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Design And Implementation Of A Fuzzy Controller For A Multi-Input DC-DC Buck Converter In A Coordinated Renewable Energy Generation System

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Abstract
This paper aims to introduce a multi-input control converter tailored for hybrid systems, with the primary goal of streamlining power grid management and cutting down on related expenses. Sustainable energy technologies harness the power of resources like sunlight and wind, which naturally renew themselves. As the demand for power increases, so does the risk of power outages. Hence, renewable energy sources can play a crucial role in providing a stable power supply. In this context, a novel converter topology is proposed for hybrid energy systems that integrate both wind and photovoltaic sources. This integration of solar and wind power sources presents a cost-effective approach to power generation. The proposed topology employs a combination of Buck converters, enabling each energy source to supply power independently or concurrently, depending on the availability of these energy sources Totally The system undergoes simulation in MATLAB/SIMULINK software, and the results for both the Buck converter and the hybridized converter are showcased in the paper.

Keywords: Renewable energy, Buck converter, Fuzzy controller.

1. Introduction

The world is experiencing a significant surge in energy consumption due to rapid population growth.[2] To meet the rising energy demands while ensuring sustainability, renewable energy sources are taking centre stage. Solar and wind energy are particularly prominent among these resources due to their numerous advantages in terms of production, maintenance, and more. However, a major challenge with renewable energy generation is the variability in output, heavily dependent on climatic conditions such as solar irradiance, wind speed, and temperature.

Numerous research efforts are underway to improve the efficiency of systems harnessing both wind and solar power. Batteries are commonly used as storage mechanisms to smooth out power output, enhance startup transitions, improve dynamic characteristics, and increase peak power capacity. By combining photovoltaic (PV) generation with wind power generation, it is possible to mitigate the instability in each other's output

characteristics, leading to the emergence of PV/Wind/battery hybrid power systems.India, blessed with abundant solar insulation and a strong presence in wind power generation, is an ideal setting for implementing PV/Wind hybrid systems. Projections suggest that India will rapidly adopt solar photovoltaic (PV) technology, driven by various factors. As global energy demands continue to rise, there is an increasing need for environmentally friendly renewable energy sources. Predictions indicate that worldwide energy demand will nearly triple by 2050. Currently, the contribution of new and renewable energy resources to global power generation remains modest but is steadily increasing. Wind energy, in particular, is becoming increasingly significant due to surging energy requirements and minimal environmental impact. Solar and wind energy systems (WES) stand out as the most promising paths in the realm of future energy technology. Projections suggest that renewable energy sources will contribute approximately 30% of the world's total energy production by 2020, leading to a notable 25% reduction in energy-related CO2 emissions. Wind and solar energy complement each other, making a hybrid Wind/PV power system the ideal choice for providing electricity to remote areas.[3] Given the inherent unpredictability of weather conditions, standalone PV or wind energy systems often struggle to deliver a consistent and reliable power supply. Therefore, the installation of a battery bank is essential. Hybrid Wind/PV systems offer greater reliability and cost-effectiveness when compared to the separate utilization of these two energy sources. This approach not only decreases overall expenses but also reduces the demand for extensive battery storage.[4] Furthermore, the evolution of power electronics has allowed for the optimization of solar-wind applications, resulting in a balanced system size. Typically, wind speeds are higher at night and on cloudy days, while sunny days may have limited wind activity. Consequently, a hybrid Wind-solar system adeptly addresses the intermittency associated with relying solely on one energy source.

2. Proposed Framework

The point of the proposed study is to present another different info power converter for the framework associated mixture sustainable power framework, determined to smooth out the power framework and diminishing expenses. This different info power converter includes a multi-input DC converter and a full-span DC-AC inverter [5]. The concentrate basically underlines the demonstrating of a crossover photovoltaic and wind electric power framework, with PV and wind filling in as the essential sources and the battery working as a reinforcement supply.

