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OPEN LOOP & CLOSED LOOP CONTROLLER FOR STAND-ALONE PV SYSTEM: A REVIEW

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Abstract

In a photovoltage power generation, there are numerous control techniques required to get the satisfied output power. The investigation depends on the recent manuscripts of researchers helps to understand the controllers for the standalone system. The basic controllers for PV systems are current and voltage controllers, MPPT methods and their synchronization policies. The main purpose of this paper is to get the idea about the control structure that distinguish the recent patterns. The initial findings are summated in the advancement of gradually strong controllers for the functions with improved effectiveness, power quality and improve the economy.

Index Terms: *controllers; open and closed loops; grid integrated; standalone system; PV system*

INTRODUCTION

Solar based energy is abundant and environment approachable energy source. It is an attractive energy management system because of its unlimited supply source and it is pollution free in nature. Initially the Solar power generation was introduced for microgrids and standalone systems but nowadays large-scale solar power generations are proposed for the interconnection with ON and OFF grid systems and thus several control techniques have been developed with high penetration of power electronics-based generation. [1] The heat and irradiation of the sun coming to the earth are the initial raw materials for the generation of electrical energy required to fulfil the demand of the world. Also, it does not carry any harmful or poisonous particles that effect the environment. The benefits by the sun powered energy will turn into the most aspect during the energy progress in 21st century. [2] In the recent years, the controllers in solar photovoltaic system had become an important and fundamental tool firstly for MPPT strategies and power electronics (converter and inverter) control for both the systems standalone mode and grid connected mode.

First Level Controller - In this Section the basic controllers for PV systems are compiled. The controllers are: current and voltage controllers, MPPT strategies and synchronization techniques.

a)Current and Voltage Control –The current and voltage control strategy uses two loop technique. In order to avoid the impact of changing ecological parameters on the performance of inverter operation, two control loops such as inner control loop (current) and outer control loop (voltage) are applied.

The main objective of the inverter control is to properly feed the extracted power to the grid. This can be achieved through a dual loop control of current. The outer loop can be a DC link voltage control or a power control loop which generates the inner current waveforms.

Linear controllers are used for inner and outer loop control. Because of the limitations on voltage regulation, struggle between the loops and stability problems, non-linear controllers are proposed. Researchers are working on some other control techniques for the advancement of inner and outer loop control such as predictive control, droop control, adaptive controllers etc.

b) Maximum Power Point Tracking Methods- In order to obtain the maximum available power from a PV system and to enhance the installation efficiency, MPPT methods are used [23]. The perturb and observe (P&O),

incremental conductance, fractional open circuit voltage and fractional short circuit current are commonly used MPPT methods [24]. These algorithms are very popular because of its easiness and dissolute convergence [31]. In recent years, MPPT methods based on computational intelligence such as ANN, grey wolf optimization algorithm, particle swarm optimization (PSO), nonlinear neuro adaptive method, genetic algorithms (GA), Levenberg- Marquardt method, fuzzy control, Marine predator algorithm, simulated annealing algorithm have been reported [30]. Intelligent algorithms have the limitations such as complex implementation and the difficulty in selection of initial point [27]. The recent work is to present robust and reliable MPPT methods. Main focus of the researchers now a days is on partial shading problems and for the betterment of classical methods. [29].

c) Partial Shading Condition- PV systems may have multiples peaks under partially shading. In addition, the tracking speed, performance and embedded boards confirms effectiveness of the techniques.

Ref. [28] The Marine predator algorithm (MPA) method which is a bio-inspired meta-heuristic algorithm show its supremacy in terms of convergence time, efficiency, accuracy, and extracted power.

These bio-inspired algorithms like particle swarm optimization (PSO), artificial bee colony (ABC), ant colony (ACO), bat algorithm (BAT), cat swarm optimization (CSO), differential evolution (DE), firefly (FA), and grey wolf optimization (GWO). The above said algorithm-based techniques have the ability to detect the MPP without any oscillations in the steady-state situations and can easily fix the global maximum power point (GMPP) using many local maximum power points (LMPPs) during attaining a value close to accuracy.

The disturbances of random variables by using a seagull optimization algorithm are focused in this scheme.[32] An optimization method [33] named the maximum power trapezium and the flower pollination MPPT algorithm integrates the chaos maps for an adaptive change of the basic algorithm parameters. A fusion firefly algorithm is an improved MPPT control technique with simplified propagation process. [34] A hybrid PSO-GA fuzzy logic MPPT optimized technique with fuzzy membership functions and fuzzy rules are executed for problem solving [35].

The nature inspired grey wolf optimization algorithm with a convergence factor is integrated for dynamic performance improvement. [36]

d) Synchronization- The PV grid integration depends on synchronization of the grid supply and the inverter output parameters. PLL is one of the techniques for synchronization. PLL tunes the reference voltage and the inverter output voltage at the point of common coupling. Researchers proposes a new orthogonal signal generator (OSG) for a generalized integrator-based PLL, known as mixed third-fourth order generalized integrator-based PLL (MTFOGI-PLL). This MTFOGI method offers high speed dynamic result, improved filtering and dc-offset refusal skill. [37]

As the traditional PLL techniques are unable to detect good phase angle when the grid voltage has high amplitude and phase variations so based on virtual flow, observer based and power instantaneous schemes are some other alternatives for synchronization algorithms [30]. Digital PLLs are the most employed synchronization algorithm like Predictive synchronous reference frames (SRF) and moving average filters (MAF) and their combinations.

Second Level Controllers-In section II, the PV grid integrated system controllers that are required for regulations for the operation are detailed. Improvement of power quality conditions, perform anti-islanding protection and grid care are the main control strategies that are also elaborated.

a) Power Quality – Integrating a PV system with an existing grid creates various power quality issues such as voltage sag and swell, inter oscillation harmonics etc. Use of non-linear loads such as SMPS and composite loads connected to the grid make them more prone to harmonics and hence increases AT and C losses. IEEE standards 519 recommends a harmonic distortion of less than 5%. The current harmonics injected in the grid are controlled by using passive, active and hybrid filters which inject compensation current to mitigate the harmonics [12] [15]. Dynamic devices like UPQC, DVR and DSTATCOM may be a good option in mitigating the power quality problems. Harmonics can be mitigated from either source side or from load side. Source side harmonic control is more difficult as it requires accurate design of inverter and its controller. [16]

b) Anti-Islanding Protection - The hybrid active anti-islanding protection technique for PV integrated system improves the protection and reliability of the operations. This method combines passive and active detection techniques, i.e. voltage and frequency protections and slip mode frequency shift (SMS) [25]. The main objective is to protect the PV system during the power outage of the grid.

c) Grid Support- The IEEE 1547 Standard for interconnection requirements of distributed energy resource was revised 2018. For inverter-based resources transmission and sub-transmission connected was reframed in IEEE 2800 in 2022. The test are required for grid support functions imposed by grid codes for Volt-Var, Volt-Watt, constant power factor, frequency watt or frequency droop, constant reactive power, active power-reactive power, evaluation of time response need to have minimum required measurement precision as specified in IEEE-1547-2018 standard. [31] [34].

CONCLUSION

Most recent control techniques applied in PV systems are reviewed in this paper. Control techniques are divided here in two levels to discuss and was developed systematically. The open loop and closed loop controllers at the intermediate level are necessary with mandatory regulations and standards are analyzed. Grid codes and standards for integration are necessary to provide greater penetration of PV system in power system. Future work will focus on power limiting, monitoring, energy storage, prediction, sizing and location of PV system in bus and battery management system in standalone system with computational intelligent techniques.

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