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Implementation of solar power optimizer to enhance output power of a solar PV plant

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Abstract

The Solar Power Optimizer (SPO) is a framework that includes a boost converter which productively reaps extreme energy from a photovoltaic (PV) board. It incorporates coupled inductor and changed capacitor advances to acknowledge high advance up voltage acquire. A high advance up DC/DC converter is expected to boost low info voltage to high voltage yield with a voltage multiplier and a coupled inductor. The spillage inductance energy of the coupled inductor can be reused to lessen power misfortunes and voltage stress. A rating switch improves framework effectiveness by utilizing the fuzzy logic technique for the (MPPT) greatest power point following calculation. It has high following exactness; henceforth the technique is broadly used to reap energy of PV frameworks. The decrease in power brought about by the current shadow impact on PV boards is an unavoidable issue in an incorporated PV framework. The utilization of a miniature inverter or AC module has as of late been proposed for individual PV boards. A SPO was created as a choice to expand energy gather from every individual PV module. Power optimizers are particularly helpful when the exhibition of the power creating segments in a circulated framework will fluctuate broadly, contrasts in hardware, concealing of light or wind, or being introduced confronting various headings or generally isolated areas.

Keywords: Solar power optimizer, fuzzy logic method, step-up boost converter, voltage multiplier and coupled inductor

Introduction

For the most part a photovoltaic power age framework is utilized as an inexhaustible asset; it has been utilized in crisis offices and producing power. This PV power age framework should be high proficiency and high unwavering quality. A customary photovoltaic age framework is either a solitary or a PV cluster is associated with one or few focal PV inverters. The PV modules are associated in arrangement with the PV cluster to acquire the DC interface voltage that is sufficiently high to power associated took care of to the DC-AC inverter. Anyway the decrease of power is brought about by impact of the shadow. That is issue of concentrated photograph voltaic framework. The miniature lattice or AC modules are utilizing as of late for isolated PV boards [1, 2]. Albeit this PV power age of shadow issue arrangement may incompletely wipe out, the design of the miniature inverter obliges the framework energy's harvesting proficiency and cost is high. An option proposed solar power optimizer is created to harvest boost energy taken from discrete photovoltaic modules. A DC-DC convertor is utilized in solar power optimizer with most extreme power point following. The PV board voltage expands quickly to ideal voltage levels and a DC miniature lattice association for the power of DC-AC inverter [3-6]. The power goes through a SPO to a DC miniature lattice framework. A 40 V information voltage is taken care of into SPO. This SPO will create high advance up voltage of 400 V DC utilizing boost converter, this yield of miniature network circulation for server farm frameworks and telecom office [7]. These are the endeavors of SPO to improve the general arrangement of inexhaustible assets and framework cost is lower, has an enemy of shadow impact of PV framework can be observed and improve the proficiency [8]. A solitary PV board voltage scope of 20 V-40 V and limits of power around 100 W - 300 W are utilized [6].

A high advance up SPO utilizing boost converter that expands low voltage to required voltage level. The progression up DC-DC converter with different geographies comprises of a boost and fly back converters

[9, 10], exchanged capacitor and coupled inductor converters and boost type that are explored with coupled inductor. The drifting switch utilized in SPO on account of its expanding voltage acquire, the spillage inductance energy of the coupled inductor can be reused and the voltage weight on the dynamic switch. If there should be an occurrence of low-stacking condition, the excess energy will store into battery or through bidirectional inverter to AC network. A solar power optimizer (SPO) was created as a choice to amplify energy gather from every individual PV module [11-17]. A solar power optimizer is a DC to DC converter innovation created to boost the energy gather from solar photovoltaic or wind turbine frameworks. They do this by independently tuning the exhibition of the board or wind turbine through most extreme power point following, and alternatively tuning the yield to coordinate with the presentation of the string inverter. Power optimizers are particularly valuable when the presentation of the power creating segments in a conveyed framework will shift generally, contrasts in gear, concealing of light or wind, or being introduced confronting various bearings or broadly isolated areas. Power optimizers for solar applications, can be like miniature inverters, in that the two frameworks endeavor to separate individual boards to improve in general framework execution. In this examination, the effects of executing SPO in a solar PV framework have been investigated.

