iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VI **Month of publication:** June 2022

DOI: https://doi.org/10.22214/ijraset.2022.44410

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

Performance Comparison of FLC MPPT with P & O and Incremental Conductance MPPT For standalone PV System

G. Chandini[1], K. Nikhila[2], E. Hanumanth Reddy[3], D. Kazol[4], A. Amruth Kumar[5], Dr. N. Narasimhulu[6]
[1, 2, 3, 4, 5]*Department of EEE, SRIT, ANANTHAPURAMU, AP, INDIA*

Abstract: Solar energy is one of the most important renewable energy sources. Photovoltaic power is one of the main ways of solar energy utilization, has the characteristics of environmentally-friendly and non-polluting, application range is very wide, has now been used in communication, transportation and other fields, has a place in the national economy energy system. However, the use of the solar energy is deeply influenced by the terrain, topography, position, weather and any other natural conditions, and has the problem about intermittence, sunlight direction and intensity changing along with the time, so it requires a higher request of collecting and using solar energy. In this paper, Fuzzy Logic Control (FLC)based MPPT is adopted for extraction of maximum power from PV panel and its performance is compared with P & O and InC algorithm for tracking a MPP on the V-I characteristic of the solar PV panel. The simulation results can be validated the effectiveness of the proposed work under various atmospheric conditions using Matlab Simulink software.

I. INTRODUCTION

There is no end to the power that the sun provides.The sun is the primary source of most of the energy on Earth.. Every year, about 1.8 × 1018 kWh of energy is radiated from the sun to Earth, that is about 10 thousand times more than Earth's power consumption. In recent years, the use of photovoltaic (PV) energy has become a worldwide phenomenon.

PV inverters are an essential component of the power system because they are responsible for transforming the direct current (DC) produced by PV power generation devices (like solar panels) into an alternating current (AC) that is compatible with the utility frequency and can be used by grid-connected or off-grid users [2].As a result, photovoltaic inverters are the essential component of every PV power generation system (grid-connected or off-grid).Because the quality of the output current of a PV inverter is considered to be an important inverter standard, the control strategy for inverter systems has been researched in order to guarantee the desired output quality[3, 4].In addition, in order to maximize the effectiveness of a photovoltaic (PV) inverter's operation, the inverter's output current should be synchronized with the reference currents that are derived from the Maximum Power Point Tracking (MPPT) module.

The grid-connected PV inverter system control problem has been of significant interest to researchers over the past few decades as a result of the continuously rising demand for solar energy over that time period.On the other hand, the large weather swings mean that the amount of sunlight is difficult to predict, and the dispersed installation of solar panels makes it difficult to identify when there is a problem with the system. Because of these factors, it will be difficult to maintain control of the PV inverters and ensure that they continue to function effectively. As a direct consequence of this, increasing the dependability of photovoltaic inverter systems has become a significant focus of research. One of the primary worries in the power industry is that the daily demand for electricity is rising, but there are not enough resources available to satisfy that demand using traditional forms of energy. This is one of the most significant challenges facing the industry. In order to satisfy the need for energy, there has been an increase in the demand for conventional energy generation systems to work in conjunction with renewable energy sources. In this context, the primary energy sources that are being utilized are renewable sources such as wind energy and solar energy. The consistent consumption of fossil fuels has led to a depletion of the biosphere and has had a profound impact on the environment, causing the amount of fossil fuel deposits to decrease. This has, in turn, contributed to the acceleration of global warming. Because solar energy is readily available in such large quantities, it has recently become feasible to collect it and put it to productive use. Depending on the proximity of an existing power grid, solar energy generation can take the form of either a self-contained unit or a unit that is connected to the grid. As a result, it can be utilised to provide power to rural areas, where the availability of grids is very limited. Using solar energy also has the additional benefit of being portable, so it can be utilised whenever and wherever it is required.

One of the first things that need to be done in order to find a solution to the current energy crisis is to devise a method that is both effective and efficient for drawing power from the sun's incoming radiation. Over the course of the past few years, the size of the power conversion mechanisms has been significantly reduced. Engineers have been able to create very compact yet powerful systems to withstand the high power demand as a result of developments in the fields of power electronics and material science. But the increased power density that these systems produce is a drawback of using them. The use of multi-input converter units that are capable of effectively managing the voltage fluctuations has become increasingly popular recently. However, because of the high production costs and the low efficiency of these systems, they are not able to compete very well in the competitive markets as a primary source of electricity generation.
The consistently accelerating development of the technology used to manufacture solar cells will unquestionably make it possible for these technologies to be implemented on a much more extensive scale than is the case in the current scenario. The implementation of the most recent power control mechanisms, which are referred to as Maximum Power Point Tracking (MPPT) algorithms, has resulted in an increase in the effectiveness of the operation of solar modules, and as a result, it is efficient in the field of the utilization of energy that comes from renewable sources [3], [8].