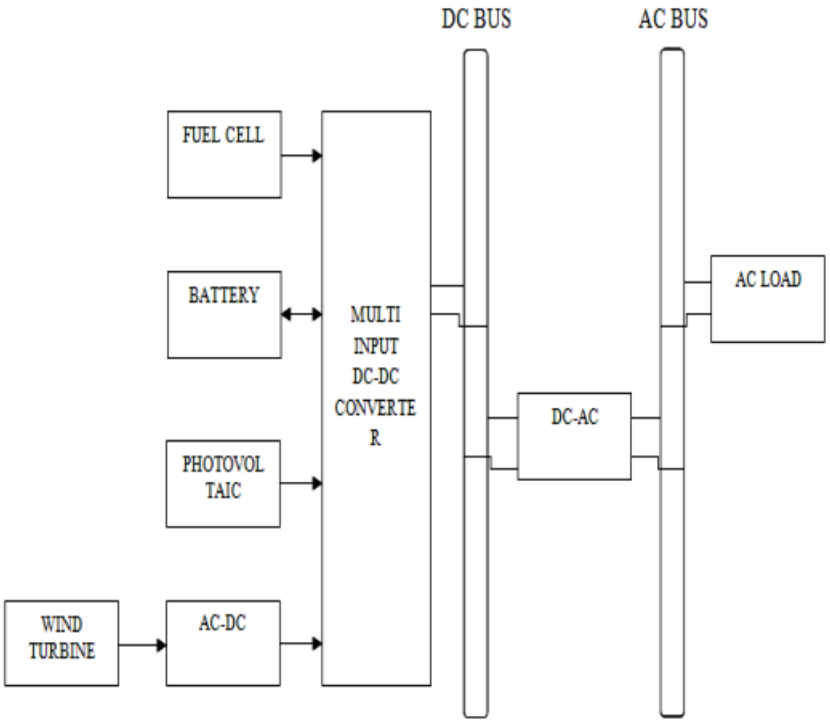

Figure 1. Presentation of the Integrated Renewable Energy System Proposed

The essential target of the proposed research is to choose reasonable geographies for the three-stage inverter/rectifier, numerous information DC converter, and their relating control schemes [4]. The concentrate likewise includes the plan and reproduction of the proposed framework, trailed by an examination with the ordinary framework.

3. The suggested configuration

The proposed twofold info buck converter portrayed in figure 3 incorporates two switches and two diodes [6]. The exchanging arrangement for switches S1 and S5 of the converter is delineated in figure 2.1.

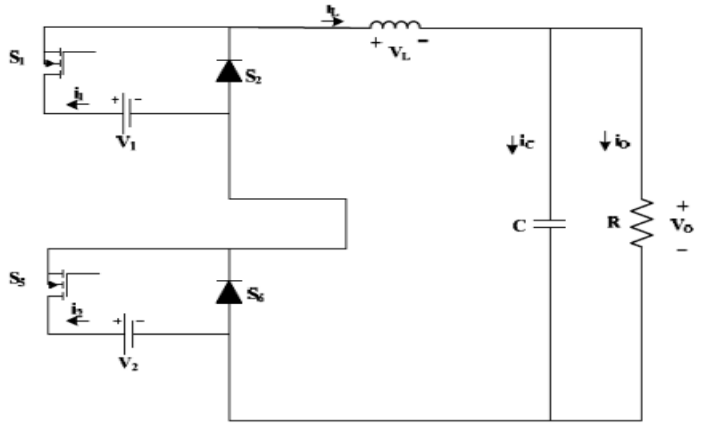

Figure 2. Buck-Buck Converter with Dual Inputs

This pattern remains consistent for the possible configurations of the converter, encompassing all four modes[7]. Table 1 displays the voltage across the inductor for various circuit operation modes.

