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Analysis and Comparison of the DC-DC converter with soft Computing algorithm

Dr. Agam Das Goswami[1,*] Shreyas R Hole[2]

[1]VIT-AP University, Amravati Andhra Pradesh, India
[2]VIT-AP University, Amravati Andhra Pradesh, India

Abstract

Due to technological discoveries in power generation or other power sources, DC-DC converters have developed more practical uses in electrical generation technologies (especially in DC micro grids). Separate the conversion components and generation of an optimized separate predictive algorithm may be achievable through model parameters. The primary goal of implementing an electronic parts converter for grid connection is to provide an amount of energy statistically and quantitatively satisfactory for the many applications at hand. Load frequency control electronics are divided into transistors, DC-to-DC converts, and rectifier diodes. The adapter from DC - DC is frequently used even among the many. The proposed technique can be applied to other parameter verification and improvement conditions, such as rectifier circuits, filter power supplies, etc.

Keywords: DC-DC Converter, Soft Computation Algorithm, Power Generation Variables, Frequency, Inverter, Rectifier Circuits Parameter

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1. Introduction

Electrical energy consumption is necessary for all areas of modern life, covering households, enterprises, construction, farming, teaching, medicine, research, and innovation. Electric-powered casserole diminishes Liquefied Petroleum Gas (LPG) use, street light development effects in Compact Fluorescent Lamp (CFL), Illumination Cathode (LED), Organic Light-Emitting Diode (OLED), and the use of electric power with lower energy consumption on equipment including fridge door, washer, and t.v. As a response, total electrical power performance has improved from 3% to 4% per year, with electricity savings of 25% realized in home appliances based on the item and region.
Product production measures a country's economic status by all means, and the demand for commodities is balanced by using direct and indirect energy sources. Diesel, gasoline, propane, electricity, natural gas, coal, and renewable energy sources (solar, biomass, wind, geothermal, hydropower, wave, and hydrogen) are direct energy sources).
The power electronics-based battery storage system supplies the prime mover's electrical energy. The primary mover's-controlled energy is utilized to stimulate the electric vehicle. DC motors, induction motors, brushless motors, and switched reluctance motors are examples of electric drives used in traction and propulsion applications. An electrochemical system that generates electricity through a chemical reaction using hydrogen and oxygen is called a fuel cell energy-producing system. It offers various advantages, including high efficiency, minimal maintenance, noise-free, vibration-free, and flexible green technology. Figure 1 depicts a fuel cell generation setup.

*Corresponding author. Email: agam.goswami@vitap.ac.in

Figure 1. Block Diagram of Fuel Cell Setup

Figure 2 depicts a wind energy-producing system consisting of a wind turbine with a coupling gearbox coupled to a generator that transforms mechanical energy into electrical energy. The electrical power obtained from a wind generator system will not be constant due to wind speed, rotor cross-section with wind, and generator rotor conversion efficiency.

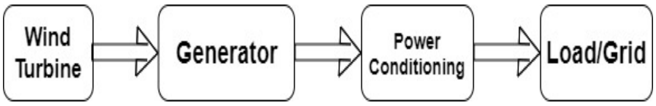

Figure 2. Block Diagram of Energy Producing System

Though the solar panel's output voltage fluctuates due to changes in air conditions and solar irradiation, the load/grid is connected to the solar panel demand for a steady power supply [2]. A power conditioning system is provided to sustain the prescribed power to the load, ideally when the solar panel output fluctuates to fulfill the power need between the seven solar panels and the load. Figure 3 depicts a block diagram of a solar energy generating system that includes a solar panel, a power conditioning device, and a load or grid [3].

Figure 3. Block Diagram of a Solar Energy Generating System

1.1. Need for a Power Conditioning System

The abovementioned pollution-free renewable energy generation systems necessitate using power electronics technology to improve energy quality, such as less ripple, high-efficiency energy conversion, reduced oscillatory transient response, and more sensitivity control to maintain specific power limits [5],[6].