2 Proposed System

SPO was created as a choice to augment energy reap from every individual PV module. Figure 1 shows a solitary PV board's energy, which goes through a SPO to a DC microgrid framework. A 400 V DC microgrid framework was proposed as an energy-proficient dispersion choice for server farm frameworks and media transmission offices. A SPO was created as a choice to augment energy collect from every individual PV module. A SPO is utilized as a DC–DC converter with most extreme power point following (MPPT), which expands PV board voltage to ideal voltage levels for a DC microgrid association or through a DC–AC inverter for power a solitary PV board's energy, which goes through a SPO to a DC microgrid framework. The circuit outline of the SPO has been shown in Figure 2.

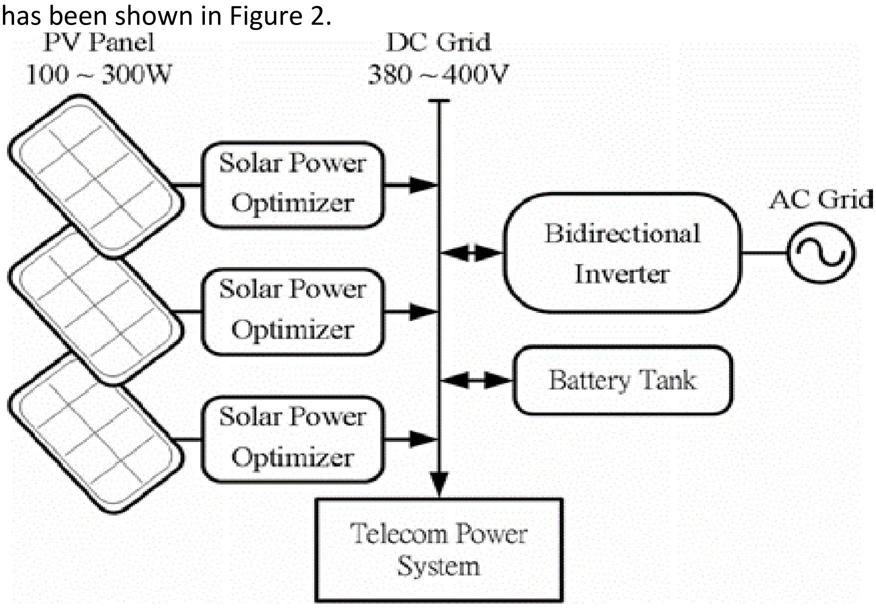

Fig. 1. Block diagram of the proposed work

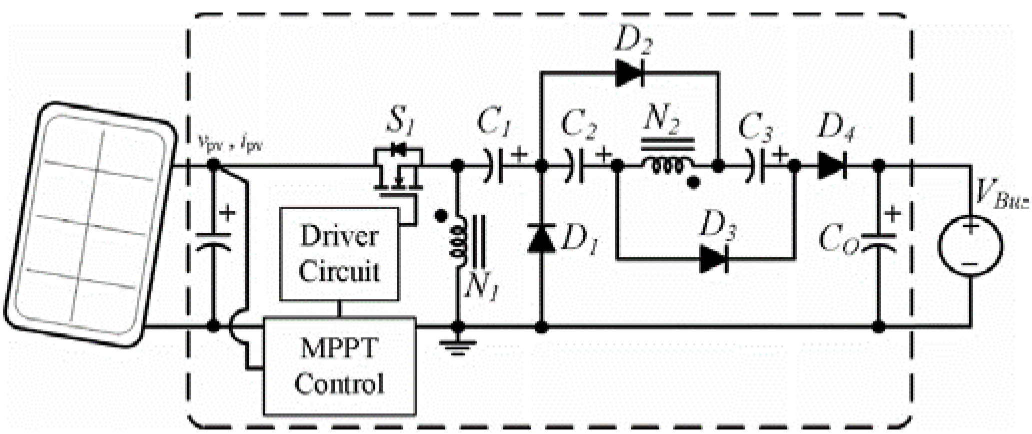

Fig. 2. Circuit diagram of SPO

To work on the circuit examination of the proposed converter, the accompanying suppositions are made:

