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A Review Paper Work on High-Performance Constant Power Generation in Grid-Connected PV Systems

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Abstract: In this paper an advanced power control strategy is proposed by limiting the maximum feed-in power of PV systems, which can ensure a fast and smooth transition between maximum power point tracking and Constant Power Generation (CPG). The proposed control method used to reduced overshoots, minimized power losses, and fast dynamics. The proposed solution can ensure a stable constant power generation operation. Regardless of the solar irradiance levels, high-performance and stable operation are always achieved by the proposed control strategy. It can regulate the PV output power according to any set-point, and force the PV systems to operate at the left side of the maximum power point without stability problems. By using the simulation results we can verified the effectiveness of the proposed CPG control in terms of high accuracy, fast dynamics, and stable transitions.

Keywords: MPPT, PV, Constant Power Generation (CPG).

I. INTRODUCTION

In order to maximize the energy maximum Power Point Tracking (MPPT) operation is mandatory for grid-connected PV systems. Catering for more PV installations requires to advance the power control schemes as well as the regulations in order to avoid adverse impacts from PV systems like overloading the power grid [1]–[3]. An active power control is referred to as a Constant Power Generation (CPG) control or an absolute power control is described in this paper[5]. Fundamentals of the CPG concept have been presented [3], [6], which reveals that the most cost-effective way to achieve the CPG control is by modifying the MPPT algorithm at the PV inverter level. Specifically, the PV system is operated in the MPPT mode, when the PV output power Ppv is below the setting-point Plimit.

$$P_{pv} = \begin{cases} P_{MPPT,}\ when\ P_{PV} \leq P_{limit} \\ P_{limit,}\ when\ P_{PV} > P_{limit} \end{cases} \quad (1)$$

However, when the output power reaches Plimit, the output power of the PV system will be kept constant, i.e., Ppv = Plimit, and leading to a constant active power injection as shown in (1) and illustrated in Fig. 1 In terms of the algorithms, the CPG based on a Perturb and Observe (P&O-CPG) algorithm was introduced in single stage PV systems [7]. However, the operating area of the CPG control is limited to be at the right side of the Maximum Power Point (MPP) of the PV arrays (CPP-R), due to the single-stage configuration. Unfortunately, this decreases the robustness of the control algorithm when the PV systems experience a fast decrease in the irradiance.

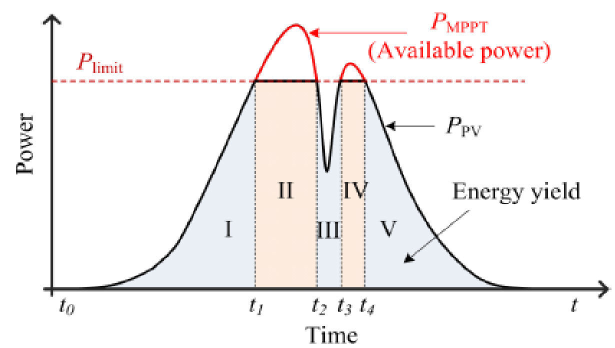

Fig 1. Constant Power Generation (CPG) concept: 1) MPPT mode during I, III, V, and 2) CPG mode during II, IV [6].

The operational principle of the conventional P&O-CPG algorithm is illustrated. It can be divided into two modes: 1) MPPT mode (Ppv ≤ Plimit), where the P&O algorithm should track the maximum power and 2) CPG mode (Ppv > Plimit), where the PV output power is limited at Plimit. The operating point may go to the open-circuit condition as illustrated in Fig. 2. This drawback applies also to other CPG algorithms presented in [8] and [9], since all the control algorithms regulate the PV power Ppv at the right side of the MPP. To tackle the above issues, a two-stage grid-connected PV is employed to extend the operating area of the P&O-CPG algorithm. By regulating the PV output power at the left side of the MPP (CPP-L) in Fig. 2, a stable CPG operation is always achieved, since the operating point will never “fall off the hill” during a fast decrease in the irradiance. Thus, the P&O-CPG algorithm can be applied to any two-stage single-phase PV system [10].