II. SOLAR PHOTOVOLTAIC

Photovoltaic (PV) represents a very important and promising energy source because it provides very clean energy without having any effect on the environment. This makes it one of the most promising of all the renewable energy sources. Sunlight, which makes up the solar energy supply, is a source of energy that is both abundant and cost-free. However, as of right now, solar photovoltaic (PV) modules have a relatively low efficiency level when compared not only to the efficiency of conventional fossil fuel but also to the efficiency of other renewable energy sources such as wind or hydro [1–4]. This is due to the fact that solar energy is still in its infancy as an energy source. It is considered to be a very hot development area to improve the efficiency of PV systems by tracking the global maximum power from PV systems both with and without partial shading conditions.
In order to achieve high voltage and current output, a PV module is constructed out of PV cells connected in series and parallel. The common technologies for photovoltaic cells can be broken down into four categories: multi-crystalline, mono-crystalline, thin-film, and multi-junction PV cells. Each different type of photovoltaic cell technology has its own distinct manufacturing process and set of properties. PV models are utilized in order to draw conclusions regarding the output PV characteristics under a variety of irradiance and temperature conditions for the purpose of investigating and studying the performance of the PV system. In most cases, the photovoltaic (PV) model will include a photocurrent source, diodes, and resistors.
Single- and double-diode models are by far the most common types of photovoltaic systems [5]. PV current, diode saturation current, ideality factor, series resistance, and parallel resistance are the five parameters that make up the single-diode model. The PV current is the most important of these parameters.In contrast to the two-diode PV model, which has an additional parallel diode to compensate for recombination losses in the depletion region, this PV model has acceptable accurate PV model estimation and low computation cost [6]. The saturation current of the diode and the ideality factor are two additional parameters that are not known. On the other hand, a three-diode PV model is suggested as a solution to the problem of leakage current caused by the periphery being connected to the PV cell while the measurement is being done [7].
In order to create electricity, a solar photovoltaic panel is utilized. A real diode connected in parallel with an ideal current source constitutes a straightforward representation of a solar photovoltaic (PV) cell's equivalent circuit.
The following equations provide a mathematical representation of the photovoltaic (PV) cell used in solar energy generation.

$$I = I_{SC} - I_0(e^{\frac{qv}{kT}} - 1) \tag{1}$$

$$V_{oc} = \frac{kT}{q}\ln\left(\frac{I_{SC}}{I_0} + 1\right) \tag{2}$$

$$P = V \times I = VI_{sc} - VI_0\left(e^{\frac{qv}{kT}} - 1\right) \tag{3}$$

Where, I is the current of solar PV cell (A), V is the voltage of the solar PV cell (V), P is the power of the solar PV cell (W), I_{SC} is the short circuit current of the solar PV cell (A), V_{oc} is the open-circuit voltage of the solar PV cell (V), I_0 is the reverse saturation current (A), q is the electron charge, $= 1.602 \times 10^{-19}\ (C)$, k is the Boltzmann's constant, $k = 1.381 \times 10^{-23}\ (J/K)$ and T is the panel temperature (K).

It has been discovered that solar photovoltaic panels are extremely sensitive to the effects of shading. Because of this, an equivalent circuit that is more accurate for the solar PV cell has been presented. This circuit takes into account the impact that shading has, as well as losses that are caused by the cell's internal series resistance, contacts, and interconnections between cells and modules.The V-I property of the photovoltaic (PV) cell can be represented by the equation (4)

$$I = I_{SC} - I_0\left(e^{\frac{q(V+IR_S)}{kT}} - 1\right) - \left(\frac{V+IR_S}{R_p}\right) \tag{4}$$

Where, $R_s$and R_p are the resistances used to consider the impact of shading and losses. In spite of the fact that manufacturers work hard to improve their wares by reducing the impact of both types of resistance, they are unable to achieve the ideal situation. At a point along the V-I characteristic of the solar PV cell where the product (V multiplied by I) is at its highest, the cell produces the most amount of power. This particular point is singular and is referred to as the MPP. Irradiation and temperature are, without a doubt, two critical aspects that must be taken into consideration in the process of calculating the amount of electricity that can be produced by a solar photovoltaic panel. These factors have a significant impact on the properties of solar photovoltaic panels. Therefore, the solar PV panel needs to be oriented such that it is perpendicular to the sunlight in order to obtain the maximum amount of irradiation. In addition, as a consequence of this, the MPP shifts throughout the day, and it is essential for the solar PV panel to track the MPP in all conditions in order to guarantee that the maximum amount of available power is obtained. The MPPT algorithms are responsible for searching for and determining MPPs under a variety of different conditions in order to solve this problem.