DC to DC Converter

It transforms the input DC (Direct Current) voltage to changeable DC output voltage and is classed based on the direction of the output current and voltage [27], the commutation of the switching device, the magnitude of the converter's output voltage, and the switching loss of the switching device [7].

DC to AC Inverter

It primarily operates through a switching sequence of power switches linked in the circuit to convert input DC voltage to AC (Alternating Current) voltage [8].

AC to DC Rectifier

The converter requires rectifying the AC input voltage to the DC output voltage, and the input voltage, output voltage, and circuit architecture determine the categorization [9],[10].

AC to AC Converter

It converts fixed alternating current to variable alternating current with magnitude and frequency [11].

The key advantages of using power electronics circuits include high efficiency, rapid dynamic response compared to electromagnetically systems, compact size, less weight, less noise, and a cheaper energy-boosting device. More advantages of power conditioning systems may be highlighted by utilizing an example of a solar power-producing system, as shown in Figure 4, which comprises a solar panel that converts solar irradiation into electrical energy and has a low output DC voltage. The low voltage DC is boosted to a high DC voltage to make it more suitable for the AC load, and the increased output DC voltage of the DC to DC converter is provided to the inverter. Essentially, the inverter converts a high-voltage DC supply to the alternating current voltage required by an alternating current load or the grid [12] [13] [14].

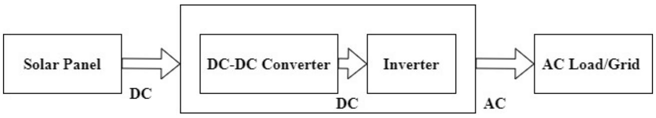

Figure 4. Solar Panel Converters

1.2 DC to DC Converter

A DC-DC converter is a power electronics circuit that transforms an input DC source into a changeable output DC power supply. The new technology improves the utilization of DC-DC converters to boost energy collection from solar and wind turbine-producing systems [15].

Boost converter

A boost converter is a DC-to-DC converter, sometimes a step-up converter that transforms a low input voltage into a higher output voltage. Generally, the Boost DC to DC converter output is always more prominent than the input voltage.

1.3 Identifying Critical Parameters

Following discovering a model flaw, the following step is to identify the problematic parameters. A converter model and its control might contain a large number of parameters. Calibrating all parameters may be computationally complex, and not all are recognizable. The essential parameters have been identified using trajectory sensitivity [16], [17], [18].

2. Soft Computing Algorithm for MPPT

Soft Computing is a branch of Artificial Intelligence (AI) that utilizes computational methods to solve complex problems, particularly those that involve uncertainty, imprecision, or ambiguity. It is a collection of computing techniques designed to mimic the human brain's problem-solving abilities and is characterized by its ability to handle incomplete, uncertain, or ambiguous information. The application of soft computing is mentioned in Figure 5.

