Volume 7, Issue 5, pp. 40-43, 2023.
International Journal of Scientific Engineering and Science
ISSN (Online): 2456-7361

Optimization of MPPT and UPF in Grid Connected PV System

Sandeep kumar[1*], V.K. Giri[2**]
[1,2]Electrical Engineering Department, Madan Mohan Malaviya University of Technology. Gorakhpur (U.P). INDIA 273010

***Abstract*— *AN inverter is used in photovoltaic (PV) systems to convert the direct current (DC) electricity generated by solar panels to AC electricity. It's used to power homes and businesses or fed back into the electricity grid. The inverter in this article designed to be more efficient and reliable by using a nonlinear control strategy. This approach considers the non-linear characteristics of the PV system and the switching functions of the inverter, which can impact the system's overall performance if left unaddressed. By using this strategy, the inverter can track the maximum power by maximum power point tracking (MPPT) generated by the PV system regardless of changing the control strategy implemented in the developed inverter enables it to adjust to various atmospheric conditions and regulate the active and reactive power output without requiring any supplementary equipment which seems to be unity power factor (UPF). This inverter is a single-stage three-phase grid-connected photovoltaic inverter [8], meaning that it can convert DC power generated by solar panels into AC power with high efficiency and directly supply it to the electrical grid. The control approach guarantees that the inverter always functions at optimal levels, thereby delivering the highest possible power output. In summary, this article presents a new approach to designing an inverter for PV systems that uses a nonlinear control strategy to improve efficiency and reliability [3].*

***Keywords*— *Active and reactive power control, DC-AC conversion, energy efficiency, grid inverter, MPP tracking, nonlinear control, PV system, renewable energy, energy.*

I. INTRODUCTION

Renewable energy sources such as solar, wind, andfuel cells have gained significant importance due tothe deregulation of electricity markets and the need to reduce greenhouse gas emissions[5]. Solar energyis particularly valuable as it is free, abundant, and pollution-free. Recent advancements have made photovoltaic (PV) systems more reliable and efficient, especially for distributed generation (DG)in low and medium voltage power systems. Introducing distributed energy resources into interconnected grids is an essential solution to meet rising electricity demands, and research is underway to develop smart grids. Photovoltaic converters are essential for converting the direct current (DC) voltage produced by PV panels into alternating current (AC) voltage that can be used to power electrical loads or feed the grid. The most common approach for handling the DC voltage rangegenerated by the PV array is the two-stage power conversion configuration. This setup involves a DC-DC power converter that uses maximum powerpoint tracking (MPPT) algorithms to optimize the power output of the PV panels, and a DC-AC powerconverter that converts the DC voltage to AC voltage suitable for use with the electrical grid or local loads. Various MPP algorithms, such as Incremental Conductance (INC), Perturb and Observe (P&O)[3], and have been developed to improve the accuracy and speed of the MPPT process. Researchers have also focused on improving the efficiency and reliability of single-phase PV systems, which are commonly used in low-power applications. These systems can provide grid support and comply with grid standards in countries that require PV systems to remain connected to the grid during a grid fault. Overall, photovoltaic converters are crucial for harnessing the power of solar energy and convertingit into usable electrical energy. The development ofnew control strategies and converter designs is essential for improving the efficiency, reliability, and overall performance of PV systems.

PV systems are known for their non-linear behavior, which is caused by the unique properties of PV cells and the switching functions of inverters. As a result, researchers have explored various advanced nonlinear control techniques for grid-connected PV systems, including backstopping control, sliding control, and feedback linearization. The majority of these studies have focused on the two-stage topology for both three-phase and single-phase systems. achieving maximum power point tracking (MPPT) of the solar array, third achieving unity power factor(UPF) for the grid connection, and last tightly regulating the DC-bus voltage. The proposed controller is designed using the backsteppingtechnique based on a large-signal nonlinear model of the entire system. The effectiveness of the controller is demonstrated through a analysis and simulation results, which show that the objectives are achieved even under changing climatic conditions, such as temperature and radiation.

