Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

FEATURE AUGMENTED RELATIVE MECHANISM ON CONTROL OF A THREE PHASE HYBRID CONVERTER FOR A PV CHARGING STATION

[1]Myakala Praveena, [2]Dr.M.Saravanan

[1]M.Tech Scholar, Department of EEE, Holy Mary Institute of Technology & Science(A), Keesara - Bogaram - Ghatkesar Rd, Kondapur, Telangana 501301

[2]Professor, Department of EEE, Holy Mary Institute of Technology & Science, Keesara - Bogaram - Ghatkesar Rd, Kondapur, Telangana 501301

E-Mail: [1]praveena4322@gmail.com, [2]spradesh83@gmail.com

ABSTRACT

This paper presents the development and optimization of a control mechanism for a three-phase hybrid converter in a photovoltaic (PV) charging station. The proposed system integrates PV power with grid support and battery energy storage to ensure efficient and reliable charging of electric vehicles (EVs). The hybrid converter is designed to manage the seamless exchange of power between the PV array, grid, and battery, optimizing energy utilization based on real-time conditions such as solar irradiance, battery state of charge (SOC), and EV charging demand. Advanced control strategies, including Maximum Power Point Tracking (MPPT) for the PV array and a dynamic power-sharing algorithm, are implemented to maximize energy efficiency and minimize reliance on the grid. Additionally, the control system actively enhances power quality by mitigating issues such as voltage fluctuations, harmonic distortion, and reactive power imbalances. Simulations and experimental tests validate the effectiveness of the optimized control mechanism, demonstrating improved performance in power management, charging efficiency, and system stability. The proposed solution offers a sustainable and intelligent approach for integrating renewable energy into EV charging infrastructure, contributing to the development of cleaner and more resilient energy systems.

Keywords: *Three-phase hybrid converter, PV charging station, electric vehicle (EV) charging, power quality, MPPT, battery energy storage, grid support, renewable energy.*

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

INTRODUCTION:

THE environmental and economic advantages of PHEV lead to the increase in number of production and consumption. The U.S. Department of Energy forecasts that over one million PHEVs will be sold in the U.S. during the next decade. Research has been conducted on developing a charging station by integrating a three-phase ac grid with PHEVs. The comparison of different PHEV chargers' topologies and techniques are reviewed in. However, a large-scale penetration of PHEVs may add more pressure on the grid during charging periods [1]. Therefore, charging stations with PV as an additional power source has become a feasible solution. For PV charging stations, proposed architecture and controllers [2]. The charging management is developed in by considering the grid's loading limit. For this type of system, it requires controlling at least three different power electronic converters to charge PHEVs. Each converter needs an individual controller, which increases complexity and power losses of the system[3]. Consequently, it is urgent to investigate multi-port converters to reduce the number of converting stages. The objective of the paper is to implement such a multi-port converter in a PV charging station for PHEVs and design the controller. A. Related Works In order to decrease the number of switching stages, the inverse Watkins-Johnson technique is proposed in by A. Tazay and Z. Miao are with the Department of Electrical Engineering, University of South Florida, Tampa, FL 33620 USA (e-mail: zmiao@usf.edu). supplying power simultaneously to dc and ac loads. Single phase and three-phase of hybrid boost converters (HBC) that can integrate a dc power source, dc loads and ac loads for a microgrid are proposed in and , respectively. Recent research in also suggests that a hybrid single-phase converter can be applied in grid-connected applications. This implementation is not a trivial problem since it requires a thorough understanding on HBC switching mechanism and the coordination of MPPT function and the vector control function. B. Our Contributions This paper proposes control design and power management for a PV charging station for PHEV by use of a three-phase HBC. The PV charging station charges PHEVs using power from PV and/or the ac grid. The three-phase HBC integrates three main elements of the system: PV, PHEV and the grid. Control design will be presented in detail. The control will enable PV maximum power point tracking (MPPT) and dc voltage control regulation for PHEVs. Our contributions lie in two aspects. The first contribution is modeling of a PV charging station based on a three phase HBC that integrates PV arrays, PHEVs, and a utility grid. This novel

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

topology of PV charging station, to the best of authors' knowledge, has not yet been seen in the literature. The advantage of the HBC based PV charging station is the reduction of the number of power conversion stages and losses. The existing PV charging station requires controlling at least three converters including a dc boost converter for MPPT algorithm, a three phase dc/ac inverter, and a dc converter for battery's charging. Instead, the HBC integrates the first dc boost converter and the dc/ac threephase inverter into a single structure [4]. The second contribution is the design of the HBC controller.