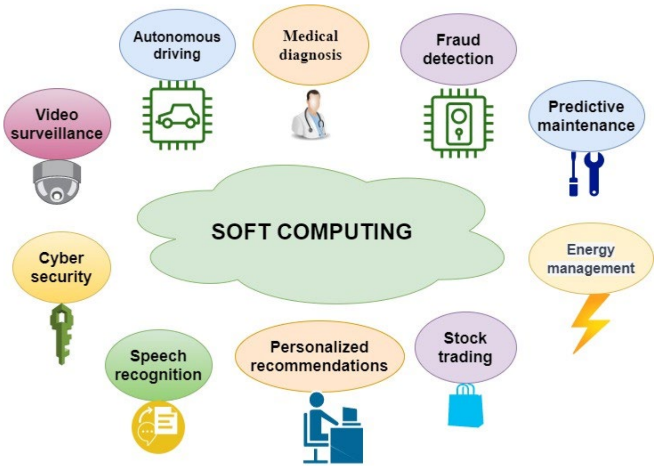

Figure 5. Block Diagram of a Solar Energy Generating System

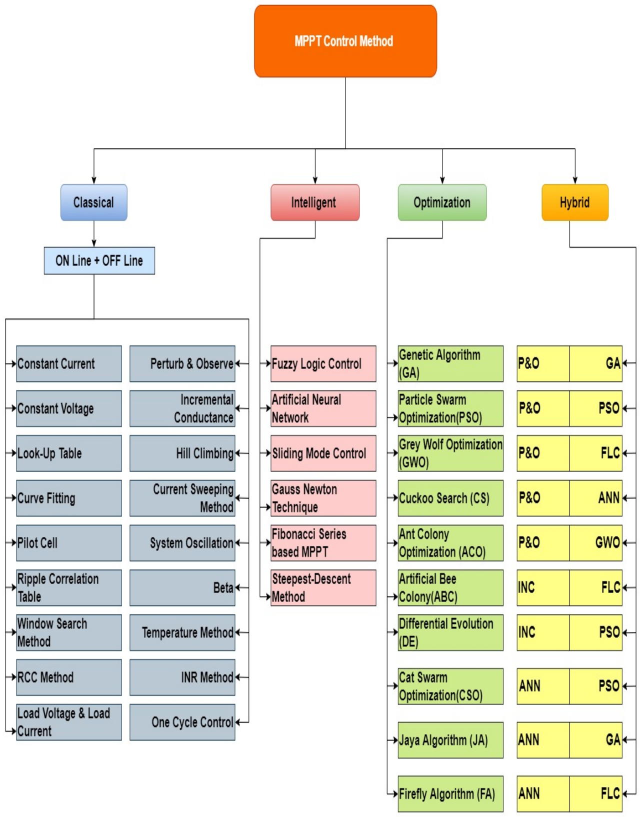

Figure 6. Classification of the MPPT Control method

Maximum PowerPoint Tracking, often known as MPPT, is a method implemented in photovoltaic (PV) systems to maximize the amount of electricity solar panels generate. Figure 9 shows the different types of MPPT algorithms categorized according to their operational principles and tactics. The following is a list of the most prevalent classes of MPPT techniques:

- P&O is a popular MPPT algorithm. It continuously perturbs the PV system operating point and monitors power output. The algorithm changes the operating point to reach the MPP based on the power change direction.
- Incremental Conductance (Inc-Cond): This MPPT method calculates MPP by evaluating power variation with voltage. It accurately tracks the MPP even under rapidly changing air circumstances by comparing incremental and instantaneous conductance.
- Fractional Open-Circuit Voltage (FOCV): This method determines MPP based on the fraction of Voc that maximizes power production. The algorithm approaches MPP by modifying the proportion and measuring power output.
- Constant Voltage (CV): CV MPPT maintains a fixed PV panel voltage to optimum power output. The algorithm monitors current and voltage to keep the PV panel at the MPP [28].

- Model Predictive Control (MPC): MPC-based MPPT algorithms predict PV system behaviour and calculate the optimal operating point using mathematical models. These models optimize power extraction using sun irradiance, temperature, and panel properties.

1. Artificial Neural Network (ANN) algorithms:
   These algorithms approximate the nonlinear PV system and estimate the MPP using neural network models. Historical data trains the neural network to track accurately in changing environmental conditions.
2. Fuzzy Logic Control algorithms:
   Fuzzy logic handles uncertainty and imprecision mathematically. Fuzzy logic-based MPPT algorithms use language rules and membership functions to determine control actions based on solar irradiation and temperature. FLC algorithms operate system uncertainty and are robust.
3. Genetic algorithms
   GA is an optimization algorithm inspired by natural selection and evolution. Genetic MPPT algorithms search a population of possible solutions for the best MPP. Selection, crossover, and mutation evolve the population to the maximal power point.
4. Particle Swarm Optimization (PSO) algorithms:
   Bird flocking and fish schooling inspired PSO. In PSO-based MPPT algorithms, a population of particles represents potential solutions. Each particle modifies its position and velocity based on its own experience and the best experiences of other particles. Cooperative searching finds the MPP quickly.
5. Ant Colony Optimization algorithms:
   Ant foraging inspired ACO algorithms. These algorithms exploit search space using pheromones. ACO methods use artificial ants to discover the MPP in MPPT applications by iteratively modifying control settings based on pheromone trails.
6. Hybrid algorithms:
   Some MPPT algorithms use soft computing approaches to complement one another. Hybrid algorithms can combine ANN and GA to improve tracking and convergence.