II. GRID CONNECTED PHOTOVOLTAIC UNITS

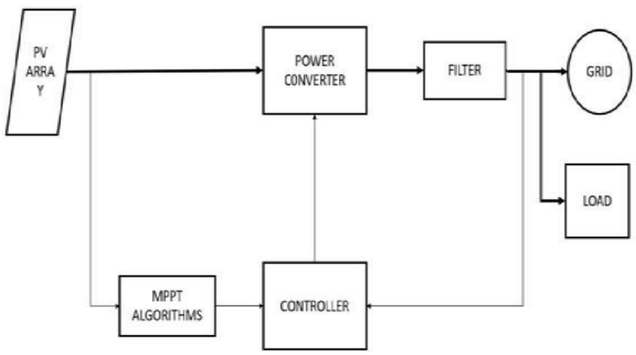

Fig. 1: Units Of Grid Connected PV System

Volume 7, Issue 5, pp. 40-43, 2023.
ISSN (Online): 2456-7361

A: Photo Voltaic Array:

Photovoltaic (PV) arrays demonstrate nonlinear behavior that varies according to changesin temperature and irradiation levels. Variousmodels of PV cells have been described in the article for the purpose of MPP tracking (MPPT). Various models of solar cells have been developed to accurately estimate the maximum power point of the PV array under varying conditions of temperature and irradiation. These models comprise the single- diode model, empirical model, artificial neural network models, and fuzzy logic models, among others. The objective of these models is to improvethe performance of the PV array by optimizing its operation under different operating conditions.

The I-V characteristics are described by mathematical equations as follows:

$$I = Ip - Id - Vd/Rp \quad (1)$$

$$Vd = IRs + V \quad (2)$$

$$Id = I0\,[exp\,(qVd/AKT) - 1] \quad (3)$$

$$Ip = [Isc + Kl\,(T - Tr)]\lambda \quad (4)$$

The current and voltage characteristics of a photovoltaic system can be represented using equations. These equations take into account the photocurrent (Ip), average current through the diode (Id), and voltage of the photo voltaic cell (Vd) which are average. The (I0) is denoted reverse saturation current at the reference temperature (Tr), and A refer to the diode ideal factor. T represents temperature of PV array in absolute scale (Ko), K = 1.38×10^-23J/Ko, where K is value of Boltzmann constant, Isc is the short circuit current at the reference (Tr) and radiation, Kl is the temperature coefficient of short circuit current, and λ is denoted for solar radiation while q is the charge of electron

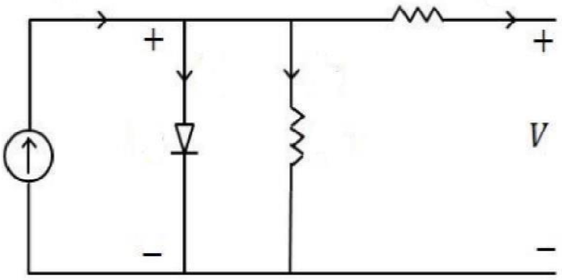

Fig. 2: Equivalent Circuit of Photovoltaic

B: Maximum Power Point Tracking Algorithm:

MPP Tracking (MPPT) to optimize the act of a solar PV system under changing atmosphericconditions. Specifically, the Incremental Conductance algorithm is being used due to its proven effectiveness in tracking the Maximum Power Point (MPPT) and generating a reference voltage that ensures maximum power output, regardless of variations in the environment.

III. PRESENTATION AND MODELING OF SYSTEM

Presentation and modeling of a grid-connected photo voltaic system involves defining the components and parameters of the system and developing a model that describes the behavior of the system under different operating conditions. The main components of a grid-connected PV system include a photo voltaic panel, a converter, a DC-ACinverter, also various grid. the photo voltaic array is made up of solar cells and generates DC power that is dependent on the solar irradiance and temperature. The DC-DC converter adjusts the voltage of the photo voltaic array to the level required by the inverter. The DC-AC inverter converts the DC power from the PV array to AC power that is synchronized with the grid and feeds it into the grid. The grid provides a load for the system and may also supply power to the system when needed.

To model the behavior of the grid-connected PVsystem, various parameters such as the solarirradiance, temperature, and load conditions must be considered. Mathematical models can be developedto describe the behavior of each component of the system. These models can then be combined to form a comprehensive model of the entire system. the system analysis can provide insights into the system's behavior under various operating conditions and guide the optimization of the designof its components by help of simulations tools as MATLAB or PSCAD.