It is absolutely necessary to carry out the measurements in accordance with the standard test conditions in order to obtain accurate readings of the I-V characteristics (STC).This means that the total irradiance on the solar cell that should be measured is equal to 1000 W/m^2. Additionally, the temperature of the solar cell should be kept constant at 25 °C.

III. MAXIMUM POWER POINT TRACKING

A maximum power point tracking controller, or MPPT controller, is a type of controller that monitors the maximum power point locus of a photovoltaic array. There are a few common maximum power point tracking algorithms that have been discussed here, and there are a few different algorithms that can track the MPP. In order to ensure the most efficient operation, the line of the load must be aligned with the MPP locus of the PV array. Furthermore, if the load in question does not consume the maximum amount of power, a power conditioner should be installed between the array and the load.

The fuzzy logic controller (FLC) utilizes the selected fuzzy relationship in order to map the significant and measurable variables to the controlled variables when performing a control task. After being processed, the defuzzification output is typically passed back to the fuzzification interference in the form of crisp or non-fuzzy input. Error and variations in error are mapped with fuzzy sections, and these are included in the crisp input. The output variables that have been manipulated are made available at the defuzzification stage for use as input to the process.

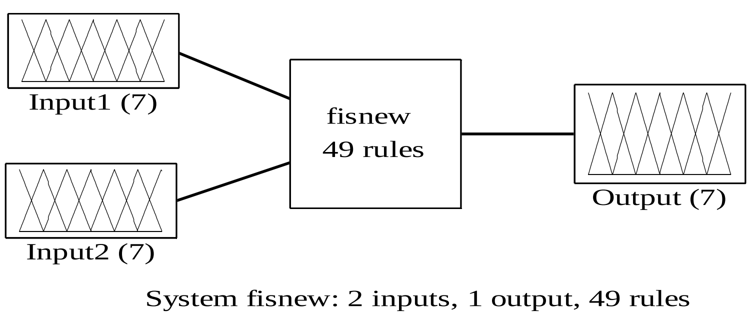


Fig.1: FLC membership functions (MF) with two input and single output

IV. SIMULATION RESULTS AND DISCUSSION

In this section, detailed simulation results of the proposed solar photovoltaic system using improved InC MPPT will be presented and compared with those of conventional MPPT.The software MATLAB/SIMULINK is used to run simulations in order to track the maximum power points of the solar PV array. The array's parameters and specifications can be found in Table1.

Table 1: Simulation parameters

S. No.	Description	Values
1.	Maximum power, P_{max}	22 W
2.	Short-circuit current, *Is* c	1.34 A
3.	Open-circuit voltage, *Voc*	21.99 V

