial Electronics



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