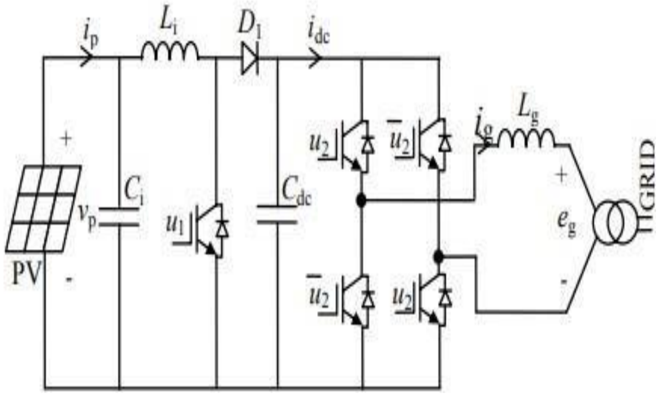

Fig. 3: 1ϕ Grid connected PV System

A 1ϕ connected photovoltaic (PV) system asillustrated in Figure 3. The system comprises a PV array, and input capacitor (Ci), a boost DC-DC converter that increases the array voltage and achieves MPP tracking, a direct current link capacitor (Cdc), unity power factor maintaining by the inverter which having four semiconductors for change DC to AC power, an isolation transformer and filter inductor (Lg) are also included in the system along with the inverter.

IV. FLOW CHART

Flow chart will help us understand well about method of MPPT and UPF in Grid Connected PV System.

The control system for the 1ϕ grid-connected PVsystem begins with reading and measuring the solarradiation input. The input is then used to calculate the (I-V) characteristics of the PV module and determine the MPP of the photovoltaic module Next, the DC bus voltage is measured and regulatedto ensure stable operation of the system. For unity power factor (PF) of the grid is also calculated and the inverter output is adjusted to achieve UPF in thegrid. to achieve stable and optimal system performance, a feedback linearization control approach is applied. The stability of the closed-loopsystem is then checked and the system performanceis monitored and adjusted based on feedback the robustness of the closed-loop system is then

Volume 7, Issue 5, pp. 40-43, 2023.
ISSN (Online): 2456-7361

evaluated, and the performance of the system is continuously monitored and fine-tuned based onfeedback.

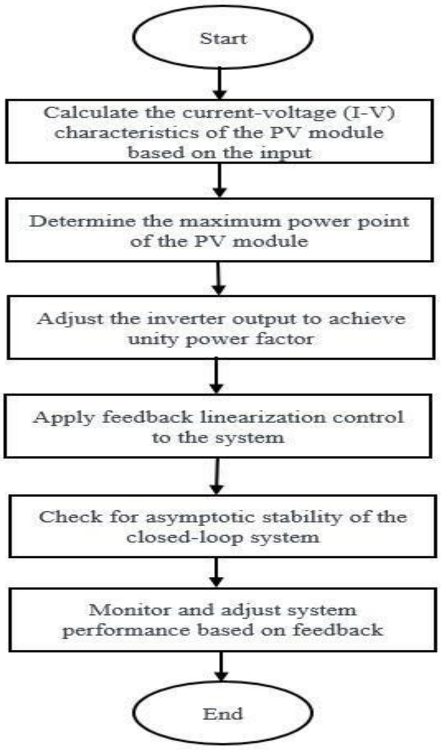

Fig. 4: Flow Chart of Single-Phase GridConnected PV System

Ultimately, the control system successfully fulfills its goals of regulating the direct current bus voltage, achieving UPF in the grid, and ensuring stable operation of the system with MPP tracking ofthe PV module before stopping its operation.

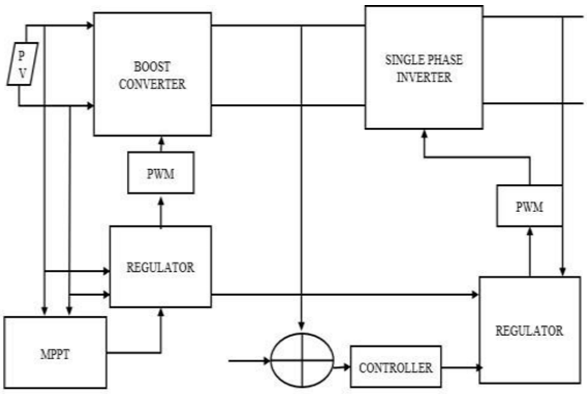

Fig.5: Architecture of Single-Phase Grid ConnectedPV System Control

V. Methodology

1ϕ grid-connected photovoltaic (PV) system, consisting of a solar panel, a boost power converter, and a single-phase inverter which are connected to grid. The proposed control approach aims to achieve four main objectives, as like unity power factor (PF)in the grid second asymptotic stability of the closed-loop system, maximum power point (MPP) trackingof the PV module, and tight regulation of the DC bus voltage, to achieve these objectives, a nonlinear controller based on feedback linearization is developed using an averaged nonlinear model of theentire system. The developed controller is able to maintain the optimal operation of the system The model considers the nonlinear dynamics of the inverter also boost converter as well as the nonlinearcharacteristics of the PV panel. The proposed controller is shown to achieve its objectives throughsimulation result.