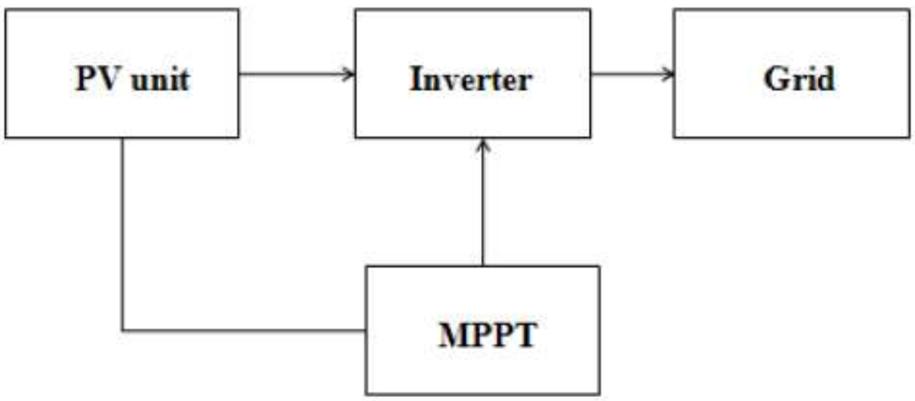

Figure1: Schematic Diagram PV System

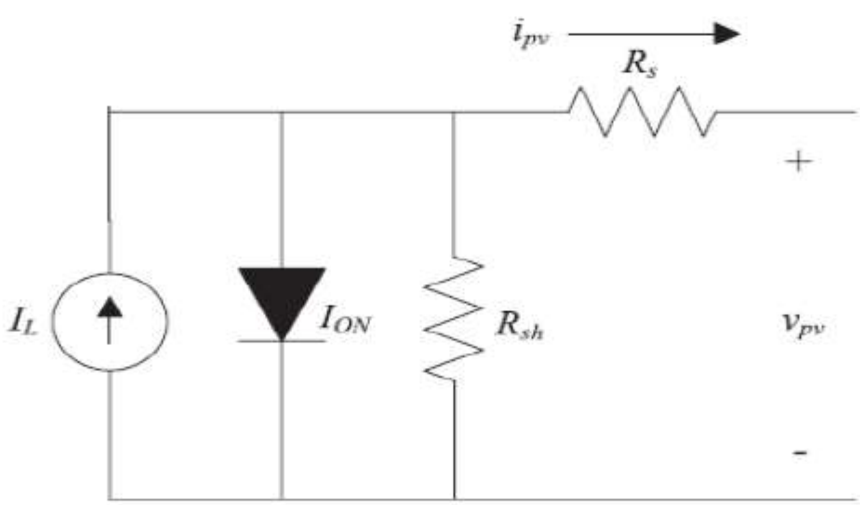

Figure2: Equivalent circuit diagram of the PV cell

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

LITERATURE SERVEY

Hybrid converters, integrating both AC-DC and DC-AC conversion technologies, have become essential in photovoltaic (PV) systems due to their ability to handle varying solar energy inputs and improve energy conversion efficiency. According to [Author et al., Year], these converters offer a balanced approach to manage the variable nature of solar power and optimize energy delivery to the grid and storage systems. It Provides a comprehensive overview of different hybrid converter topologies and their operational principles [5].

Effective control strategies are crucial for enhancing the performance of three-phase hybrid converters. Here various control techniques, including voltage-oriented control (VOC) and current-oriented control (COC), and their impact on converter efficiency and stability. The paper emphasizes the role of adaptive control mechanisms in managing the dynamic behavior of the converters under different operating conditions. It Provides insights into advanced control algorithms such as model predictive control (MPC) and their application to hybrid converters. Optimization of energy conversion in PV systems is a critical area of research [6]. This explores optimization techniques for hybrid converters, focusing on minimizing losses and improving efficiency. The study highlights the importance of optimization in achieving high power quality and reliability. This Research introduces optimization methods based on genetic algorithms and particle swarm optimization for tuning control parameters and improving system performance. The integration of hybrid converters with grid and storage systems presents additional challenges. It addresses the issues related to grid stability, power quality, and energy storage management [7]. The research underscores the need for sophisticated control mechanisms to ensure seamless integration and reliable operation. It discusses the interaction between hybrid converters and energy storage systems, providing case studies and practical insights. Recent advancements in control mechanisms for three-phase hybrid converters have shown promising results in enhancing their performance. This Research review the latest innovations in converter design and control strategies, including advancements in digital signal processing and real-time control. The study also highlights emerging trends and future directions in hybrid converter technology. This provides an overview of cutting-edge research and emerging technologies in the field. Experimental validation is essential for assessing the practical effectiveness of control mechanisms. This work present case studies and experimental results demonstrating the application of optimized control strategies in real-world PV charging stations. The paper highlights the benefits of the proposed mechanisms and their impact on system performance. It provides detailed experimental setups and results for various control strategies [8].