1. Every one of the parts utilized in optimizer circuit are ideal, with the exception of the spillage inductance of coupled inductor T1 is considered.
2. Capacitors C1 to C3 and C0 are adequately enormous that the voltages across them are viewed as consistent,
3. The same arrangement opposition (ESR) of capacitors C1 to C3 and C0, just as the parasitic obstruction of coupled inductor T1, is disregarded.
4. Turns proportion n of coupled inductor is equivalent to N2/N1. A SPO can be constrained by a Fuzzy Logic regulator (FLC).

3 Solution Methodology

FLC is perhaps the most mainstream control strategies which is known by its multi-rule-based factors thought. FLC utilizes the fuzzy logics to settle on the choices and to control the yield of the regulator. This strategy gives quicker outcomes contrasted with other MPPT regulators. The information mistake E(k) shows if the heap activity point at the moment k is situated on the left or on the privilege of the most extreme power point on the PV trademark, while the info CE(k) communicates the moving course of this point. The fuzzy deduction is done by utilizing Mamdani strategy. FLC contains three essential segments: Fuzzification, Control rule Base and defuzzifcation. The square outline and stream diagram of FLC have been appeared in Figure 3 and 4 separately. The fuzzy principles have been introduced in Table 1.

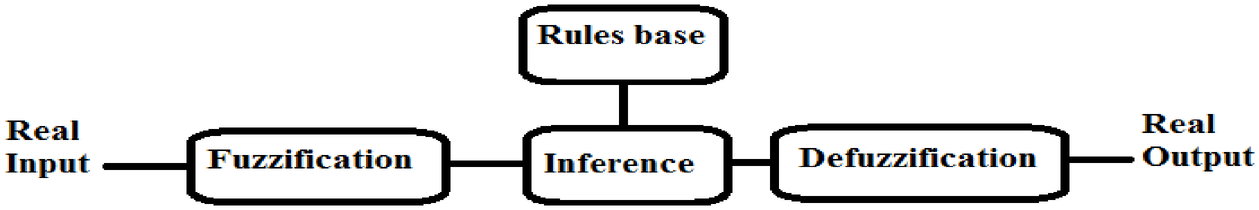

Fig. 3. Block diagram of FLC

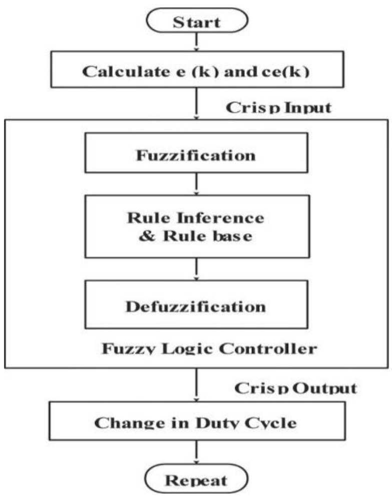

Fig. 4. Flowchart of FLC

Table 1 Fuzzy rules table

Change Error	Error				
	NB	NS	ZE	PS	PB
NB	PB	PB	PS	PB	PB
NS	PB	PS	PS	PS	PB
ZE	NS	NS	ZE	PS	PS
PS	NB	NS	NS	NS	NB
PB	NB	NB	NS	NB	NB