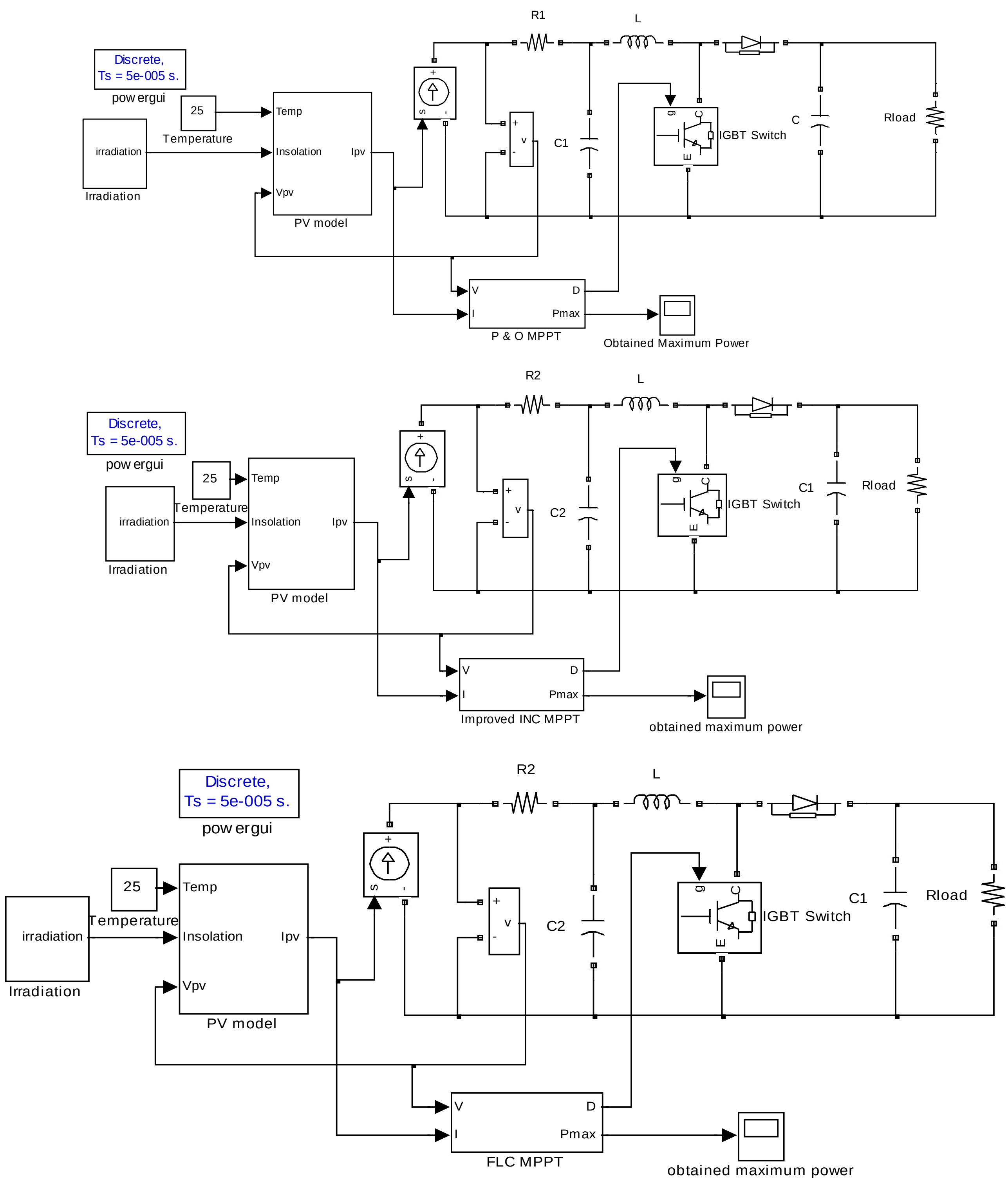


Fig.2: Matlab Simulink model for solar PV system

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

The solar PV panel provides a maximum output power at a MPP with V_{MPP} and I_{MPP}. The MPP is defined at the standard test condition of the irradiation,1 kW/m^{2}and module temperature, 25°C but this condition does not exist most of the time. The following simulations are implemented to confirm the effectiveness of the FLC which is compared with those of the InC, improved InC algorithm and P&O algorithms. Matlab Simulink block diagram is shown in Fig, 2.