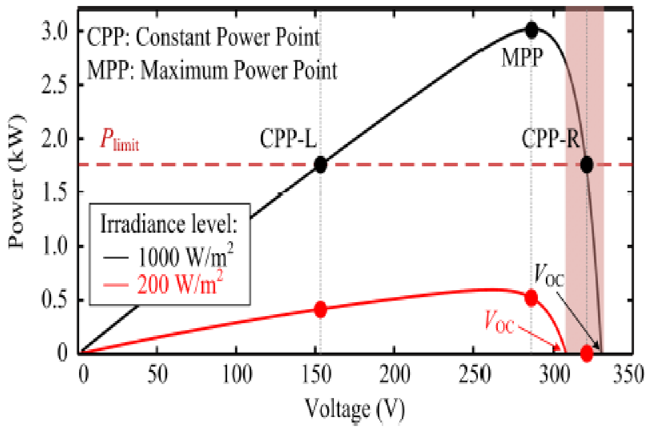

Fig2.Stability issues of the conventional CPG algorithms, when the operating point is normally located at the right side of the MPP.

In terms of the algorithms, the CPG based on a perturb and observe (P&O-CPG) algorithm was introduced in single-stage PV systems [7]. However, the operating area of the CPG control is limited to be at the right side of the maximum power point (MPP) of the PV arrays (CPP-R), due to the single-stage configuration. Unfortunately, this decreases the robustness of the control algorithm when the PV systems experience a fast decrease in the irradiance. The operating point may go to the open-circuit condition as illustrated in Fig. 2. This drawback applies also to other CPG algorithms presented in [8] and [9], since all the control algorithms regulate the PV power Ppv at the right side of the MPP. To tackle the aforementioned issues, a two-stage grid connected PV is employed to extend the operating area of the P&O-CPG algorithm. By regulating the PV output power at the left side of the MPP (CPP-L) in Fig. 2, a stable CPG operation is always achieved, since the operating point will never "fall off the hill" during a fast decrease in the irradiance. Thus, the P&OCPG algorithm can be applied to any two-stage single-phase PV system [10].

II. CONVENTIONAL CPG ALGORITHM

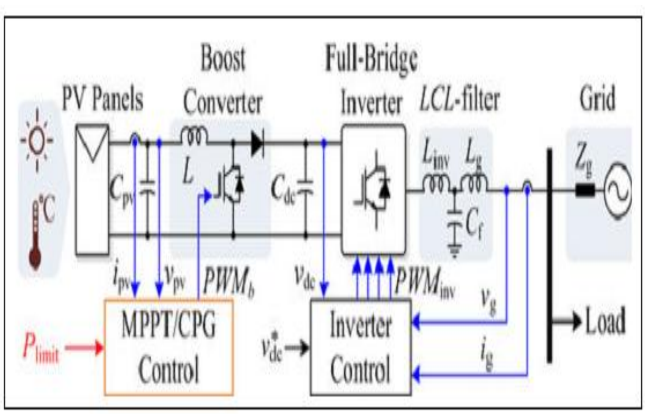

Fig 3. Schematic and overall control structure of a two-stage single phase grid-connected PV system.

Fig. 3 shows the basic hardware configuration of a two-stage single-phase grid-connected PV system and its control structure. The CPG control is implemented in the boost converter, which will be described in the next section. The control of the full bridge inverter is realized by using a cascaded control where the dc-link voltage is kept constant through the control of the ac grid current, which is an inner loop [11]. Notably, only an active power is injected to the grid, meaning that the PV system operates at a unity power factor. Notably, as it has been mentioned earlier, the two-stage configuration can extend the operating range of both the MPPT and CPG algorithms. In the two-stage case, the PV output voltage v pv can be lower (e.g., at the left side of the MPP), and then, it can be stepped up by the boost converter to match the required dc-link voltage (e.g., 450 V).