- Combining fuzzy yields − by applying fuzzy rough thinking, find the fuzzy yield and consolidation them.
- Defuzzification − at long last, start defuzzification interaction to frame a fresh yield.
- In P&O technique, if step size of information variable is exceptionally little, the exactness in following MPP is adequate yet following pace turns out to be excessively sluggish. Then again if the progression size is expanded to mimic the quickly changing climate conditions, precision crumbles and startling outcomes happen because of wavering around the MPP in spite of the fact that following rate expanded. Yet, on account of proposed FLC whatever the progression size of information variable it most appropriate to follow MPP ceaselessly and precisely. FMPPT gives a steady reaction as the fuzzy regulator gives a variable irritation size as indicated by the circumstance. Since swell in the yield relies upon the converter model, MPPT regulator has no impact on swell. Consistent state blunder is less in P&O in contrast with fuzzy MPPT. Speed of reaction is quicker in FMPPT than P&O MPPT that has moderate intermingling speed.

Despite the fact that P&O calculation is not difficult to execute, not at all like fuzzy MPPT, they can't adapt to quickly changing natural condition. In Perturb and Observe calculation, step size is fixed. At the point when the working point meets to MPP, framework sways around the most extreme power point because of a fixed addition or decrement in obligation cycle. Conversely, FMPPT give a steady reaction in following of MPP because of its variable advance size regardless of whether there is variety in PV module attributes. Reenactment results demonstrate prevalent execution of fuzzy logic based canny greatest power point following

4 Simulation Results and Discussion

Solar boards have comparative issues because of the speed at which the cell can change over solar photons into electrons, encompassing temperature, and a large group of different issues. For this situation there is a complex non-direct connection between voltage, current and the aggregate sum of power being delivered, the "I-V bend". To enhance assortment, current solar clusters utilize a procedure known as MPPT to screen the complete yield of the exhibit and ceaselessly change the introduced burden to keep the framework activity at its pinnacle proficiency point.

DC-DC power optimizers convert variable DC voltage from PV boards to a fixed DC voltage. This is additionally alluded to as the MPPT stage. MPPT is a strategy used to amplify power extraction under any ecological conditions, remembering changes for illumination levels and temperature. MPPT can happen either be led straightforwardly at and independently for a PV board through single units introduced at each board or at a fundamental buck/boost phase of an inverter where a few photovoltaic boards are associated in arrangement at the information. MPPT calculation utilizing Fuzzy Logic in MATLAB-Simulink module close by an insightful examination with the conventional methodology. This MPPT procedure diminishes the following time and furthermore tackles the different issues related with customary MPPT calculations like Perturb and Observe, Incremental Conductance. The strategy includes as Fuzzy Logic Controller which controls the exchanging of the DC-DC Boost Converter. In this paper the fuzzy logic MPPT regulator is tried against variable irradiance, and temperature. Different execution pointers have been recorded for the proposed MPPT.

Fuzzy logic give client complete adaptability to pick the data sources and their relationship (rule base). The reproduced results show that the fuzzy logic strategy controls the incorporated PV module yield straightforwardly and quickly. The recreation chart of SPO has been represented in Figure 5.

