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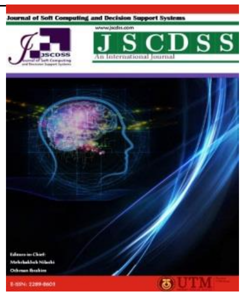

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An Intelligent Tracking Algorithm on Solar Cell Using Boost Converter

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Abstract

Solar energy can be regarded the most potent source of renewable energy as the globe shifts to renewable energy. The most prevalent device for generating electricity from light energy is solar photovoltaic cells. The final aim of this paper is to create a new Maximum Power Point Tracking (MPPT) approach based on a Fuzzy Logic Control (FLC) and a step up converter that can go Maximum Power Points (MPPs) rapidly, and adapt to changing environmental conditions. The simulation results indicated that the fuzzy tracking system can find the maximum point under quick sun radiation changing.

Keywords: Solar System; Fuzzy Logic Controller (FLC); DC to DC Step up Converter

1. Introduction

The globe is on the lookout for potential renewable and sustainable energy sources (Li et al., 2021). New sources of energy, including solar and wind have piqued the interest of experts in recent years since they are inexhaustible, non-polluting, and cost-free (Gopi, Lalitha, & Bhanu, 2021). Solar energy is becoming a more attractive source of energy due to significant improvements in efficiency and lower production costs of Photovoltaic (PV) cells (Rabaia et al., 2021). The Direct Current (DC) appliances require a converter to provide the appropriate DC voltage for their purposes (Sedaghati & Pourjafar, 2019). The step up converter is a converter that convert a lower voltage to a higher range (Sayed, Gronfula, & Ziedan, 2020). PV system is one of the applications that may necessitate the use of a boost converter. At least three factors influence the efficiency of PV modules: the efficiency of the module which is about 15%, inverter efficiency, and the tracking system efficiency (Motahhir, El Hammoumi, & El Ghzizal, 2020). Increasing the efficiency of solar panels and inverters is difficult and dependent on the available technology. However, improving the MPPT's control algorithm is easier and less expensive. The maximum power concept states that if the PV system's internal resistance is equal to its external resistance, the source will provide maximum power to the load (Aldalbahi, Shahabi, & Jasim, 2021; Bollipo, Mikkili, & Bonthagorla, 2020). There are numerous MPPT algorithm techniques. The complexity, accuracy, and time-to-response of these technologies vary one to another. To illustrate procedures for designing fuzzy controllers, a fuzzy control technique will be used in this article (Macaulay & Zhou, 2018; Taremi, Shahri, & Kalareh, 2019; Yousefiankalareh, Najari, & Hosseynzadeh, 2020). The simulation program MATLAB is used. The test results show that simulation graphics can display strong static and dynamic tracking effects by using FLC with a step up converter (Attou, Massoum, & Saidi, 2014).

2. PV system design

The PV system which is investigated in this paper is using a DC to DC step up and the FLC system (Balal & Shahabi, 2021b; Fathah, 2013).

A. Characteristics of the proposed PV system

Each PV system has its own features. Table 1 indicates the features of the proposed panel.

Table 1. Characteristics of the solar panel

Cells	96	Tilt angle	28°
Temperature	-40 - 85 °C	Latitude angle	27.93°
Panels	14	Longitude	-82.46°
Efficiency	14.8%	Azimuth	180° South
DC power	331 W	Frame	Al
V_{OC}	69 V	Weight	16.6 kg
I_{SC}	5.88 A	SIZE	(1.66 * 0.99) m
I_{MPP}	5.67 A	Type of module	Mono-Silicon
V_{MPP}	67 V	Mounting system	Fixed rack

As we can see from Table 1, the number of modules is 14, the efficiency of the system is 14.8 %, the short circuit current is 5.88 amperes and the rated DC power is about 331 watts.

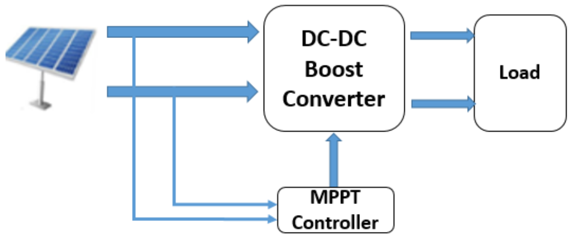

Fig. 1. The diagram of the presented approach

According to Fig. 1, the presented diagram has a step-up converter, a MPPT controller which track the best point of getting power with different sun radiation and ambient temperature. An equivalent circuit is demonstrated in Fig. 2. For a module, solar cells will be connected to one another to get the appropriate power from the sun (Numbi & Malinga, 2017). In addition, the amount of solar energy (photons) that strikes solar cell determines the current source.

