Design and Implementation of a Hybrid System with Enhanced Power Smoothing Functionality using NN Controller

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Abstract **--** *The output power from a solar power generation system (SPGS) change significantly because of environmental factors, which affects the stability and reliability of a power distribution system. This study proposes a SPGS with the power smoothing function. The proposed SPGS consists of a solar cell array, a battery set, a dual-input buck-boost DC-AC inverter (DIBBDAI) and a boost power converter (BPC). The DIBBDAI combines the functions of voltage boost, voltage buck and DC-AC power conversion. The BPC acts as a battery charger between the solar cell array and the battery set. For the proposed SPGS, the DC power that is provided by the solar cell array or the battery set is converted into AC power through only one power stage. The proposed power conversion interface increases power efficiency, smooth's power fluctuation and decreases leakage current for a SPGS. The simulation results show that multilevel STATCOM will correct the disturbances.*

Key words: *Solar power generation, power smoothing, buck-boost DC-AC inverter*

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I. INTRODUCTION

Global warming is caused by extreme climatic change. To avoid irreversible climate change, the United Nations advocated for an international agreement on greenhouse gas emissions. Most nations are aggressively expanding renewable energy generation in order to lessen the environmental effect of greenhouse gas emissions. Renewable energy technologies such as solar and wind power are mature and commonly utilized to generate electricity. Renewable energy generation used to be expensive and required government subsidies, but with the advancement of manufacturing technology, the cost of renewable energy generating has dropped dramatically. The power output of a solar power generation system can vary widely due to environmental factors. These environmental factors change with time and seasons and cannot be controlled. As the penetration rate of solar power generation system increases, drastic changes in its power generation will affect the voltage and frequency of the distribution system and may cause outages. This reduces the power quality of the distribution system. Because of environmental conditions, the power output of a solar power producing system might fluctuate greatly. These environmental conditions fluctuate with the seasons and are uncontrollable. As the penetration rate of solar power production systems grows, abrupt variations in power generation may alter the voltage and frequency of the distribution system, potentially resulting in outages. This decreases the distribution system's power quality. As a result, the power supply circuit becomes more complex, and power supply efficiency suffers. Furthermore, the charging power from the solar panel to the battery pack must be handled by integrating the Battery Storage Energy system to accomplish the power levelling function of the solar power generating system. Buck-boost converters can also be included into bridge topologies on the DC side. The energy efficiency of the buck-boost converter is lowered, however, because all of the converted power must be held in the inductor before being released. Moreover, these DC-AC power converters only control one DC supply. This research suggests a solar power generating system with force smoothing capabilities. The suggested solar power generating system integrates solar panels and batteries to create energy for injection into the grid using a dual-input buck-boost DC-AC convert and PCB. The converter combines two DC power suppliers. The DC power supplied by the solar panel or battery bank is converted to AC power solely using a converter in the proposed solar power generating system, 3 and the battery bank is charged from the solar panel using just PCBs. When the output power of the solar array varies greatly and the battery is charged/discharged to smooth out the output power of the solar power production system.

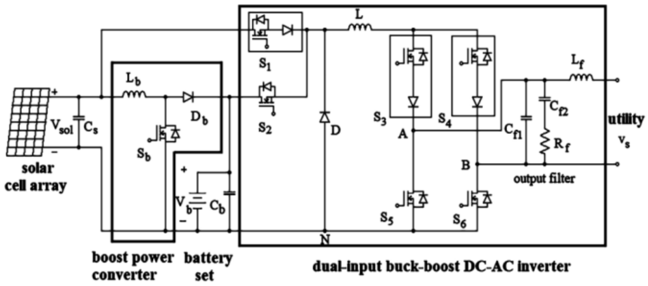


Fig. 1 . Circuit configuration of proposed solar power generation system.

The circuit configuration of the proposed solar power generation system is shown in Figure illustrated. The CC link configuration is used for the proposed SPGS. as the picture shows. As shown in Figure, the proposed solar power generation system consists of a solar panel, a battery pack and a power conversion interface. The power conversion interface is made up of a converter and a BPC. To regulate the electricity from the solar panel to charge the battery pack, the BPC is linked between the solar panel and the battery pack. To lower battery capacity, the battery will only operate when the power fluctuation of the solar generator exceeds the defined range. Because the solar generator is the only source of power for the battery, the power flow from the PCB is unidirectional. Converter features include step-up, step-down, and DC-AC power conversion. BPC works simultaneously to convert the electricity from the solar panel into the grid and charge the battery respectively.