III. RELATED WORK

A. T. Stetz et.al proposes this work discusses the technical and economical benefits of different active and reactive power control strategies for grid-connected photovoltaic systems in Germany. The aim of these control strategies is to limit the voltage rise, caused by a high local photovoltaic power feed-in and hence allow additional photovoltaic capacity to be connected to the mains. Autonomous inverter control strategies, which do not require any kind of data communication between the inverter and its environment, as well as an on-load tap changer for distribution transformers, is investigated. The technical and economical assessment of these strategies is derived from 12-month root mean square (rms) simulations, which are based on a real low voltage grid and measured dc power generation values. The simulation results show that the provision of reactive power is an especially effective way to increase the hosting capacity of a low voltage grid for photovoltaic systems.

B. A. Ahmed, et.al proposes a fast maximum power point tracking (MPPT) control algorithm for the photovoltaic (PV) in a hybrid wind-PV system, in which the PV generator may also need to work in a reduced power mode (RPM) to avoid dynamic overloading. The two control modes, MPPT and RPM, are inherently compatible and can be readily implemented, without the need of a dumping load for the RPM. Following the establishment of a dynamic system model, the study develops the guidelines to determine the variables of a direct hill-climbing method for MPPT: the perturbation time intervals and the magnitudes of the applied perturbations. These simulation results are used to optimally set up a variable-step size incremental conductance (VSIC) algorithm along with adaptive RPM control. The power tracking performance and power limiting capability are verified by simulation and experiment.

C. Y. Yang, et.al letter proposes a hybrid power control concept for grid-connected photovoltaic (PV) inverters. The control strategy is based on either a maximum power point tracking control or a constant power generation (CPG) control depending on the instantaneous available power from the PV panels. The essence of the proposed concept lies in the selection of an appropriate power limit for the CPG control to achieve an improved thermal performance and an increased utilization factor of PV inverters, and thus, to cater for a higher penetration level of PV systems with intermittent nature. A case study on a single-phase PV inverter under yearly operation is presented with analyses of the thermal loading, lifetime, and annual energy yield. It has revealed the trade-off factors to select the power limit and also verified the feasibility and the effectiveness of the proposed control concept.

D. F. Blaabjerg et.al proposes with an imperative demand of clean and reliable electricity generation in some countries, the increasing adoption of new photovoltaic (PV) systems pushes the Distribution System Operators (DSOs) to expand the transmission/distributed lines. However, the potential cost brought by such extensions and increased maintenances introduce new obstacles. In view of this concern, the DSOs starts to reduce PV installations in order to avoid an extension of the power infrastructure. Besides, another alternative solution is to limit the maximum feed-in power of the existing PV systems to a certain level. It can contribute to a weakened requirement of grid expansion and at the same time an increased penetration level. Therefore, to meet the need of this emerging ancillary service provided by future PV systems, a Constant Power Generation (CPG) control concept of PV inverters is proposed in this paper. Thereby, the implementation possibilities for PV systems in CPG operation mode are also discussed in this paper. Additionally, the loss of energy is calculated to reveal the viability of the proposed CPG control method. Operation examples of a PV system are presented to show the effectiveness of the CPG control method to unload the distributed grid.

E. R. G. Wandhare et.al proposes Significant expansion of PV-grid installations have escalated new problems of PV penetration because of intermittent nature of the PV source and inertia-less interface. In this paper, a novel active and reactive power control scheme for a single stage PV-grid system is proposed to counter the potential PV penetration problems for the futuristic grid with large distributed generation system (DGS) contributions. The proposed work incorporates a PV power control algorithm, which not only facilitates maximum power point tracking (MPPT) but also provides precise PV power control, unlike conventional MPPT schemes.. In addition, the reactive power control ability increases the effectiveness of the proposed scheme for feeder voltage profile improvement and utilization of the interfacing power converter. A 3-Ph, single stage PV-grid system is considered with the PV source directly integrated with the DC link of the inverter. The DC link voltage is controlled by the inverter. Detailed analysis, modeling and control design are included and supported by key simulation and experimental results.