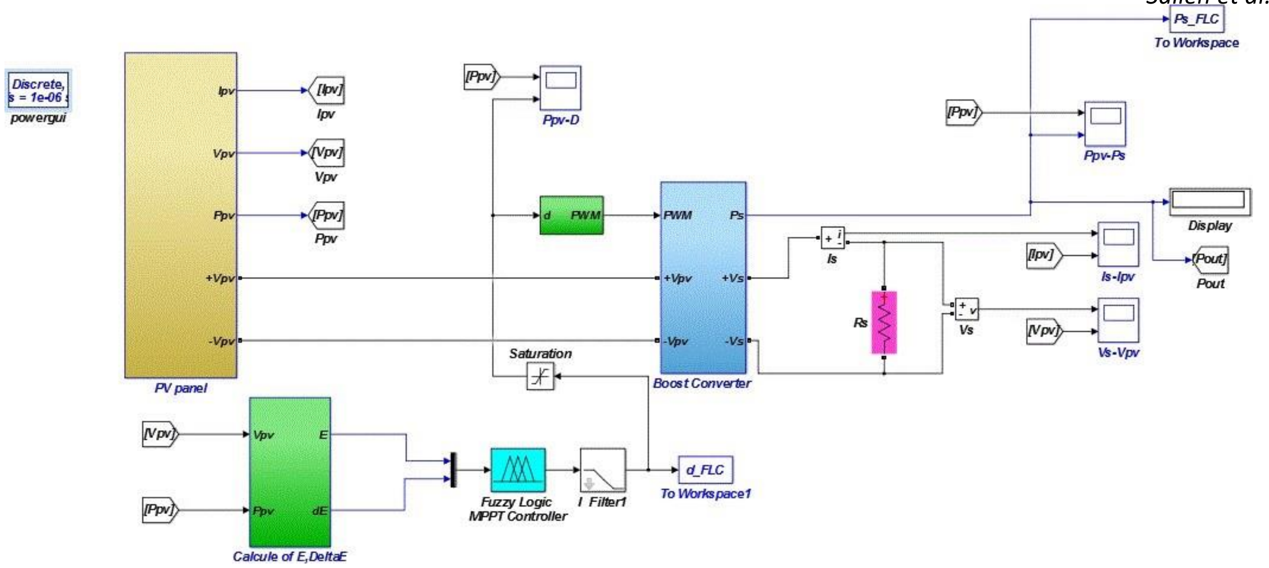

Fig. 5. Simulation diagram of SPO

By and large V-I attributes of a PV exhibit are non-direct so it is hard to follow the MPPT. The V-I attributes and P-V under fixed light and temperature conditions the obligation pattern of the DC chopper is shifted and the cycle is rehashed until the most extreme power point has been reached. The shut circle control of the solar power optimizer framework utilizing FLC. The yield voltage of the solar power optimizer got is 400 V. The info voltage is differed from 20 V to 40 V. Info current from 6 A to 7 A. Yield current from 0.5 A to 0.9A the yield voltage of the solar power optimizer is taken care of to the DC framework. The DC matrix voltage is kept up to be of 400 V by utilizing solar power optimizer. So the yield voltage is kept up continually at 400 V, whatever the info voltage.