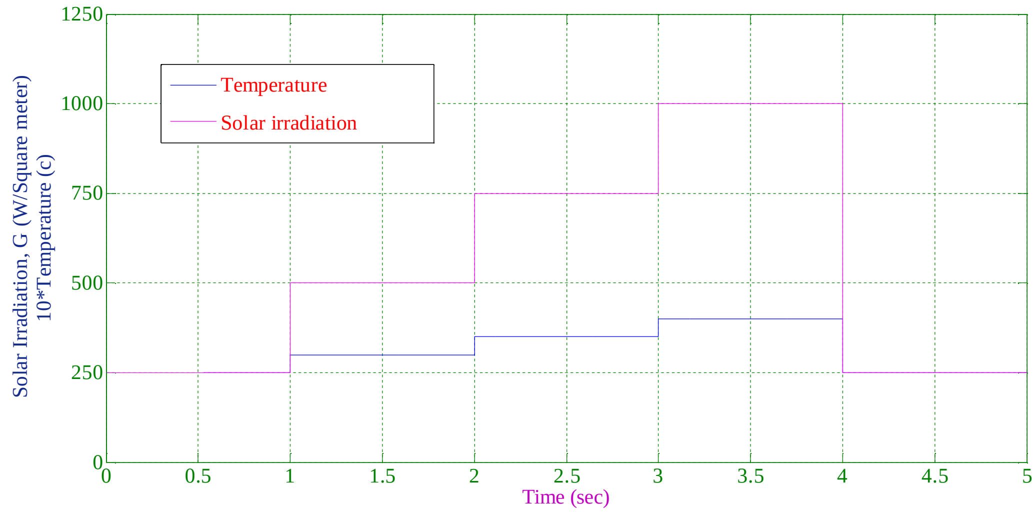


Fig.3: The variations of the solar irradiation and temperature

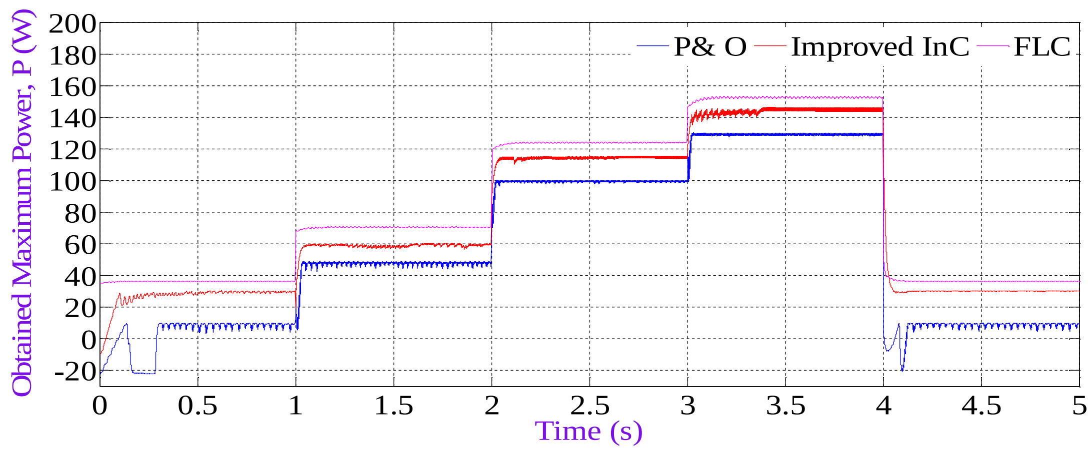


Fig.4: OMP with the P&O, improved InCalgorithms and FLC under the variation of the solar irradiation

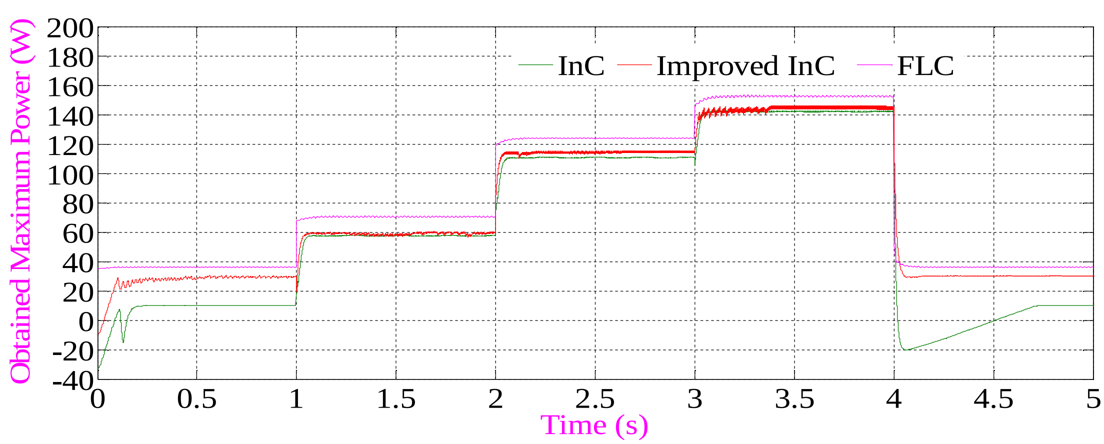


Fig.5: OMP with the InC and improved InC algorithms under the variation of the solar irradiation

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

The obtained output powers are shown as in Fig. 4, Fig.5, Fig.6 & Fig.7 using the P&O, InC, improved InC algorithms and FLC under the variation of both the temperature and solar irradiation. It can be realized that the simulation results of the cases using the FLC are always better than the cases using the P&O, InC algorithms, and improved InC algorithm FLC. The better results are shown through the algorithm convergence and the MPPs' tracking ability, especially with the rapid variation of both the temperature and solar irradiation. This means that the drawbacks of the InC algorithm have been overcome using the proposed FLC algorithm.