II. LITERATURE SURVEY

J. Martins, S. Spataru, D. Sera, D.-I. Stroe, and A. Lashab, proposes a high variability of solar irradiance, originated by moving clouds, causes fluctuations in Photovoltaic (PV) power generation, and can negatively impact the grid stability. For this reason, grid codes have 5 incorporated ramp-rate limitations for the injected PV power. Energy Storage Systems (ESS) coordinated by ramp-rate (RR) control algorithms are often applied for mitigating these power fluctuations to the grid. These algorithms generate a power reference to the ESS that opposes the PV fluctuations, reducing them to an acceptable value. Despite their common use, few performance comparisons between the different methods have been presented, especially from a battery status perspective. This is highly important, as different smoothing methods may require the battery to operate at different regimes (i.e., number of cycles and cycles deepness), which directly relates to the battery lifetime performance. This paper intends to fill this gap by analyzing the different methods under the same irradiance profile, and evaluating their capability to limit the RR and maintain the battery State of Charge (SOC) at the end of the day.

H. Nazaripouya, C.-C. Chu, H. R. Pota, and R. Gadh, proposes a novelty of the proposed method is to provide a systematic way to optimize the size of the battery capacity for the desired level ofsolar power smoothing. This goal is achieved by designing a two-stage filter solution. The first stage is a fast response digital finite impulse response (FIR) filter that makes a trade-off between smoothing of the solar output and battery capacity. This paper proposes an optimal design of a minimum-length, low-group-delay FIR filter by employing convex optimization, discrete signal processing, and polynomial stabilization techniques. The new strategy proposed in this paper formulates the design of a length-N low-group-delay FIR filter as a convex second-order cone programming, which guarantees that all the filter zeros are inside the unit circle (minimum phase).

K. Koiwa, K.-Z. Liu, and J. Tamura, proposes a new filter design method that can smooth the wind power generation output while keeping the energy capacity and power rating of the energy storage system (ESS) small. Wind power generation causes frequency fluctuations in power systems. Therefore, in many cases, the ESS is needed for smoothing the fluctuations of wind generator output. In order to improve the performance of the ESS controlled with the conventional low-pass filter (LPF), this paper investigates other types of filters. First, the relations between filter and energy capacity/power rating of the ESS are disclosed through the worst-case study. Then, the frequency fluctuation analysis of the power system with respect to the wind power generation is carried out in order to realize a pin-point smoothing. Finally, a metaheuristic optimization method is proposed for the multi-objective design of the filter based on these relations so as to achieve an optimal tradeoff between the output smoothing and energy capacity/power rating of the ESS.

lll. METHODOLOGY

SIMULINK, a product of Math Works, is a commercial tool for visualizing, simulating, and researching multi-space dynamic frames. An editable square library layout and a square outline graphics tool make up the basic user interface. It can drive or write to MATLAB and offers tight integration with any remaining element of MATLAB state. For multi-space representation and model-based design, SIMULINK is frequently used to manage assumptions and advanced notation. For model-based design and multi-space reintroduction, SIMULINK is a quadratic graph condition. It ensures replication, programming code age, framework-level organization, ongoing testing, and framework installation inspection. To display and simulate dynamic frames, SIMULINK offers a graphics manager, a customized square library, and solvers. It works in tandem with MATLAB, enabling you to add MATLAB calculations to models and make notes rerun results in MATLAB for further investigation.

In SIMULINK, the model may be explored using the Explorer bar and Model Browser. The Explorer bar allows us to ascend up and down the progressive system while displaying the length of the chain of importance that we are now surveying. Similar to how the Explorer bar may be used to go between the dimensions of advancement, the Model Browser provides a comprehensive, multi-leveled tree perspective of your model.

The two parameters and indicators are part of SIMULINK models. The lines connecting the squares speak to us with signs, which are time-changing messages. Parameters are coefficients that describe the behaviour and components of the framework. The accompanying sign and parameter quality shown in fig. are chosen by SIMULINK. •Data type: 8-bit, 16-

bit, or 32-bit single, double, signed, or unsigned integers; Boolean; identification; or fixed-point Scalar, vector, grid, N-D, or variable-sized clusters are examples of dimensions. •Complexity—real or complicated characteristics •The minimum and maximum range, the beginning quality, and the number of construction units 49 If we choose not to provide information quality, SIMULINK determines them based on spread estimates and behaviour consistency checks to ensure information integrity. The model itself or another information language may indicate these flag and parameter features. The Model Explorer could then be used to create, view, modify, and add information without having to explore the entire model.