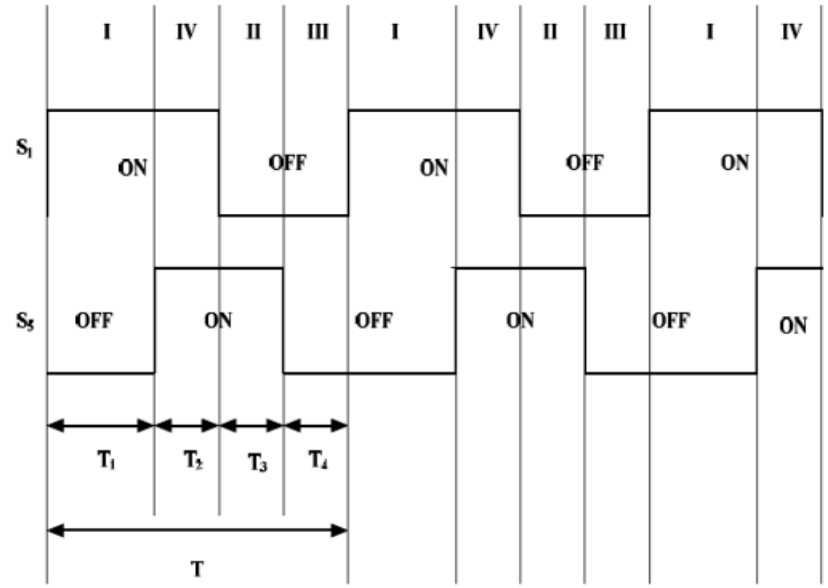

Figure 3. Switching Sequence of Dual-Input Buck-Buck DC-DC Converter

PT Double-input buck-buck converter configuration, as shown in Figure 3, consists of two switches and two diodes. The switching patterns for switches S1 and S5 are depicted in Figure 2.1.

4. Fuzzy Controller

Over the times, PD, PI, and PID controllers have been broadly utilized in brilliant power electronic unlimited circle frameworks. in any case, ongoing investigation has shown a fruitful surrender of the Fluffy Rationale Regulator (FLC) as a smart volition. This concentrate explicitly utilizes a fluffy sense controller with voltage undertaking input. The voltage undertaking is taken care of into the fluffy controller to acquire a material proportion of the consistent state signal. This approach is appropriate to bright DC engine geographies comparative as Buck, Lift, and Buck-Lift. DC engine and the presentation of the proposed controllers [9]. The plan of the fluffy sense controller can give advantageous powerful execution for both enormous and little signals, ware not feasible with direct control ways. accordingly, the fluffy sense controller has the certain to upgrade the Vigor of DC transformers. The abecedarian construction of the controller comprises of four essential elements, including Fuzzification, which converts input information values into reasonable verbal qualities; an information base, containing a control rule set and a data set with vital verbal depictions; Dynamic sense, feigning a human choice interaction and gathering the fluffy control activity from the control rules and verbal variable outlines; and a Defuzzification interface, yielding anon-fluffy control activity from a derived fluffy control activity.