F. W. Cao, et.al paper proposes a method of modeling and emulation of a two-stage photovoltaic (PV) inverter system by using a single power converter. The PV emulator is intended to be used in a converter-based power grid emulation system - Hardware Test-bed (HTB), in order to investigate the influence of solar energy sources on the power grid. Both physical components and control strategies of the two-stage PV inverter system are modeled in the converter controller, which enables the emulator to represent the behaviors of the two-stage PV inverter system accurately. The performance of the two-stage PV inverter system emulator in both the MPPT mode and the reserved power control mode under variable solar irradiance circumstances is illustrated by using simulation results.

G. A. Urtasun et.al proposes photovoltaic (PV) systems are generally based on Maximum Power Point Tracking (MPPT), many situations such as stand-alone systems or microgrids increasingly require the PV system to operate below maximum power. The problem here is that the power regulation becomes unstable when the MPP power is lower than the reference power as a result of a decrease in irradiance. This paper proposes a control strategy for a DC/DC boost converter that makes it possible to operate in both modes: at either maximum or limited power point tracking. By using the simulation results, we can verify the high dynamics and stability of the proposed method at any situation.

H. S. B. Kjaer, et.al proposes on inverter technologies for connecting photovoltaic (PV) modules to a single-phase grid. The inverters are categorized into four classifications: 1) the number of power processing stages in cascade; 2) the type of power decoupling between the PV module(s) and the single-phase grid; 3) whether they utilizes a transformer (either line or high frequency) or not; and 4) the type of grid-connected power stage. Various inverter topologies are presented, compared, and evaluated against demands, lifetime, component ratings, and cost. Some of the topologies are analyzed for either single PV module or multiple PV module applications.

I. F. Blaabjerg, et.al proposes a Renewable energy sources like wind, sun, and hydro are seen as a reliable alternative to the traditional energy sources such as oil, natural gas, or coal. Due to the increasing number of DPGSs connected to the utility network, new and stricter standards in respect to power quality, safe running, and islanding protection are issued. As a consequence, the control of distributed generation systems should be improved to meet the requirements for grid interconnection. This paper gives an overview of the structures for the DPGS based on fuel cell, photovoltaic, and wind turbines. In addition, control structures of the grid-side converter are presented, and the possibility of compensation for low-order harmonics is also discussed. Moreover, control strategies when running on grid faults are treated. In this paper analyze the overview of synchronization methods and their importance in the control.

J. B. Yang, et.al proposes a grid-connected photovoltaic (PV) power system with high voltage gain is proposed, and the steady-state model analysis and the control strategy of the system are presented in this paper. The proposed PV system employs a ZVT-interleaved boost converter with winding-coupled inductors and active-clamp circuits as the first power-processing stage, which can boost a low voltage of the PV array up to a high dc-bus voltage. Accordingly, an accurate steady-state model is obtained and verified by the simulation and experimental results, and a full-bridge inverter with bidirectional power flow is used as the second power-processing stage, which can stabilize the dc-bus voltage and shape the output current. Two compensation units are added to perform in the system control loops to achieve the low total harmonic distortion and fast dynamic response of the output current. Furthermore, a simple maximum-power-point-tracking method based on power balance is applied in the PV system to reduce the system complexity and cost with a high performance.

K. T. Esram and P. L. Chapman proposes The many different techniques for maximum power point tracking of photovoltaic (PV) arrays are discussed. The techniques are taken from the literature dating back to the earliest methods. It is shown that at least 19 distinct methods have been introduced in the literature, with many variations on implementation. This paper should serve as a convenient reference for future work in PV power generation.

IV. CONCLUSION

In this paper, a high-performance active power control scheme by limiting the maximum feed-in power of PV systems has been proposed. The proposed solution can ensure a stable constant power generation operation. Compared to the traditional methods, the proposed control strategy forces the PV systems to operate at the left side of the maximum power point, and thus it can achieve a stable operation as well as smooth transitions. By using the simulation results verified the effectiveness of the proposed control solution in terms of reduced overshoots, minimized power losses, and fast dynamics. Notably, for single-stage PV systems, the same CPG concept is also applicable. However, in that case, the PV voltage operating range is limited and minor changes in the algorithms are necessary to ensure a stable operation.

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