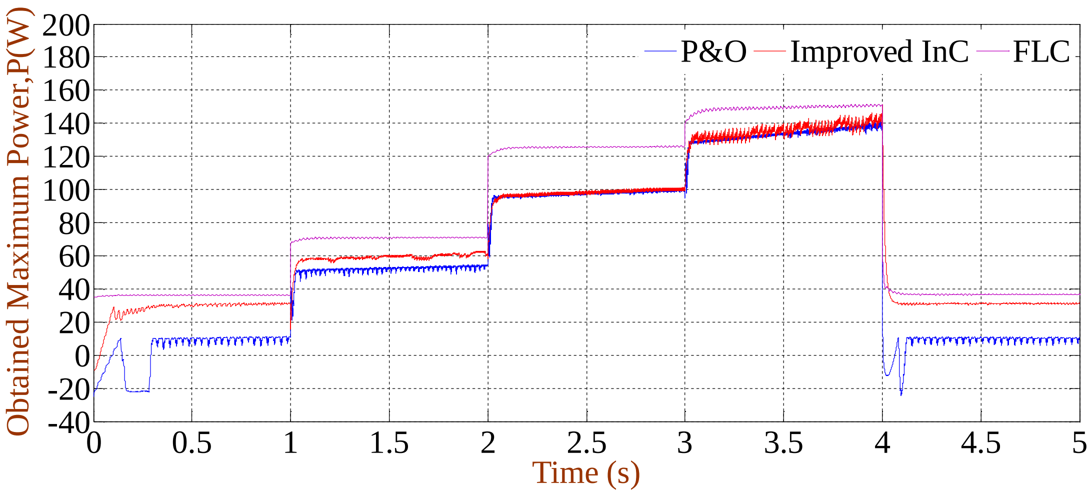


Fig.6: OMP with the P&O and improved InC algorithms under both the variations of the solar irradiation and temperature

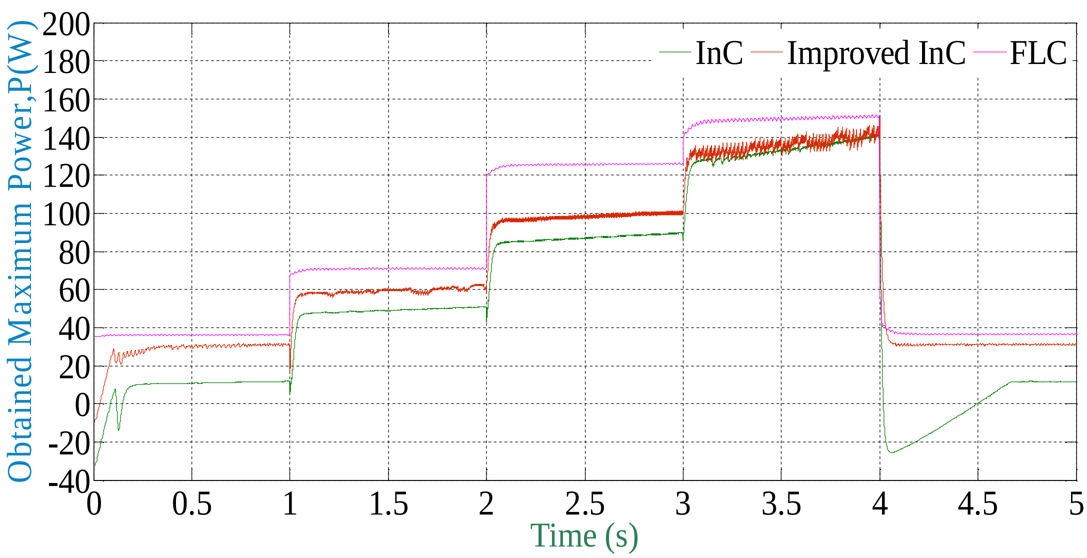


Fig.7: OMP with the InC and improved InC algorithms under both the variations of the solar irradiation and temperature

V. CONCLUSION

In the work being presented here, the adaptive and optimal control strategy is given a significant part to play in the process of developing solar PV systems. This strategy is based on the combination of the ST and the MPPT in order to ensure that the solar PV panel is capable of capturing the maximum amount of solar energy following the trajectory of the sun from dawn until dusk and is always operated at the MPPs with an improved algorithm for the inductance control. This strategy was developed in order to ensure that the solar PV panel was able to do so. The conventional InC algorithm is made better by the proposed InC algorithm thanks to an approximation that reduces the computational burden, as well as the application of the CV algorithm to limit the search space and increase the convergence speed of the InC algorithm. Both of these improvements were made possible by combining the two algorithms. This enhancement eliminates the deficiencies that were previously present in the InC algorithm. Validation of the FLC control strategy in the solar PV panel was accomplished through simulation studies by comparing it to various other control strategies.