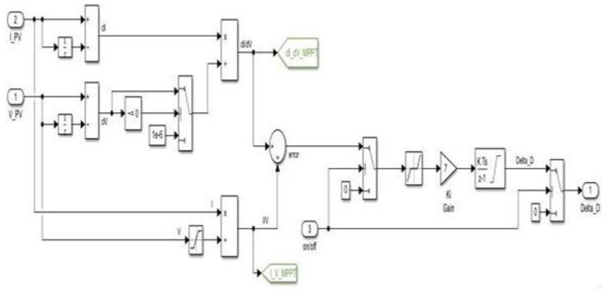

Fig. 6: Simulink model of MPPT (incremental conductance)

VI. Test Results And Discussion

The Solar power generated varies within a certain range, which corresponds to the MPP of the curves associated with the given radiations. The DC bus voltage is regulated to a targeted level. A different figure displays the grid energy, where the current issinusoidal and in sync with the voltage, indicating that the system has achieved UPF. The temperature of the system fluctuates while the radiation remains constant. Nonetheless, the developed controller facilitates sustained optimal operational parameters of the system, resulting in the maximum captured solar power values at the respective temperatures. Throughout the temperature changes, the regulationof the DC bus voltage is maintained at the targeted level through the proposed control system. The gridcurrent and voltage are also illustrated, indicating that the current graph is sinusoidal and synchronizedwith the voltage level, reflecting the achievement ofunity power factor

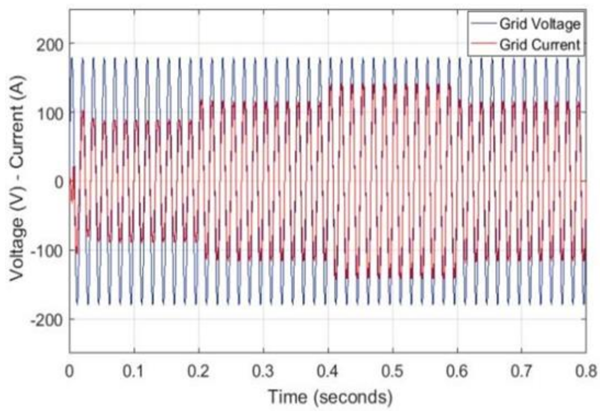

Fig. 7: phase current and voltage grid

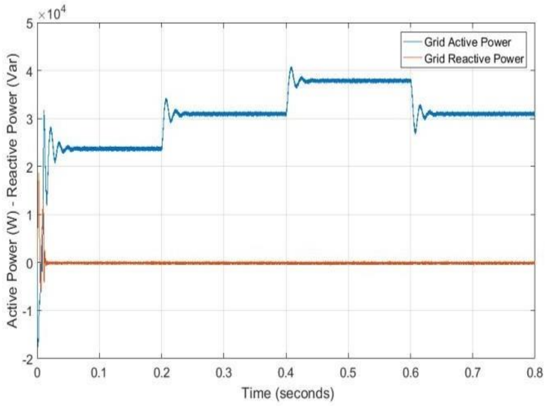

Fig. 8: Reactive and Active Power Grid

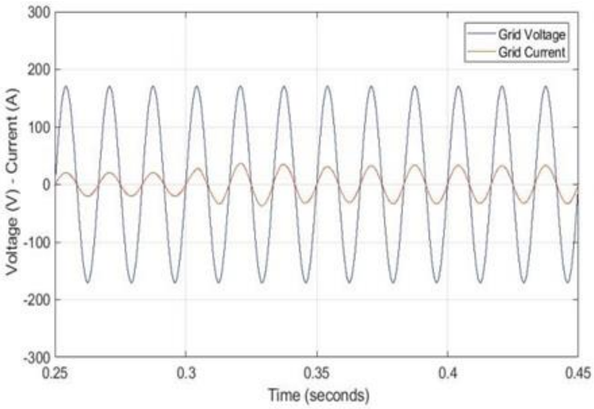

Fig. 9: Voltage and Current Output Grid

VII. CONCLUSION

With the implementation of the proposed controller, the single-phase grid-connected PV system is capable of achieving maximum power point tracking (MPPT)and maintain unity power factor(UPF)under varying atmospheric conditions.Stable and efficient operation is ensured as the proposed controller effectively regulates the DC bus voltage to the aim value. Additionally, the system is capable of achieving maximum power point tracking, making it a highly efficient single-phase grid-connected photovoltaic system. The controller is effective in adapting to temperature changes, allowing the system to operate at optimalconditions and achieve maximum captured solar power.