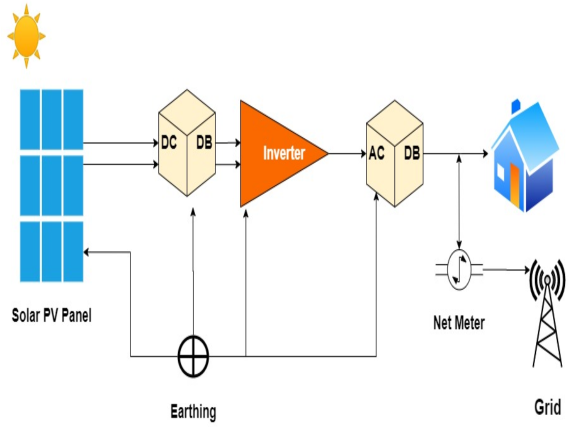

Figure 7. ON-Grid Residential Solar System

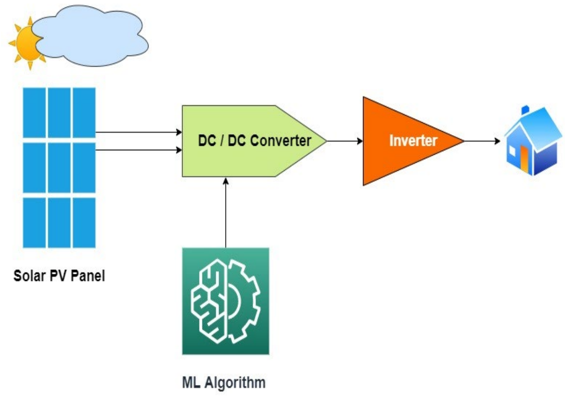

Figure 8. ML iterated with the Solar System

1. Figure 7 shows On-Grid Solar PV System: A grid-tied or grid-connected solar power system is connected to the utility grid. It has solar panels, inverters, and a bi-directional meter. An on-grid system generates solar energy and feeds it to the grid to profit from net metering or feed-in tariffs.
   On-grid solar panels generate DC electricity from sunshine. The inverter converts DC electricity into AC electricity for households and businesses. Building loads use AC electricity. The bi-directional meter feeds excess power from the solar system back into the grid, crediting the owner's energy account.
   The grid automatically supplies power when the solar system cannot, for example, at night or during cloudy weather. This guarantees customer electricity reliability. On-grid solar PV systems lower electricity prices, provide feed-in tariffs and minimize fossil fuel use.
2. Figure 8 ML-Based Solar PV System: This system optimizes solar power generation using machine learning (ML) approaches. ML algorithms optimize system operation by optimizing previous solar data, environmental conditions, and system parameters.
3. Solar PV systems can use ML:

- Performance Prediction: ML algorithms can anticipate solar energy generation using previous weather data, solar panel attributes, and other criteria. These predictions let system operators predict output and plan.
- Fault Detection and Diagnostics: ML algorithms may detect defects or anomalies in real-time sensor data from the solar PV system. ML can prevent downtime by spotting panel degradation, shading, and inverter faults.
- Optimal Power Generation: Based on real-time weather conditions and electricity demand, ML algorithms can optimize solar PV system tilt angle, orientation, and power production. This maximizes energy generation and system efficiency.
- Energy Management and Demand Response: ML can help manage energy use by assessing historical usage trends and optimizing energy-intensive activities. ML algorithms can also automate energy consumption based on power pricing or grid demand.
- Grid Integration and Stability: ML algorithms can forecast grid voltage variations and adapt the solar system's power output for grid stability. ML-based control techniques can improve grid-friendly solar PV system coordination.

ML-based solar PV systems may improve solar power generation performance, efficiency, and grid integration. ML algorithms help these systems adapt to changing conditions, enhance energy management, and maximize renewable energy use.