We can recreate the dynamic conduct of the framework and view the outcomes as the reproduction runs. To guarantee reenactment speed and exactness, SIMULINK gives fixed advance and variable-advance ODE solvers, a graphical debugger, and a model profiler. Solvers. They are numerical combination computations that, over time, using data from the model, register the framework elements. A wide range of frameworks, including continuous time (simple), discrete time (computerized), mixture (blended flag), and multi rate frameworks of any scale, may be recreated with the use of solvers provided by SIMULINK. These solvers can reproduce solid frameworks and frameworks with discontinuities. We can determine reenactment choices, including the sort and properties ofthe solver, recreation begin and stop times, and whether to load or spare reproduction information. We can likewise set advancement and indicative data. Diverse mixes of alternatives can be spared with the model.

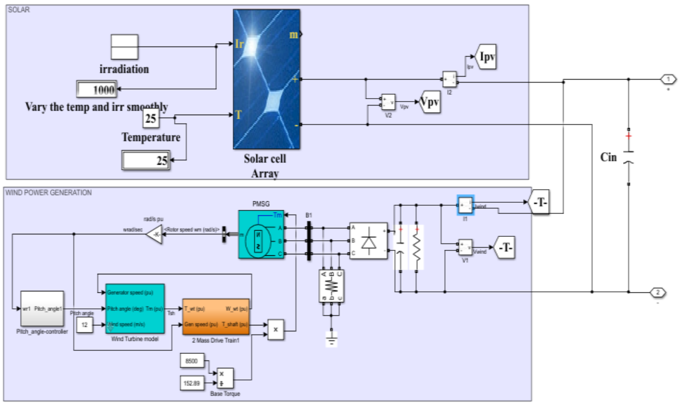
We may perform your simulation systematically from the MATLAB order line or intelligently from the SIMULINK Editor. The following recreation options are available: •Normal (the default), which apes the model in interpretation •Accelerator, which increases recreation execution by creating and running accumulated target code while also allowing the possibility to modify display parameters while re-creating •Rapid Accelerator, which creates an executable that can continue to operate outside of SIMULINK on a second preparation centre, may produce models more quickly than Accelerator mode. We can run many recreations concurrently on a multi-center PC or PC group to reduce the time needed to perform them.

In the wake of running a reproduction, we can break down the reenactment results in MATLAB and SIMULINK. It incorporates troubleshooting devices to comprehend the reproduction conduct.

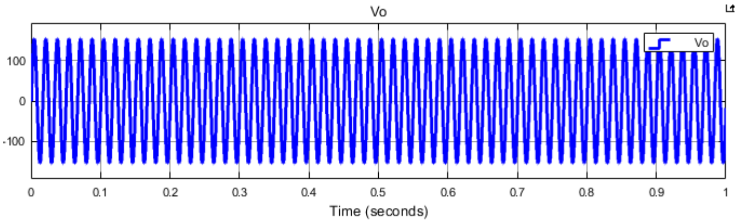
With the aid of the SIMULINK displays and degrees, we may visualise the simulation that is carried out by signal analysis. In the Simulation Data Inspector, where we can view a variety of indicators from various reenactment runs, we can also observe reproduction information. By using the SIMLINK extension square, we can measure and visualise the voltage, flow, and power in electrical space. The yield of a staggered converter during expansion is shown in Fig.1.6. On the other hand, we can create unique HMI displays using MATLAB, or we can add signs to the MATLAB workspace so that we can see and analyze the data using MATLAB computations and perception tools

IV. Results & Discussion

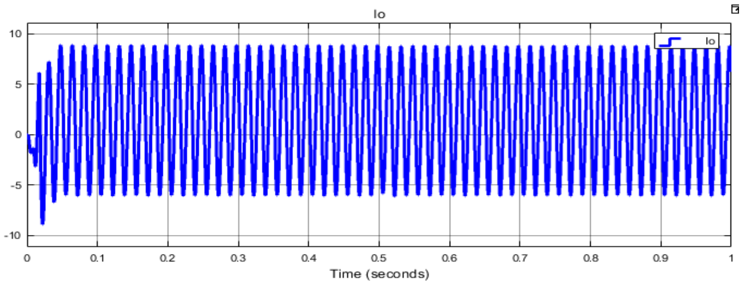
At constant irradiation:



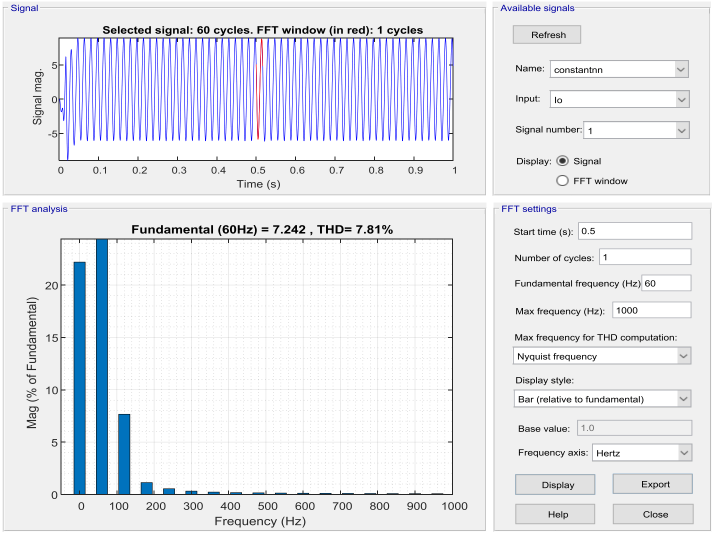
Hybrid generation



Output voltage

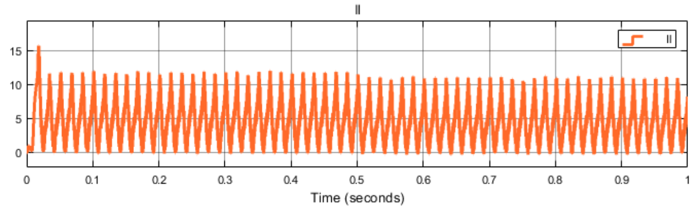


Output current

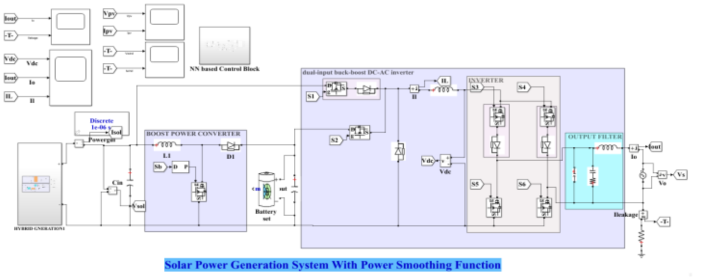


Name: constantnn
Input: Io
Signal number: 1
Display: ● Signal ○ FFT window
Start time (s): 0.5
Number of cycles: 1
Fundamental frequency (Hz) 60
Max frequency (Hz): 1000
Max frequency for THD computation: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