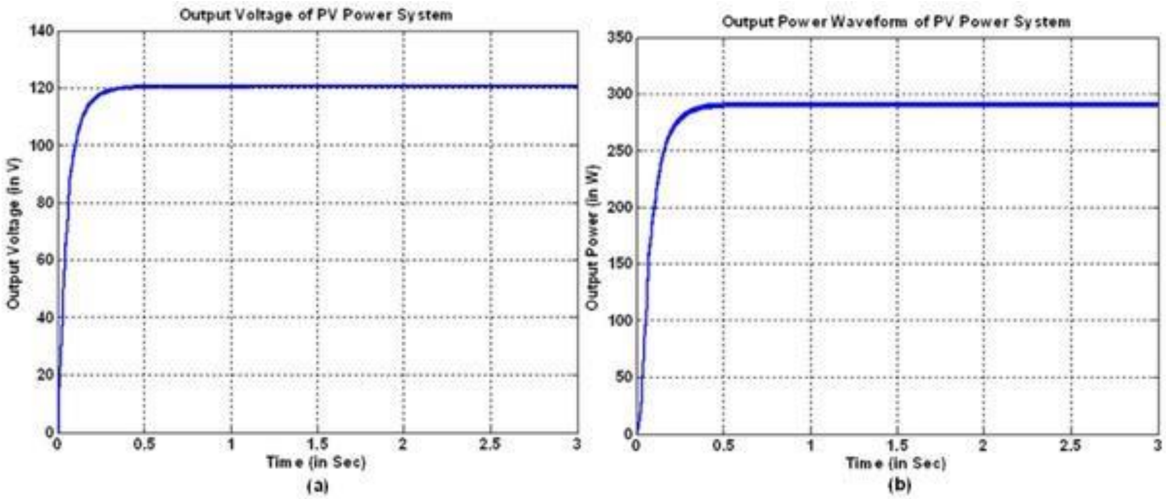

Fig. 6. Waveform of output voltage and output power

Table 2 Overall output power and efficiency

		Output power	Power loss	Total Efficiency
a) Constant rating of solar panel	For 1 table (42modules)	13.86 kWh	NIL	100%
	For 73 table (3066 modules)	1000 kWh	NIL	100%
b)Before installing solar power optimizer	Uncontrollable losses	860 kWh	2.0%	60%
	Controllable losses	878 kWh	0.9%	65%
c)After installing solar power optimizer	For 1 table	13.20 kWh	1.4%	80%
	For 73 table	950 kWh	0.5%	85%

4.1 Constant rating of solar panel

The total output power for 73 tables of solar modules is 1012 kWh. The total efficiency is 100%. This is the constant power and efficiency rating of solar panel.

4.2 Before installing the SPO

The total uncontrollable loss of output power for 73 tables of solar modules is 9089 kWh. The total controllable loss of output power for 73 tables of solar modules is 9106 kWh. For uncontrollable (climatic changes) power loss at solar power plant is 2%. For controllable (shades of clouds and leaves) power loss is 0.9%. The total output power for 73 tables of solar modules is 9106 kWh. The overall efficiency is reduced to 65%. There is a reduction in power due to some losses like hotspot, soiling and shading, climatic changes. To overcome these types of losses the power optimizer is fixed under each solar module. The SPO act as a boost up converter.

4.3 After installing the SPO

The power loss is reduced to 1.4% for uncontrollable losses (climatic changes). For controllable losses (hotspot, shades of cloud and leaves) it can be reduced to 0.5%. Hence power optimizer can boost up the overall output power is 1010 kWh and the overall efficiency of solar panel is 85%.

5 Conclusion

In this study, the Solar Power Optimizer (SPO) for a DC conveyance framework includes a boost converter which proficiently gathers greatest energy from a solar PV board. The regulator has been displayed utilizing Fuzzy Logic Controller (FLC). The reproduction and constant examinations have been made to uncover the advantages of the proposed model. The outcomes suggest that the power misfortune has been limited impressively in the wake of introducing the SPO. Besides the productivity of the solar PV framework has been expanded by 20% subsequent to consolidating SPO.

References

L. Gao, R. A. Dougal, S. Liu, and A. P. Iotova, "Parallel-Connected Solar PV System to Address Partial and Rapidly Fluctuating Shadow Conditions," IEEE Transactions on Industrial Electronics, vol. 56, no. 5, pp. 1548-1556, 2009.

W. Yu, J. J. Lai, H. Qian, and C. Hutchens, "High-Efficiency MOSFET Inverter with H6-Type Configuration for Photovoltaic Nonisolated AC-Module Applications," IEEE Transactions on Power Electronics, vol. 26, no. 4, pp. 1253-1260, 2011.

R. Gules, J. D. P. Pacheco, H. L. Hey, and J. Imhoff, "A Maximum Power Point Tracking System With Parallel Connection for PV Stand-Alone Applications," IEEE Transactions on Industrial Electronics, vol. 55, no. 7, pp. 2674-2683, 2008.

B. Liu, S. Duan, and T. Cai, "Photovoltaic DC-Building-Module-Based BIPV System—Concept and Design Considerations," IEEE Transactions on Power Electronics, vol. 26, no. 5, pp. 1418-1429, 2011.

W. Xiao, N. Ozog, and W. G. Dunford, "Topology Study of Photovoltaic Interface for Maximum Power Point Tracking," IEEE Transactions on Industrial Electronics, vol. 54, no. 3, pp. 1696-1704, 2007.

L. Zhang, K. Sun, Y. Xing, L. Feng, and H. Ge, "A Modular Grid-Connected Photovoltaic Generation System Based on DC Bus," IEEE Transactions on Power Electronics, vol. 26, no. 2, pp. 523-531, 2011.