3. Literature Review

[1] [5] environmentally friendly power Sources (RES) have shown tremendous development over recent years. In examination with different RES, sunlight-based power has turned the possible source because of its extraordinary properties like spotless, silent, eco-accommodating nature, and so forth. During the extraction of electric power, the DC converters were given specific s due to their broad use in different applications.

[2],[19] Apply a signal stream diagram and Bricklayer's gain equation to determine the open circle input-yield move capability and the control-yield move capability of the Single Finished Essential Inductance Converter (SEPIC).

[3], [20] Proposed a computerized assessment technique to get an open circle reaction of the buck and lift converter in light of the time-space determination. Distinguishing proof of the converter model is carried out in the equipment and is confirmed with the reproduction yield.

[4], [21] Interface the interleaved support converter with two inductors. To expand the effectiveness of the converter with a diminished size yield channel, a semi-consistent recurrence hysteretic current control in the criticism is carried out in the FPGA.

[5] Present another condition-based circuit demonstrating the buck DC/DC converter procedure in light of the circle remuneration technique. A block outline portrays every part, and the required exchange capability for the shut circle converter is acquired.

4. Methodology & Simulation Result

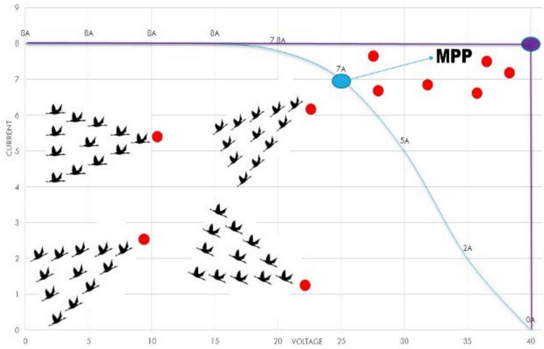

Figure 9. Concept of Particle Swarm Optimization for MPPT Solar PV

1) Initialization:
   - Define the swarm size or particle count.
   - Randomly initialize particle positions and velocities within PV system settings.
   - Position-based fitness (power output) evaluation.
2) Particle's velocity and position:
   - The following equation updates particle velocity:

     V[i] = w * V[i] + c1 * r1 * (Pbest[i] - X[i]) + c2 * r2 * (Gbest-X[i]).

     Where V[i] is the i-th particle's velocity, w is the inertia weight, c1 and c2 are acceleration coefficients, r1 and r2 are random numbers between 0 and 1, Pbest[i] is the particle's personal best position, X[i] is its current position, and Gbest is the global best position among all particles [28],[29],[30}.
   - Update particle positions based on velocity:

     X[i] =X[i] + V[i]
3) Fitness and Positions:
   - Assess each particle's fitness (power production) in its new place.
   - If the fitness value improves, update each particle's Pbest.
   - Update the global best position (Gbest) if any particle has a more excellent fitness.
4) Steps 2–3 again:
   - Repeat Steps 2 and 3 until a convergence requirement is fulfilled (e.g., fitness improvement is below a threshold). Output:
   - After iterations, the PV system MPP is the maximum fitness (power output) particle.

- The particle position determines the best PV system characteristics like power converter voltage and duty cycle.

The PSO algorithm effectively traverses the search space and converges to the PV system's MPP by changing particles' locations and velocities based on their best and global positions. Its adaptability and simplicity make it a popular MPPT algorithm for solar PV installations.

4.1 Parameter setting

In this exploration, we use q = 0.75 in all reproductions to decide the limits. We chose 0.4 in light of the reproduction discoveries. A similar applies to a Gaussian dissemination portion. We picked T = 1 as the most extreme number of emphases. The DC buck converter model depends on the TPS40200EVM-002 model made in MATLAB/Simulink [22], and the recommended procedure is carried out in Python.
Sensitivity

$$ACC = \frac{N}{N_S} \quad (1)$$

The acknowledgment rate for fifty separate reproductions with the recommended weight and web is displayed in Figure 10. [23] As can be noticed, the suggested weight has a higher acknowledgment rate through all reproductions.