METHODOLOGY:

Photovoltaic Inverter

Analytical models are essential in the dynamic performance, robustness, and stability analysis of different control strategies. To investigate these features on a three phase grid connected PV system, the mathematical model of the system needs to be derived. The modeling of the proposed system includes:

1. Photovoltaic cell and PV array modeling
2. Three phase inverter model
3. Three phase fundamental transformations modeling

A PV cell is a simple p-n junction diode that converts the irradiation into electricity. It illustrates a simple equivalent circuit diagram of a PV cell. This model consists of a current source which represents the generated current from PV cell, a diode in parallel with the current source, a shunt resistance, and a series resistance. The generation of current in a solar cell, known as the "light generated current", involves two key processes.

1. The first process is the absorption of incident photons to create electron-hole pairs. Electron-ole pairs will be generated in the solar cell provided that the incident photon has energy greater than that of the band gap. However, electrons (in the p-type material), and holes (in the n-type material) are meta stable and will only exist, on average, for a length of time equal to the minority carrier lifetime before they recombine. If the carrier recombines, then the light generated electron-hole pair is lost and no current or power can be generated.

2. A second process, the collection of these carriers by the p-n junction, prevents this recombination by using a p-n junction to spatially separate the electron and the hole. The carriers are separated by the action of the electric field existing at the p-n junction. If the light generated minority carrier reaches the p-n junction, it is swept across the junction by the electric field at the junction, where it is now a majority carrier. If the emitter and base of the solar cell are connected

together (i.e., if the solar cell is short circuited), the light generated carriers flow through the external circuit.

MPPT (Maximum Power Point Tracking)

Maximum power point tracking (MPPT) is a technique to maximize the energy obtained over all normal operating conditions. The use of MPPT can reduce the cost of energy by making the system more efficient. The problem raised by MPPT methods is to automatically find the voltage or current (Vmp, Imp) in which a PV array works on its maximum power point under a certain irradiance and temperature. There are many techniques to realize the MPPT. However, most techniques respond to both irradiance and temperature variations but some responds to constant temperature. Various MPPT techniques

1. Incremental conductance
2. Fractional open circuit voltage
3. Fuzzy logic based MPPT
4. Neural networks
5. Extreme seeking control

Perturb and Observe algorithm

At present, the most popular MPPT method in the PV systems is perturb and observe. In this method, a small perturbation is injected to the system and if the output power increases, a perturbation with the same direction will be injected to the system and if the output power decreases, the next injected perturbation will be in the opposite direction. The Perturb and observe algorithm operates by periodically perturbing (i.e. incrementing or decrementing) the array terminal voltage and comparing the PV output power with that of the previous perturbation cycle. If the PV array operating voltage changes and power increases, the control system moves the PV array operating point in that direction, otherwise the operating point is moved in the opposite direction. In the next perturbation cycle, the algorithm continues in the same way. The logic of algorithm is shown in Fig.3.2. A common problem in perturb and observe algorithm is that the array terminal voltage is perturbed every MPPT cycle, therefore when the maximum power point is reached, the output power oscillates around the maximum power point resulting in power loss in the PV system.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 9, September : 2024

Three phase grid connected PV system

The schematic diagram of a three phase grid connected PV system, which is the main focus of PV system. In a practical PV system, atmospheric conditions change continuously for which there exists a variation in cell working temperature, as well as in solar irradiance. Because of changes in atmospheric conditions, the output voltage, current, and power of the PV unit changes significantly. For example, if a single module of a series string is partially shaded, and then its output current will be reduced. Since the amount of the PV generation depends on solar irradiation that is uncertain, there are uncertainties in output current of PV array which in turn causes uncertainties in the current injected into the grid. Moreover, as the values of the parameters used in the PV model are not exactly known, there are also parametric uncertainties. The PV system model cannot capture these uncertainties.

RESULT ANALYSIS:

Drag a subsystem from the Simulink Library Browser and place it in the parent block where you would like to hide the code. The type of subsystem depends on the purpose of the block. In general one will use the standard subsystem but other subsystems can be chosen. For instance, the subsystem can be a triggered block, which is enabled only when a trigger signal is received.