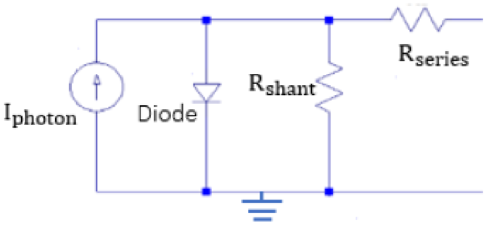

Fig. 2. A circuit diagram of a solar cell

Based on Fig. 2 and Eq. (1), the generated current can be calculated:

$$I = N_P I_{SH} - N_P I_S \left[\left(\frac{q\left(\frac{V}{N_S} + \frac{IR_S}{N_P}\right)}{KTA} \right) - 1 \right] - \frac{\left(\frac{N_P V}{N_S} + IR_S\right)}{R_{SH}} \quad (1)$$

Based on above equation, the resistances of the cell's model is series resistance R_S as well as parallel resistance R_{SH}, which must be lower and higher respectively. As it is obvious the temperature of the ambient is also matter in this calculation and the diode in the model represents the breakdown voltage of junction of the cell (Balal & Shahabi, 2021a; Salmi, Bouzguenda, Gastli, & Masmoudi, 2012). Fig. 3 indicates the I-V and P-V curve of the presented system.

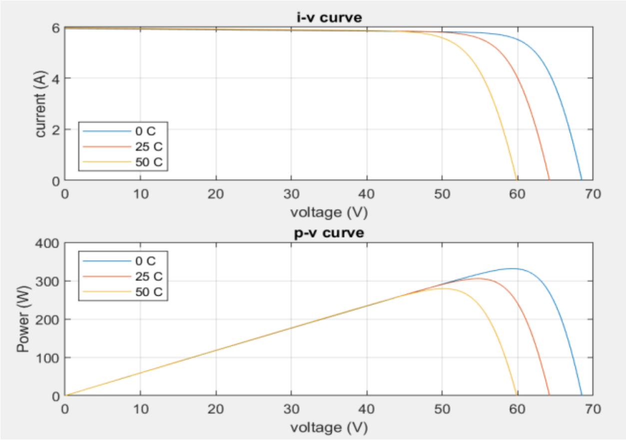

Fig. 3. I-V and P-V characteristics of the presented module.

The sun radiation and cell temperature changes will impact the form of the I-V curve as well as the voltage and power of the MPP (Awasthi et al., 2020). As a result, a novel and promising method is employed in order to solve this challenge. One method is to utilize a fuzzy controller. The ability to work without sensors is a benefit of fuzzy logic controllers In addition, in Hybrid Electric Vehicles (HEV), by using FLC, the amount of solar energy which feeds the batteries will be much higher (Balal & Herrera, 2021).

B. FLC system

Fuzzy logic-based solutions have lately been employed to tackle control difficulties. Fuzzy logic control allows for non-linear computations with erroneous inputs, making it ideal for a variety of climatic fluctuations. It is feasible to decrease power losses by using fuzzy algorithms that are not dependent on the physical properties of solar cells and do not require temperature or light intensity sensors. Fuzzification, execution of all relevant rules in the rule base, and de-fuzzification are all steps in the fuzzy logic control process (Kim, Huh, & Ko, 2020). The first step is called fuzzification, and it turns input variables with true values into a fuzzy set. The second part is called the fuzzy inference engine, and it expresses fuzzy IF-THEN rules. The third part is called de-fuzzification, and it converts a fuzzy set back to a real variable. According to the P-V diagram, the maximum power point has an important property of $\frac{dp}{dv} = 0$. Also, the voltages of the points having the property of $\frac{dp}{dv} > 0$, are lower than (MP), and $\frac{dp}{dv} < 0$ are more than (MP) (Ajiatmo & Robandi, 2016). The following variables are created for this purpose:

$$E(t) = \frac{P_{PV}(t) - P_{PV}(t-1)}{V_{PV}(t) - V_{PV}(t-1)} \quad (2)$$

$$CE(t) = E(t) - E(t-1) \quad (3)$$

In Eq. (2) and Eq. (3), inputs are E(t) and CE(t). In Fig. 4, the duty cycle of the system coming from the FLC can be realized and the equation below explain the behavior of the

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whole system. Therefore, $CD(t) = D(t) - D(T-1)$ can be determined (Ali, Mahmoud, Lehtonen, & Darwish, 2021; Rubio, Berenguel, & Camacho, 1995).