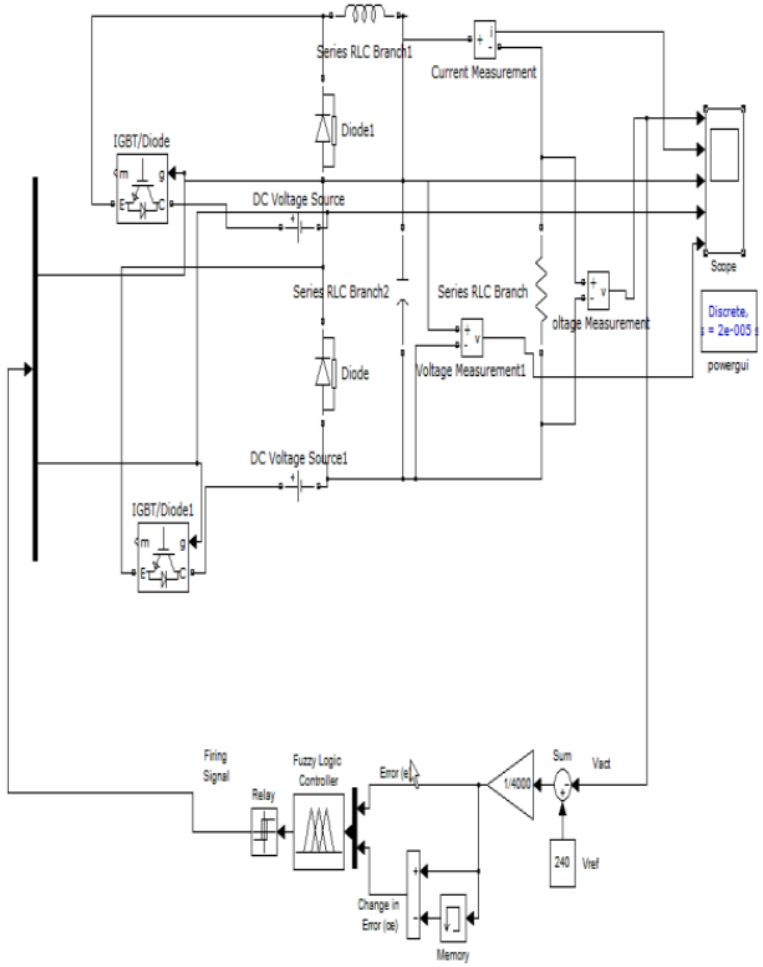

Figure 4. Twofold information buck converter utilizing fluffy regulator.

5. Simulation Outcomes Employing Fuzzy Controller

You can notice the run of the mill recreation consequences of the buck converters utilizing a Fluffy controller[10]. The information voltage sources use two DC voltage sources: V1 = 200V and V2 = 250V. The obligation proportion and exchanging recurrence for S1 and still up in the air by the fluffy regulator. The waveforms are introduced start to finish, exhibiting the heap voltage, load current, exchanging orders for S1 and S5, and the capacitor voltage V c. A perception from these waveforms uncovers that the ideal typical result voltage is accomplished.

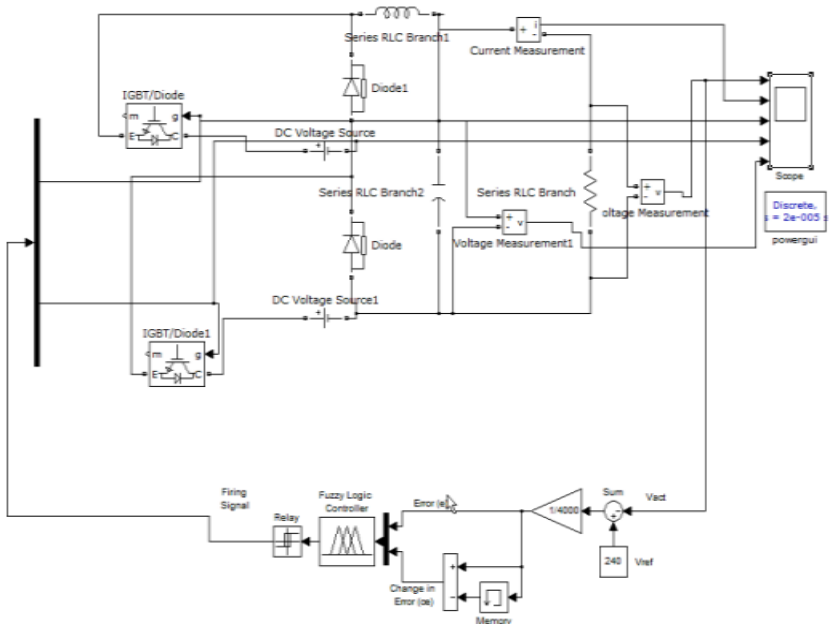

Figure 5. Reproducing a Twofold Information Buck Converter with Fluffy Regulator

6. Conclusion

This research delves into the fundamental operational principles of the innovative multi-input DC-DC converter. Employing MATLAB/Simulink software, a meticulously designed circuit for the multiple input DC-DC buck converter has been developed and subjected to comprehensive simulation. The resulting simulation data firmly establish the proficiency and effectiveness of the proposed multi-input DC-DC converter system, effectively demonstrating its coveted attributes. This study underscores the feasibility of implementing a well-crafted system, characterized by a judiciously selected converter and a high-performance controller, which can be readily employed to achieve a commendable level of efficiency in the context of PV modules and wind turbines.

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