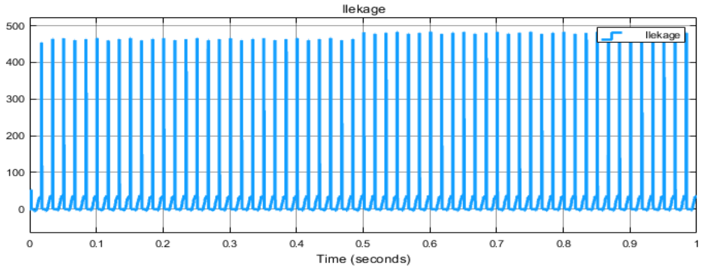
Io NN based



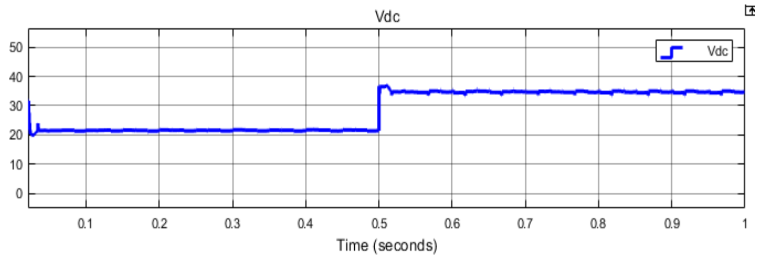
Inductor current



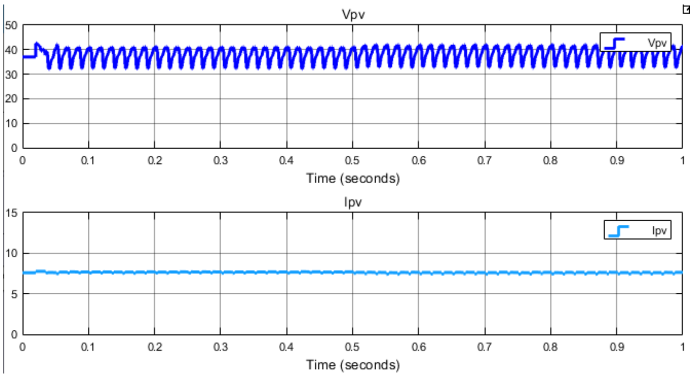
Schematic diagram



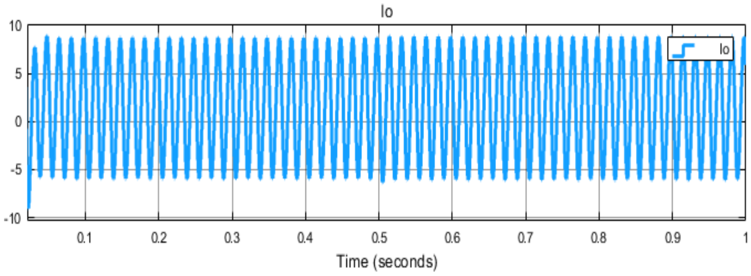
I_lekage current



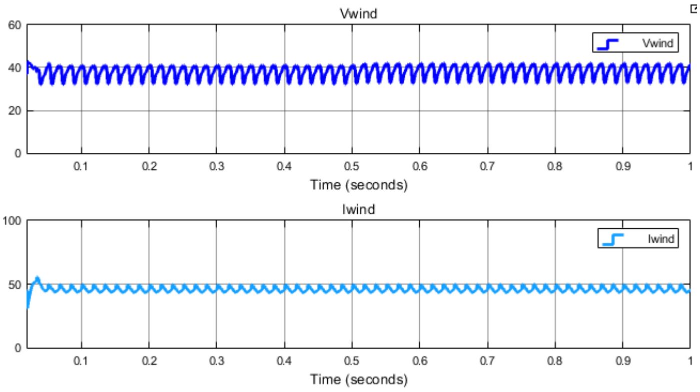
DC link voltage (Vdc)



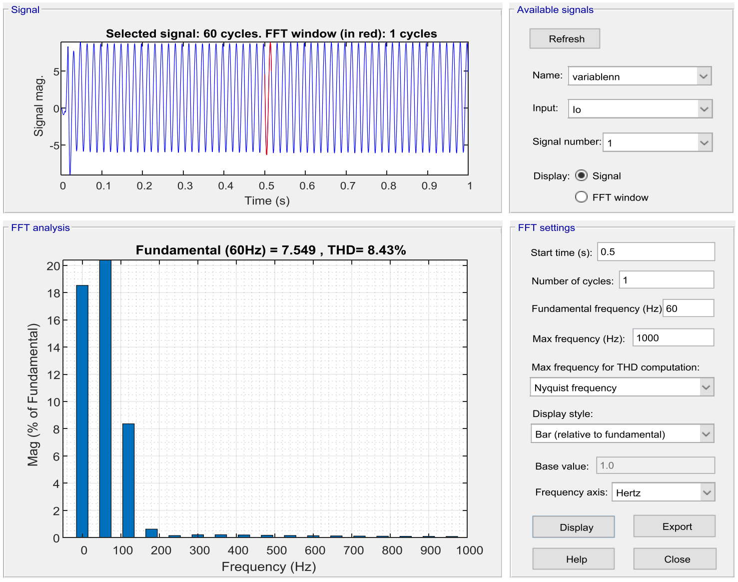
PV side voltage and current



Output current (Io)



Wind side dc voltage and current



Selected signal: 60 cycles. FFT window (in red): 1 cycles

Fundamental (60Hz) = 7.549 , THD= 8.43%

Name: variablenn

Input: Io

Signal number: 1

Display: ● Signal ○ FFT window

Start time (s): 0.5

Number of cycles: 1

Fundamental frequency (Hz): 60

Max frequency (Hz): 1000

Max frequency for THD computation: Nyquist frequency

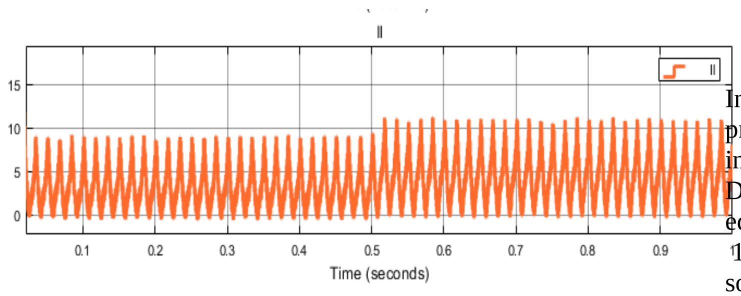
Display style: Bar (relative to fundamental)