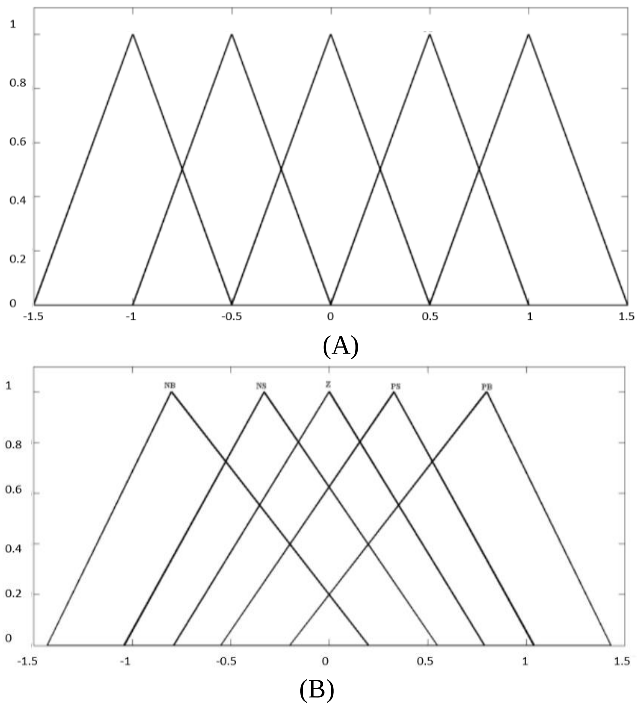

Fig. 4. A: Members of inputs E & CE, B: Fuzzy membership functions after applying to the system

In this system, the triangular membership function has been used for both the input and the output of the system. the Mamdani inference engine, the center average defuzzifier, and the singleton fuzzifier have been used. According to Fig. 4, at the beginning, these parameters must be in the range of applied changes through the whole fuzzy system (Seguel & Seleme, 2021).

Table 2: fuzzy rule base

	NB	NS	ZZ	PS	PB
NB	ZZ	PS	PB	PB	PB
NS	NS	ZZ	PS	PB	PB
ZZ	NB	NS	ZZ	PS	PB
PS	NB	NB	NS	ZZ	PS
PB	NB	NB	NB	NS	ZZ

Based on Table 2, the parameters contain all the values which have to be in the range of the changes in FLC (Kelareh, Shahri, Khoshnevis, & Valikhani, 2020; Setnes, Babuska, Kaymak, & van Nauta Lemke, 1998).

3. Simulation and results

The output power of panels is simulated using fuzzy algorithm. It is obvious that there is a fewer oscillation in the fuzzy system. Therefore, there will be lower power losses because of the lower fluctuation. Fig. 5 demonstrates the DC voltage of the reference and the actual.

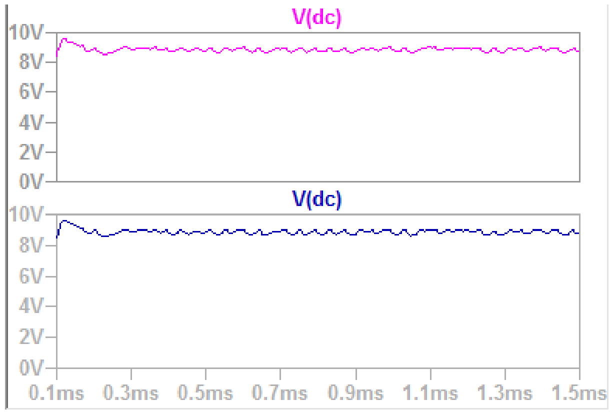

Fig. 5. Following the reference waveform by the output generated waveform

In Fig. 5, the bottom waveform is the reference voltage and the top waveform is the actual output DC voltage. the proposed technique is evaluated by progressively increasing irradiance from 600 W/m2 to 800 W/m2 and then returning to 600 W/m2. According to the findings, the proposed FLC may be employed with the MPPT algorithm and can quickly react to changing irradiation.

4. Conclusion

This paper presents a new way for extracting MPPs under changing conditions using an MPPT-based fuzzy logic controller to match the reference output of the solar panel. Then, to maintain the output voltage waveform consistent with the reference voltage input, a FLC is employed in conjunction with a step up voltage converter. The findings demonstrated that this new method can reliably identify the maximum operated points with a lower time under rapid irradiance fluctuations.

References

Ajiatmo, D., & Robandi, I. (2016). *A hybrid Fuzzy Logic Controller-Firefly Algorithm (FLC-FA) based for MPPT Photovoltaic (PV) system in solar car.* Paper presented at the 2016 IEEE International Conference on Power and Renewable Energy (ICPRE).

Aldalbahi, A., Shahabi, F., & Jasim, M. (2021). BRNN-LSTM for Initial Access in Millimeter Wave Communications. *Electronics, 10*(13), 1505.

Ali, M. N., Mahmoud, K., Lehtonen, M., & Darwish, M. M. (2021). An efficient fuzzy-logic based variable-step incremental conductance MPPT method for grid-connected PV systems. *IEEE Access, 9*, 26420-26430.

Attou, A., Massoum, A., & Saidi, M. (2014). Photovoltaic power control using MPPT and boost converter. *Balkan journal of electrical & Computer Engineering, 2*(1), 23-27.