The outcome of the paper suggest that the proposed system and controller are effective for grid-connected photovoltaic applications.Specifically, the system has been able to regulate the DC bus voltage to the desired value, ensuring stable and efficient operation. These results showcase the potential of the proposed system andcontroller for practical implementation in the fieldof photovoltaic power generation.

ACKNOWLEDGMENT

I express my sincere gratitude to my department Electrical Engineering Department, Madan Mohan Malaviya University of Technology. Gorakhpur (U.P) for his unwavering support throughout this project. His commitment to exploring new challenges and seeking innovative solutions has created a stimulating and rewarding academic environment for me.

I would also like to thank to faculty members and other staffs for his valuable suggestions andfeedback that helped me to improve the quality of my research work. His patience, dedication, and unflinching assistance have been a constant source of motivation for me.

REFERENCES

[1] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, "Optimization of perturb and observe maximum power point tracking method," IEEE Transactions on Power Electronics, vol.20, no. 4, pp. 963-973, Jul. 2005
[2] Bikram Das, Anindita Jamatia, Abanishwar Charaborti Prabir Rn. Kasari & Manik Bhowmik, "New perturb & observe MPPT and its validation using data from PV module" IJAET (2012) 579-591
[3] G. Dileep, S.N.Singh, "Maximum power point tracking of solar photovoltaic system using modified perturbation and observationmethod" ELSEVIER (2015) 109-129
[4] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review ofsingle-phase grid-connected inverters for photovoltaic modules," IEEE Transactions on Industry Applications, vol. 41, no. 5, pp. 1292-1306, Sep./Oct. 2005.
[5] M. Calais, A. M. Sharaf, and H. Abu-Rub, "Power electronics for renewable energy systems, transportation and industrial applications," IEEE Transactions on Industrial Electronics, vol. 56, no. 3, pp. 902-908, Mar. 2009.
[6] S. Jain and V. Agarwal, "A new algorithm for rapid trackingof approximate maximum power point in photovoltaic systems," IEEE Transactions on Power Electronics, vol. 22,no. 2, pp. 623-633, Mar. 2007.
[7] Sliding Mode Control of Single-Phase GridConnected PV System", IFAC-PapersOnLine, 2021
[8] N. Femia, D. Granozio, G. Petrone, G. Spagnuolo, and M. Vitelli, "Predictive & adaptive MPPT perturb and observe method," IEEE Trans. Aerosp.Electron. Syst., vol. 43, no. 3, pp. 934–950, Jul. 2007
[9] Kjaer, S. B., Pedersen, J. K., & Blaabjerg, F. (2005). A review of single-phase grid-connected inverters for photovoltaic modules. IEEE Transactions on Industry Applications, 41(5), 1292-1306.
[10] Calais, M., Sharaf, A. M., & Abu-Rub, H. (2009). Power electronics for renewable energy systems, transportation and industrial applications. IEEE Transactions on IndustrialElectronics, 56(3), 902-908
[11] Bikram Das, Anindita Jamatia, Abanishwar Charaborti Prabir Rn. Kasari & Manik Bhowmik, "New perturb & observe MPPT and its validation using data from PV module" IJAET pg. 579-591 (2012)
[12] Ahmed M. Atallah, Almoataz Y. Abdela Ziz, and Raihan S. Jumaah, "Implementation of Perturb and Observe MPPT ofPV system with Direct control method using Buck and Buck-Boost Converter, EEIEJ, (2014) 31-44
[13] A. Fezzani, I. Hadj Mahammed, and S. Said, "MTALAB Based Modeling of Shading Effects in Photovoltaic arrays",
STA IEEE (2014) pg.781-787
[14] N. Mutoh, M. Ohno, and T. Inoue, "A method for MPPT control while searching for parameters corresponding to weather conditions for PV generation systems," IEEE Trans. Ind. Electron., vol. 53, no. 4, pp. 1055–1065, Aug. 2006.
[15] B. K. Perera, P. Ciufo, S. Perera, "Point of CommonCoupling (PCC) voltage control of a grid-connected solarPhotovoltaic (PV) system," 39th Annual Conference of theIEEE Industrial Electronics Society (IECON 2013), 2013, pp.7475-7480.

*Corresponding author
Email- sandeepku3010@gmail.com