S. Chen, K. Hu, T. Liang, Y. Hsieh, and L. Yang, "Implementation of high step-up solar power optimizer for DC micro grid application," in 2012 Twenty-Seventh Annual IEEE Applied Power Electronics Conference and Exposition (APEC), 2012, pp. 28-32.

A. Pratt, P. Kumar, and T. Aldridge, Evaluation of 400V DC distribution in telco and data centers to improve energy efficiency. 2007, pp. 32-39.

S. Chen, T. Liang, L. Yang, and J. Chen, "A Boost Converter With Capacitor Multiplier and Coupled Inductor for AC Module Applications," IEEE Transactions on Industrial Electronics, vol. 60, no. 4, pp. 1503-1511, 2013.

A. C. Nanakos, E. C. Tatakis, and N. P. Papanikolaou, "A Weighted-Efficiency-Oriented Design Methodology of Flyback Inverter for AC Photovoltaic Modules," IEEE Transactions on Power Electronics, vol. 27, no. 7, pp. 3221-3233, 2012.

O. Abutbul, A. Gherlitz, Y. Berkovich, and A. Ioinovici, "Step-up switching-mode converter with high voltage gain using a switched-capacitor circuit," IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications, vol. 50, no. 8, pp. 1098-1102, 2003.

B. Axelrod, Y. Berkovich, and A. Ioinovici, "Transformerless DC-DC converters with a very high DC line-to-load voltage ratio," in Proceedings of the 2003 International Symposium on Circuits and Systems, 2003. ISCAS '03., 2003, vol. 3, pp. III-III.

B. Axelrod, Y. Berkovich, and A. Ioinovici, "Switched-Capacitor/Switched-Inductor Structures for Getting Transformerless Hybrid DC–DC PWM Converters," IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 55, no. 2, pp. 687-696, 2008.

Z. Guangyong and A. Ioinovici, "Switched-capacitor power supplies: DC voltage ratio, efficiency, ripple, regulation," in 1996 IEEE International Symposium on Circuits and Systems. Circuits and Systems Connecting the World. ISCAS 96, 1996, vol. 1, pp. 553-556 vol.1.

F. L. Luo, "Switched-capacitorized DC/DC converters," in 2009 4th IEEE Conference on Industrial Electronics and Applications, 2009, pp. 1074-1079.

S. Tan, S. Bronstein, M. Nur, Y. M. Lai, A. Ioinovici, and C. K. Tse, "Variable Structure Modeling and Design of Switched-Capacitor Converters," IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 56, no. 9, pp. 2132-2142, 2009.

L. Yang, T. Liang, and J. Chen, "Transformerless DC–DC Converters With High Step-Up Voltage Gain," IEEE Transactions on Industrial Electronics, vol. 56, no. 8, pp. 3144-3152, 2009.

Bakhtiari, Reza, and Armen Adamian. "OPTIMIZATION AND APPLICATION OF SOLAR ABSORPTION CHILLER BY USING GA." International Journal of Mechanical Engineering (IJME) 8.5, Aug–Sep 2019; 17–24

Vijayanand, Y., et al. "New Multilevel Cascaded PWM Inverter Topology for Hybrid Electric Vehicle Drive." International Journal of Electrical and Electronics Engineering (IJEEE) 2.2: 27-40.

Narayan, Sunny, Ali Sulaiman Alsagri, and Vipul Gupta. "The design and analysis of hybrid automotive suspension system." International Journal of Mechanical and Production Engineering Research and Development 9.4 (2019): 637-642.

ASRORI, ASRORI, et al. "The Design and Performance Investigation Of Solar E-Bike Using Flexible Solar Panel by Different Battery Charging Controller." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD) 10.3 (2020): 14431-14442.

Susana, I. GEDE BAWA, I. B. Alit, and I. MADE Mara. "Optimization of corn drying with rice husk biomass energy conversion through heat exchange drying devices." International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), 9 (5) (2019): 1023-1032.