An International Journal JSCDSS E-ISSN: 2289-8603

Awasthi, A., Shukla, A. K., SR, M. M., Dondariya, C., Shukla, K., Porwal, D., & Richhariya, G. (2020). Review on sun tracking technology in solar PV system. *Energy Reports, 6*, 392-405.

Balal, A., & Herrera, M. (2021). *Design a Power Converter to Charge a Hybrid Electric Vehicle.* Paper presented at the 2021 IEEE 18th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET).

Balal, A., & Shahabi, F. (2021a). *Designing and Simulation a Reliable Standalone Solar/wind Hybrid System.* Paper presented at the 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT).

Balal, A., & Shahabi, F. (2021b). *Ltspice Analysis of Double-Inductor Quadratic Boost Converter in Comparison with Quadratic Boost and Double Cascaded Boost Converter.* Paper presented at the 2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT).

Bollipo, R. B., Mikkili, S., & Bonthagorla, P. K. (2020). Critical review on PV MPPT techniques: classical, intelligent and optimisation. *IET Renewable Power Generation, 14*(9), 1433-1452.

Fathah, A. (2013). *Design of a Boost Converter.*

Gopi, P., Lalitha, M. P., & Bhanu, S. A. J. (2021). *A wind and solar based ac micro grid with optimized power quality for local non-linear loads.* Paper presented at the 2021 International Conference on Technology and Policy in Energy and Electric Power (ICT-PEP).

Kelareh, A. Y., Shahri, P. K., Khoshnevis, S. A., & Valikhani, A. (2020). *System Response Processing and HHT Method on Dynamic Specification Determination using Cloud Computation.* Paper presented at the 2020 IEEE 17th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET).

Kim, J.-C., Huh, J.-H., & Ko, J.-S. (2020). Optimization design and test bed of fuzzy control rule base for PV system MPPT in micro grid. *Sustainability, 12*(9), 3763.

Li, Q., Cherian, J., Shabbir, M. S., Sial, M. S., Li, J., Mester, I., & Badulescu, A. (2021). Exploring the relationship between renewable energy sources and economic growth. The case of SAARC countries. *Energies, 14*(3), 520.

Macaulay, J., & Zhou, Z. (2018). A fuzzy logical-based variable step size P&O MPPT algorithm for photovoltaic system. *Energies, 11*(6), 1340.

Motahhir, S., El Hammoumi, A., & El Ghzizal, A. (2020). The most used MPPT algorithms: Review and the suitable low-cost embedded board for each algorithm. *Journal of cleaner production, 246*, 118983.

Numbi, B., & Malinga, S. (2017). Optimal energy cost and economic analysis of a residential grid-interactive solar PV system-case of eThekwini municipality in South Africa. *Applied Energy, 186*, 28-45.

Rabaia, M. K. H., Abdelkareem, M. A., Sayed, E. T., Elsaid, K., Chae, K.-J., Wilberforce, T., & Olabi, A. (2021). Environmental impacts of solar energy systems: A review. *Science of The Total Environment, 754*, 141989.

Rubio, F. R., Berenguel, M., & Camacho, E. F. (1995). Fuzzy logic control of a solar power plant. *IEEE transactions on fuzzy systems, 3*(4), 459-468.

Salmi, T., Bouzguenda, M., Gastli, A., & Masmoudi, A. (2012). Matlab/simulink based modeling of photovoltaic cell. *International Journal of Renewable Energy Research (IJRER), 2*(2), 213-218.

Sayed, K., Gronfula, M. G., & Ziedan, H. A. (2020). Novel soft-switching integrated boost DC-DC converter for PV power system. *Energies, 13*(3), 749.

Sedaghati, F., & Pourjafar, S. (2019). Analysis and implementation of a boost DC–DC converter with high voltage gain and continuous input current. *IET Power Electronics, 13*(4), 798-807.

Seguel, J. L., & Seleme, S. I. (2021). Robust Digital Control Strategy Based on Fuzzy Logic for a Solar Charger of VRLA Batteries. *Energies, 14*(4), 1001.

Setnes, M., Babuska, R., Kaymak, U., & van Nauta Lemke, H. R. (1998). Similarity measures in fuzzy rule base simplification. *IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 28*(3), 376-386.

Taremi, R. S., Shahri, P. K., & Kalareh, A. Y. (2019). Design a tracking control law for the nonlinear continuous time fuzzy polynomial systems. *Journal of Soft Computing and Decision Support Systems, 6*(6), 21-27.

Yousefiankalareh, A., Najari, A., & Hosseynzadeh, M. (2020). *Tree-based Routing Protocol in Wireless Sensor Networks using Optimization Algorithm Batch Particles with a Mobile Sink.* Paper presented at the 2020 IEEE 17th International Conference on Smart Communities: Improving Quality of Life Using ICT, IoT and AI (HONET).

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