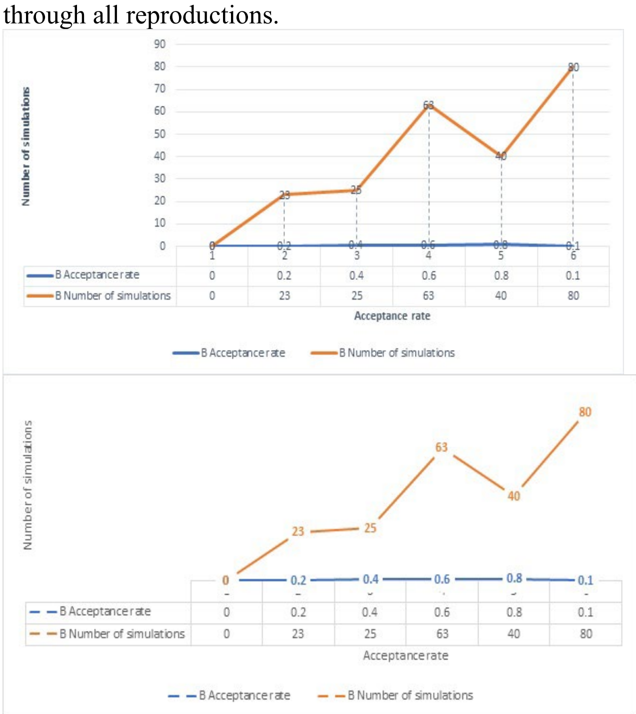

Figure 10. Weight and Web

Critical Factor

Distinguishing proof, we assess eight fundamental variables from the direction responsiveness that best affect the results. Table 1 shows the best eight boundaries and their standardized responsive qualities.

Table 1. Model Parameters

Parameter	Sensitivity
L	1
R_S	2.3
C_S	0.6
C_{IN}	5.9

Power Converter Certification

We will investigate the non-disconnected buck converter in this examination. Table 2 portrays its geography. In the first place, we get the results of the Buck converter utilizing a bunch of boundaries, genuine c, whose values we know. [24] We break down the model's results regarding genuine c as z. We assume we don't have past dissemination for the power supply obstruction. Then, at that point, to represent all vulnerabilities, we embrace uniform dissemination as U (0, 10000) [25], [26].

Table 2. Non-disconnected buck converter

Time (Ms)	Output current (A)
5	0.263
5.5	0.59
6	0.258
6.5	0.169
7	0.286
7.5	0.169

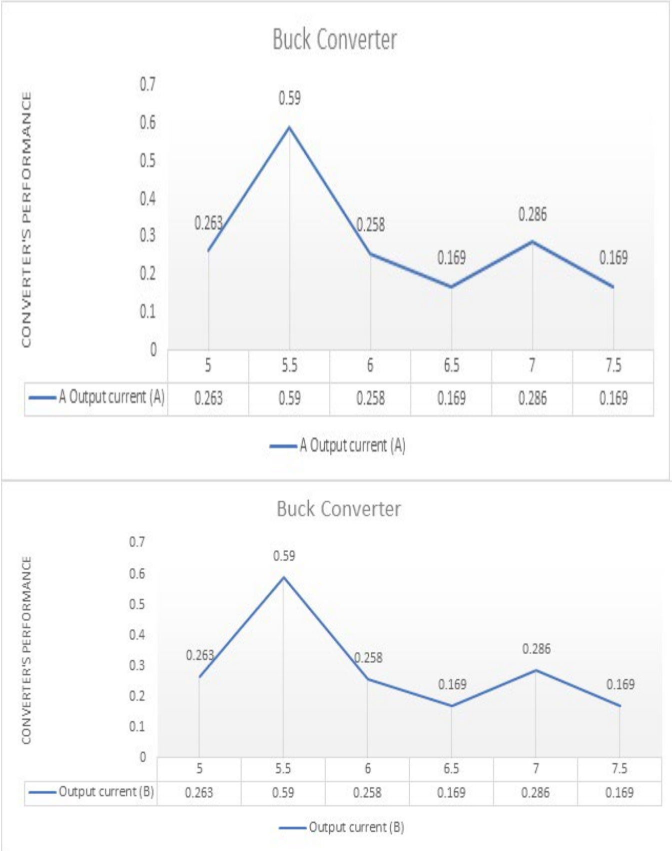

Figure 11. Buck converter using a set of parameters

Figure 11 portrays the converter's presentation under transient circumstances, though Figure 5 portrays the converter's exhibition under consistent state conditions.
As should be visible, the converter's result with assessed boundaries is exceptionally near the estimations [25,] [26].