Base value: 1.0

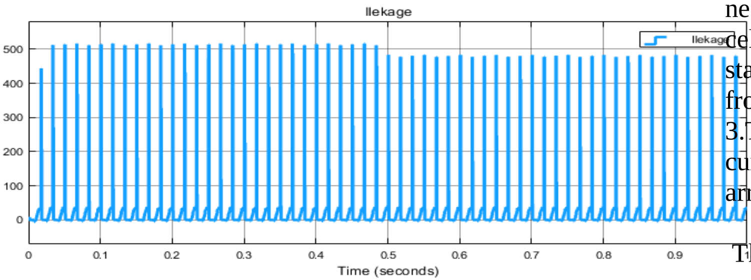
Frequency axis: Hertz

Io

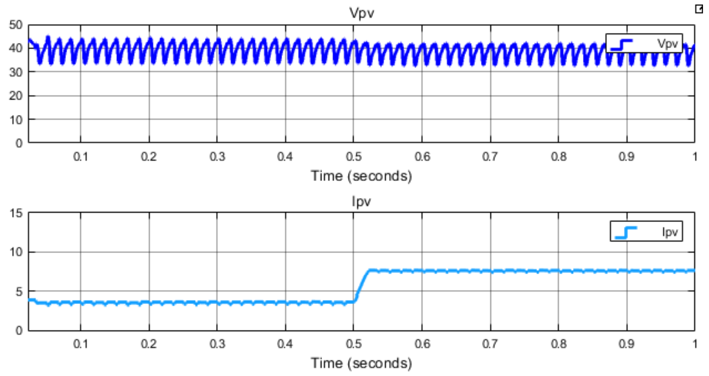
At variable irradiation:



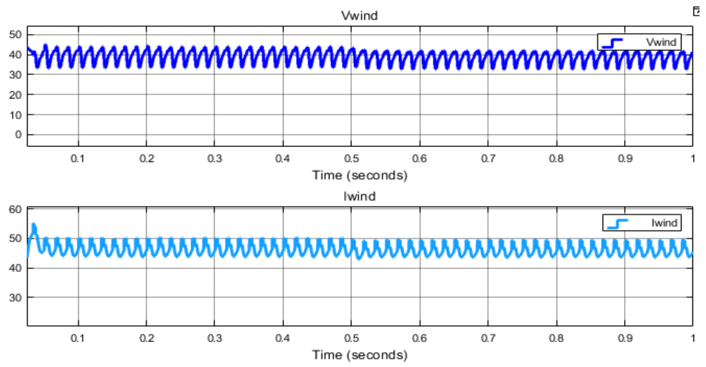
Inductor current



I_lekage current (I_lekage)



PV side voltage and current



Wind side dc voltage and current

V. Conclusion

In this paper, an SPGS with a power smoothing function is proposed. For smoother power output, the suggested SPGS integrates the battery set and solar cell array using a DIBBDAI. The suggested SPGS has the following cutting-edge attributes.

1. The SPGS includes two interchangeable input power sources: a battery set and a solar cell array. To tame the power fluctuation from the SPGS, the battery set functions as an energy buffer. Since the suggested SPGS only uses two power stages, the power circuit is made simpler.

2. To convert DC power to AC power, only one power stage is needed, regardless of whether the input power source is a solar cell array or a battery bank. Moreover, there is just one power stage used to charge the battery system using the electricity from the solar cell array.

3.The suggested SPGS is used, which reduces the leakage current brought on by the stray capacitance of the solar cell array.

The simulation results demonstrate that the proposed SPGS smooths the power variation brought on by the power fluctuation from the solar cell array and produces a sinusoidal current in phase with the utility voltage. Moreover, the solar cell array's leakage current is successfully reduced. As a result, it demonstrates that the suggested SPGS can effectively address the key issues of power fluctuation and leakage current. Further research will include an assessment of the battery set capacity needed for smoothing and a comparison of different smoothing techniques in the context of actual use

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