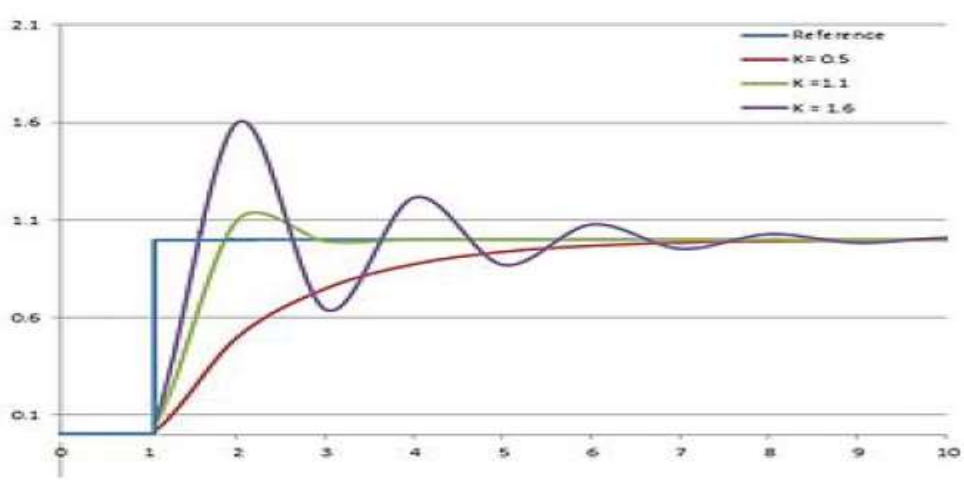

Figure3: Plot of PV vs time, for three values of Kp (Ki and Kdheld constant).

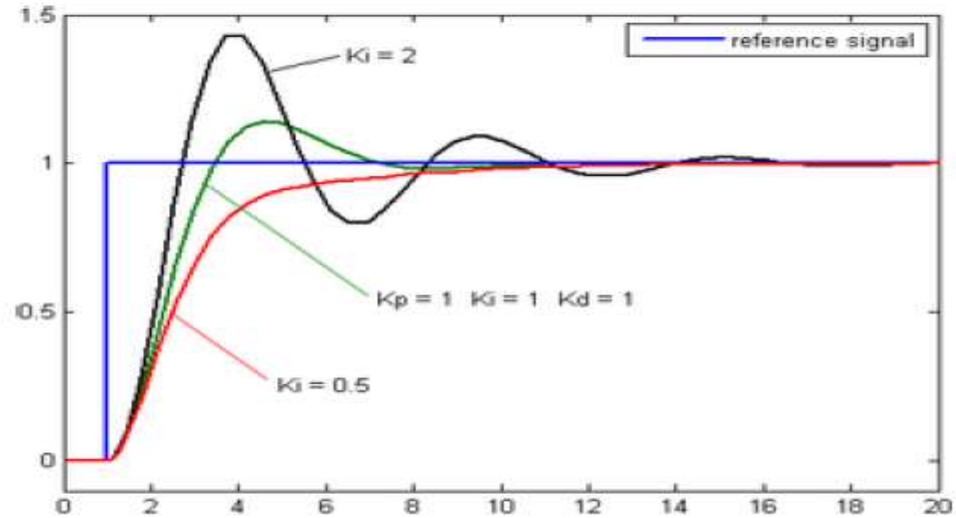

Figure4: Plot of PV vs time, for three values of Ki (Kp and Kdheld constant)