5. Conclusions and Future Work

This research suggested an adaptive parameter calibration approach for DC-DC buck power converters.
The suggested technique was tested on a DC-DC converter with the parasite and passive converter parts [27]. Test findings reveal that the proposed method can determine the precise values of a converter's parameters by considering the passive and parasitic components.
The power electronics circuit of a power generation system has been briefly explored. The essential operation of an ideal boost converter is illustrated via a circuit diagram.
Finally, a brief literature study has been conducted on DC-to-DC converter and controller.
We look at the converter's consistent state and quick execution utilizing the determined boundaries. The discoveries exhibit the calculation's magnificent presentation. Be that as it may, in this paper, we fabricate the methodology for the reproduction-based converter, and we will test the recommended calculation on an actual situation with its regulators later on.

References

[1] Raghavendra, Kummara Venkat Guru, et al. "A comprehensive review of DC–DC converter topologies and modulation strategies with recent advances in solar photovoltaic systems." Electronics 9.1 (2019): 31.

[2] Kumar, Ashok, and Parthasarathi Sensarma. "Ripple-free input current high voltage gain DC–DC converters with coupled inductors." IEEE Transactions on Power Electronics 34.4 (2018): 3418-3428.

[3] Hossain, M. Zakir, Jeyraj A/L. Selvaraj, and N. A. Rahim. "High voltage-gain full-bridge cascaded dc-dc converter for photovoltaic application." Plos one 13.11 (2018): e0206691.

[4] Upadhyay, Prashant, and Rajneesh Kumar. "A high gain cascaded boost converter with reduced voltage stress for PV application." Solar Energy 183 (2019): 829-841.

[5] Laha, Arpan. "A High voltage gain quadratic boost converter using a voltage doubler and voltage-lift technique." 2020 IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy (PESGRE2020). IEEE, 2020.

[6] Hayerikhiyavi, Mohammadali, and Aleksandar Dimitrovski. "Comprehensive analysis of continuously variable series reactor using gc framework." 2021 IEEE Power {\&} Energy Society General Meeting (PESGM). IEEE, 2021.

[7] Khazeiynasab, Seyyed Rashid, Junjian Qi, and Issa Batarseh. "Generator parameter estimation by q-learning based on pmu measurements." 2021 IEEE Power {\&} Energy Society Innovative Smart Grid Technologies Conference (ISGT). IEEE, 2021.

[8] Barwar, Manish Kumar, et al. "Demystifying the Devices Behind the LED Light: LED Driver Circuits." IEEE Industrial Electronics Magazine (2022).

[9] Abanihi, V. K., et al. "Complementarity Problem Approach to Economic Power Dispatch of Nigeria Power System." ATBU Journal of Science, Technology and Education 8.2 (2020): 240-249.

[10] Balakrishnan, Hariharan, et al. "DC-DC buck converter parameter identification based on a white-box approach." 2018 IEEE 18th International Power Electronics and Motion Control Conference (PEMC). IEEE, 2018.

[11] Rojas-Dueñas, Gabriel, Jordi-Roger Riba, and Manuel Moreno-Eguilaz. "Nonlinear least squares optimization for parametric identification of DC–DC converters." IEEE Transactions on Power Electronics 36.1 (2020): 654-661.

[12] Bhaduri, Rupam, G. Rahul Saravana, and C. Vaskar. "Supervisory controller for power management of microgrid using hybrid technique." Transactions on Electrical and Electronic Materials 21.1 (2020): 30-47.