REFERENCES

[1] G. M. Master, “Renewable and efficient electric power systems,” in Renewable and Efficient Electric Power Systems. New York, NY, USA: Wiley, 2004, pp. 385–604.

[2] B. Liu, S. Duan, F. Liu, and P. Xu, “Analysis and improvement of maximum power point tracking algorithm based on incremental conductance method for photovoltaic array,” in Proc. 7th Int. Conf. Power Electron.Drive Syst., 2007, pp. 637–641.

[3] W. Ping, D. Hui, D. Changyu, and Q. Shengbiao, “An improved MPPT algorithm based on traditional incremental conductance method,” in Proc.4th Int. Conf. Power Electron. Syst. Appl., 2011, pp. 1–4.

[4] Y. Zhihao and W. Xiaobo, “Compensation loop design of a photovoltaic system based on constant voltage MPPT,” in Proc. Asia-Pacific Power Energy Eng. Conf., 2009, pp. 1–4.

[5] K. A. Aganah and A. W. Leedy, “A constant voltage maximum power point tracking method for solar powered systems,” in Proc. IEEE 43rd Southeastern Symp. Syst. Theory, 2011, pp. 125–130.

[6] J. H. R. Enslin, M. S. Wolf, D. B. Snyman, and W. Sweigers, “Integrated photovoltaic maximum power point tracking converter,” IEEE Trans. Ind. Electron., vol. 44, no. 6, pp. 769–773, Dec. 1997.

[7] R. Faranda and S. Leva, “Energy comparison of MPPT techniques for PV systems,” WSES Trans. Power Syst., vol. 3, no. 6, pp. 446–455, 2008.

[8] X. Jun-Ming, J. Ling-Yun, Z. Hai-Ming, and Z. Rui, “Design of track control system in PV,” in Proc. IEEE Int. Conf. Softw. Eng. Service Sci., 2010, pp. 547–550.

[9] Z. Bao-Jian, G. Guo-Hong, and Z. Yan-Li, “Designment of automatic tracking system of solar energy system,” in Proc. 2nd Int. Conf. Ind. Mechatronics Autom., 2010, pp. 689–691.

[10] W. Luo, “A solar panels automatic tracking system based on OMRON PLC,” in Proc. 7th Asian Control Conf., 2009, pp. 1611–1614.

[11] R. Sridhar, S. Jeevananthan, N. T. Selvan, and P. V. SujithChowdary, “Performance improvement of a photovoltaic array using MPPT P&O technique,” in Proc. Int. Conf. Control Comput. Technol., 2010, pp. 191– 195.

[12] L. Chun-Xia and L. Li-qun, “An improved perturbation and observation MPPT method of photovoltaic generates system,” in Proc. 4th IEEE Conf.Ind. Electron. Appl., 2009, pp. 2966–2970.

[13] Y. Jung, J. So, G. Yu, and J. Choi, “Improved perturbation and observation method (IP&O) ofMPPT control for photovoltaic power systems,” in Proc. 31st IEEE Photov. Spec. Conf., 2005, pp. 1788–1791.