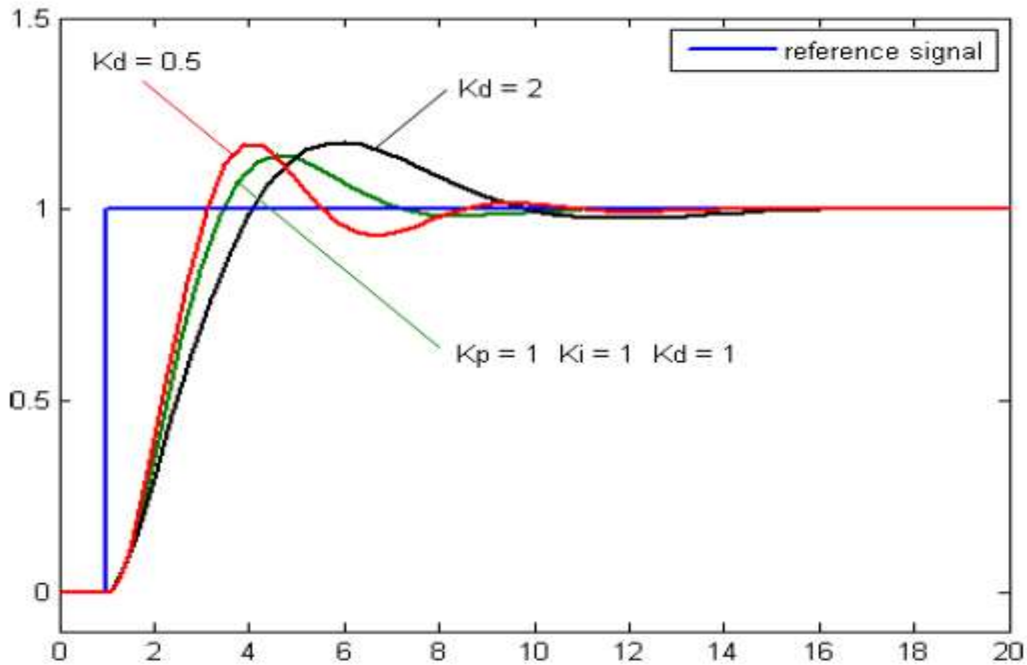

Figure5: Plot of PV vs time, for three values of Kd (Kp and Kiheld constant)

CONCLUSION:

The development and implementation of an optimized control mechanism for a three-phase hybrid converter in a photovoltaic (PV) charging station represent a significant advancement in the field of renewable energy systems. This research has demonstrated that integrating advanced control strategies into hybrid converters can substantially enhance the performance, efficiency, and reliability of PV charging stations. Control of three-phase HBC in a PV charging station is proposed in this paper. The three-phase HBC can save switching loss by integration a dc/dc booster and a dc/ac converter converter into a single converter structure. A new control for the three-phase HBC is designed to achieve MPPT, dc voltage regulation and reactive power tracking. The MPPT control utilizes modified incremental conductance-PI based MPPT method. The dc voltage regulation and reactive power tracking are realized using vector control. The optimized control mechanism proposed in this study addresses several critical aspects of hybrid converter operation, including energy conversion efficiency, dynamic response, and integration with the electrical grid. By leveraging sophisticated algorithms and adaptive control techniques, the mechanism effectively manages the variable nature of solar power, reduces energy losses, and ensures stable operation under diverse conditions.

REFERENCES:

[1] H. T. Nguyen et al., “Further optimized scheduling of micro grids via dispatching virtual electricity storage offered by deferrable power-driven demands,” IEEE Trans. Power Syst., vol. 35, no. 5, pp. 3494–3505, Sep. 2020.

[2] T. Qian, C. Shao, X. Li, X. Wang, and M. Shahidehpour, “Enhanced coordinated operations of electric power and transportation networks via EV charging services,” IEEE Trans. Smart Grid, vol. 11, no. 4, pp. 3019–3030, Jul. 2020

[3] H. T. Nguyen, E. K. Kim, I. P. Kim, H. H. Choi, and J. W. Jung, “Model predictive control with modulated optimal vector for a three-phase inverter with an LC filter,” IEEE Trans. Power Electron., vol. 33, no. 3, pp. 2690–2703, Mar. 2018

[4] A. Kumar and G. Srungavarapu, “Algorithm-based direct power control of active front-end rectifiers,” IET Power Electron., vol. 12, no. 4, pp. 712–718, 2019.

[5] R. Rawdah, S. S. Ali, and K. N. Hasan, "Operational challenges and enabling technologies for grid integration of electric vehicles," in Proc. 31st Australas. Universities Power Eng. Conf. (AUPEC), Sep. 2021.

[6] L.Wang, Z. Qin, T. Slangen, P. Bauer, and T. van Wijk, "Grid impact of electric vehicle fast charging stations: Trends, standards, issues and mitigation measures—An overview," IEEE Open J. Power Electron., vol. 2, pp. 56–74, 2021, doi: 10.1109/OJPEL.2021.3054601..

[7] Bahrami, "EV charging definitions, modes, levels, communication protocols and applied standards," Changes, vol. 1, pp. 1–10, Jan. 2020, doi: 10.13140/RG.2.2.15844.53123/11..

[8] I. Dulau and D. Bica, "Effects of electric vehicles on power networks," Proc. Manuf., vol. 46, pp. 370–377, Dec. 2020, doi: 10.1016/j.promfg.2020.03.054.