[13] Geyer, Michael, et al. "EUROTROUGH-Parabolic trough collector developed for cost efficient solar power generation." 11th International symposium on concentrating solar power and chemical energy technologies. 2002.

[14] Correa-Betanzo, Carlos, et al. "Photovoltaic-based DC microgrid with partial shading and fault tolerance." Journal of Modern Power Systems and Clean Energy 7.2 (2019): 340-349.

[15] Bayati, Navid, et al. "A fuse saving scheme for DC microgrids with high penetration of renewable energy resources." IEEE Access 8 (2020): 137407-137417.
[16] Eltamaly, Ali M., M. S. Al-Saud, and A. G. Abo-Khalil. "Performance improvement of PV systems’ maximum power point tracker based on a scanning PSO particle strategy." Sustainability 12.3 (2020): 1185.
[17] Gammoudi, Rabiaa, Houda Brahmi, and Othman Hasnaoui. "Developed and STM implementation of modified P{\&}O MPPT technique for a PV system over sun." EPE Journal 29.3 (2019): 99-119.
[18] Ernawati, Ernawati, et al. "The effects of anemia education using web-based she smart to improve knowledge, attitudes, and practice in adolescent girls." International Journal of Health and Medical Sciences 5.1 (2022): 44-49.
[19] Hossain, M. Z., and N. A. Rahim. "Recent progress and development on power DC-DC converter topology, control, design and applications: A review." Renewable and Sustainable Energy Reviews 81 (2018): 205-230.
[20] Ayop, Razman, and Chee Wei Tan. "Design of boost converter based on maximum power point resistance for photovoltaic applications." Solar Energy 160 (2018): 322-335.
[21] Wang, Faqiang. "A novel quadratic Boost converter with low current and voltage stress on power switch for fuel-cell system applications." Renewable energy 115 (2018): 836-845.
[22] Kim, Ho-sung, et al. "A highly efficient PV system using a series connection of DC–DC converter output with a photovoltaic panel." Renewable Energy 34.11 (2009): 2432-2436.
[23] Zubi, Ghassan, et al. "Techno-economic assessment of an off-grid PV system for developing regions to provide electricity for basic domestic needs: A 2020–2040 scenario." Applied Energy 176 (2016): 309-319.
[24] Saravanan, S., and N. Ramesh Babu. "Analysis and implementation of high step-up DC-DC converter for PV based grid application." Applied Energy 190 (2017): 64-72.
[25] Hole, Shreyas Rajendra, and Agam Das Goswami. "Quantitative analysis of DC–DC converter models: a statistical perspective based on solar photovoltaic power storage." Energy Harvesting and Systems 9.1 (2022): 113-121.
[26] Hole, Shreyas Rajendra, and Agam Das Goswami. "Maintain Maximum Power Point Tracking of Photovoltaic using SEPIC Converter." 2022 2nd International Conference on Power Electronics {\&} IoT Applications in Renewable Energy and its Control (PARC). IEEE, 2022.
[27] Seyyed Rashid Khazeiynasab, Issa Batarseh"Measurement-Based Parameter Identification of DC-DC Converters with Adaptive Approximate Bayesian Computation", 2021 31st Australasian Universities Power Engineering Conference (AUPEC), 2021
[28] Shreyas Rajendra Hole, Agam Das Goswami."Analysis and Performance of Solar Photovoltaic Energy System in India: Case Study", 2022 4th International Conference on Inventive Research in Computing Applications (ICIRCA), 2022
[29] Hole, Shreyas Rajendra and Goswami, Agam Das. "Design of a novel hybrid soft computing model for passive components selection in multiple load Zeta converter topologies of solar PV energy system" Energy Harvesting and Systems,10.2 2023. https://doi.org/10.1515/ehs-2023-0029
[30] Chandrahaas, B. V., Mohanty, S. N., Panda, S. K., \& Michael, G. (2023). An Empirical Study on Classification of Monkeypox Skin Lesion Detection. EAI Endorsed Transactions on Pervasive Health and Technology, 9, e4-e4.