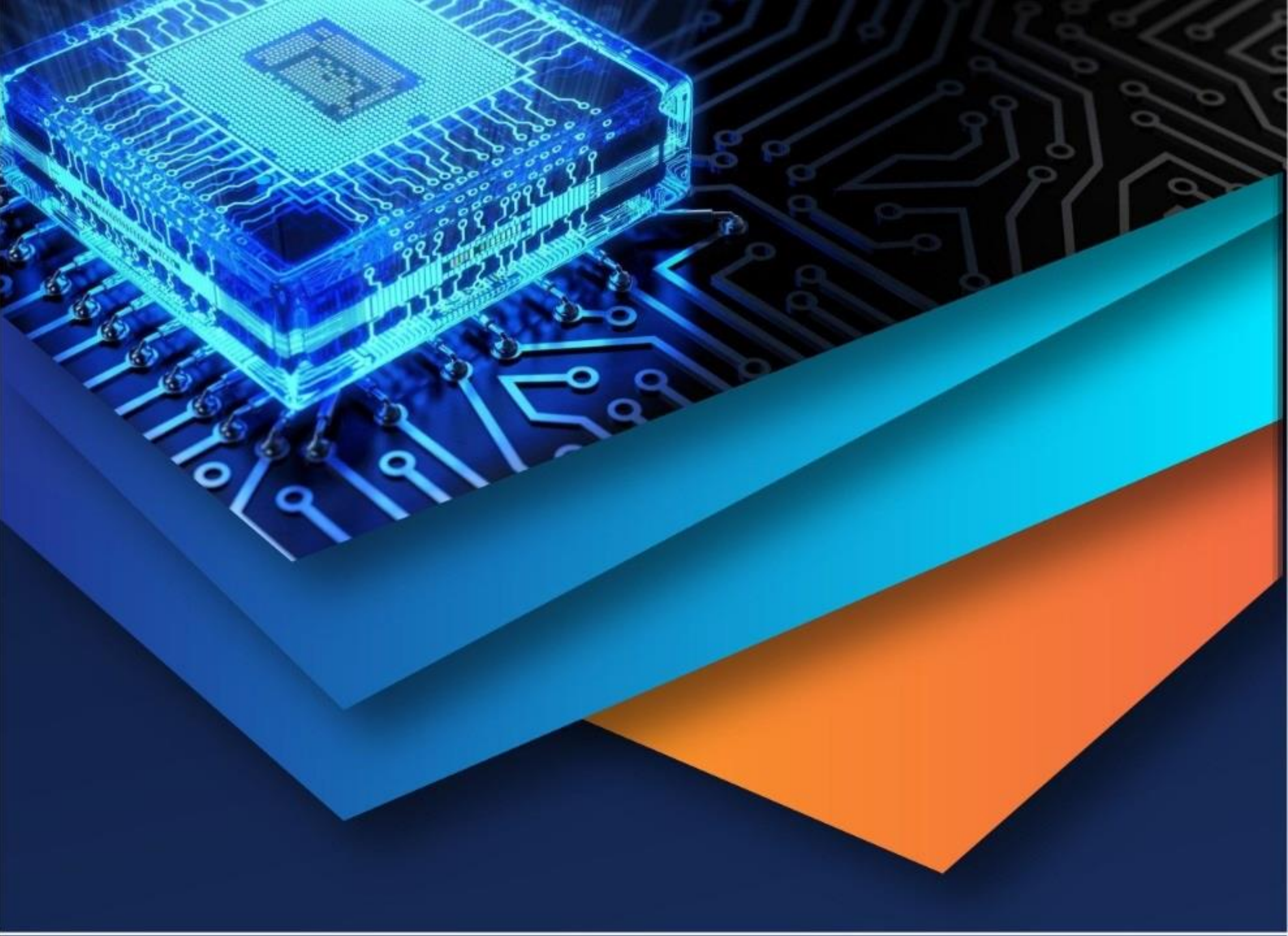
[14] X. Liu and L. A. C. Lopes, “An improved perturbation and observation maximum power point tracking algorithm for PV arrays,” in Proc. IEEE 35th Annu. Power Electron. Spec. Conf., 2004, pp. 2005–2010.

[15] D. C. Huynh, T. A. T. Nguyen, M. W. Dunnigan, and M. A. Mueller, “Maximum power point tracking of solar photovoltaic panels using advanced perturbation and observation algorithm,” in Proc. IEEE Conf. Ind. Electron. Appl., 2013, pp. 864–869.

[16] B. Liu, S. Duan, F. Liu, and P. Xu, “Analysis and improvement of maximum power point tracking algorithm based on incremental conductance method for photovoltaic array,” in Proc. 7th Int. Conf. Power Electron.Drive Syst., 2007, pp. 637–641.

[17] W. Ping, D. Hui, D. Changyu, and Q. Shengbiao, “An improved MPPT algorithm based on traditional incremental conductance method,” in Proc.4th Int. Conf. Power Electron. Syst. Appl., 2011, pp. 1–4

[18] P. Q. Dzung, L. D. Khoa, H. H. Lee, L. M. Phuong, and N. T. D. Vu, “The new MPPT algorithm using ANN based PV,” in Proc. Int. ForumStrategic Technol., 2010, pp. 402–407.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429