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Design a Two Stage Grid Connected PV Systems with Constant Power Generation and Input Output Linearizer Controller

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Abstract

The many Different techniques for Maximum Power Point Tracking of Photovoltaic arrays are discussed. This constant power generation is produced by limiting to a set limit around the MPPT, which makes the panel to reach around the MPPT, this makes the voltage and the current to stabilize so oscillations are reduced. These methods provide a better efficiency but suffer from sudden solar irradiance changes. Hence to alleviate the issues of the variation power a robust controller based on the Input Output Linearizer along with the constant power control is introduced. This controller can ensure a fast transition between maximum power point tracking 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 around MPPT which enhances the efficiency.

Keywords: Active Power Control, Constant Power Control, Maximum Power Point Tracking (MPPT), Power Converters, PV Systems, Linear Current Controller

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I. INTRODUCTION

Residential Photo Voltaic (PV) installations exceeded 21 GW by the end of 2011. It was estimated that the rate of increase in the last year (2012) would be 60%, and over 85% of the added power would come from units below 20 kW [1]. This study is concerned with the control of small-scale PV installations, to provide fast maximum power point tracking (MPPT) during normal operation as well as to limit the power level when it becomes excessive. This paper is a continuation in building a hybrid wind–PV generation system [2]–[4]. The main enhancement of the study is a solution regarding the overloading of the system which has happened in many occasions.

The problem directed to this research is the high-power, low-frequency oscillations that can happen during wind turbine soft stalling, overloading the system upto 1.5 times of the rated power. The reduced power mode (RPM) of operation as proposed in this study can be used to suppress the oscillation due to the fast response of the PV generator. Furthermore, excessive solar radiation at a low temperature can also overload the power electronics in the system. Therefore, RPM is essential to limit the power extracted from the PV array to avoid damaging the downstream circuit [5].

Power limiting may also be called upon in islanded, small-scale hybrid systems when the energy storage is full. The PV generator should normally operate in the MPPT mode. Methods for MPPT include “open circuit voltage,” “short circuit current,” “pilot cell,” and “hill climbing” [6]–[7]. Because of the low cost and simplicity in using a dc/dc boost converter, “hill climbing” is perhaps the most widely used and is often implemented in a “perturb–observe” algorithm [8]–[10]. However, the searching process for the maximum power point can easily fail to converge if the radiation changes rapidly and frequently. Incremental conductance (IC) is another interesting method which has previously been verified [11].

To improve convergence, a variable-step incremental conductance method was proposed [12]–[14]. A similar algorithm is proposed in this study with direct duty ratio adjustment. The two key parameters to design such an MPPT controller are: the time interval between two consecutive perturbations (δT_p) and the magnitude of each perturbation to the duty ratio of the dc/dc boost converter (δd_p). This study attempts to establish a design methodology based on a dynamical model of the system for these two parameters, and as a consequence, to optimize the performance of the adopted controller.

Maximum power point tracking (MPPT) operation is mandatory for grid-connected PV systems in order to maximize the energy yield. Catering for more PV installations requires advancing the power control schemes as well as the regulations in order to avoid adverse impacts from PV systems like overloading the power grid [15]. Such an active power control is referred to as a constant power generation (CPG) control or an absolute power control like described in the Danish grid code [16]. Photo Voltaic (PV) power supplied to the utility grid is gaining more and more visibility, while the world's power demand is increasing [17]. Not many PV systems have so far been placed into the grid due to the relatively high cost, compared with more traditional energy sources such as oil, gas, coal, nuclear, hydro, and wind. Solid-state inverters have been shown to be the enabling technology for putting PV systems into the grid.

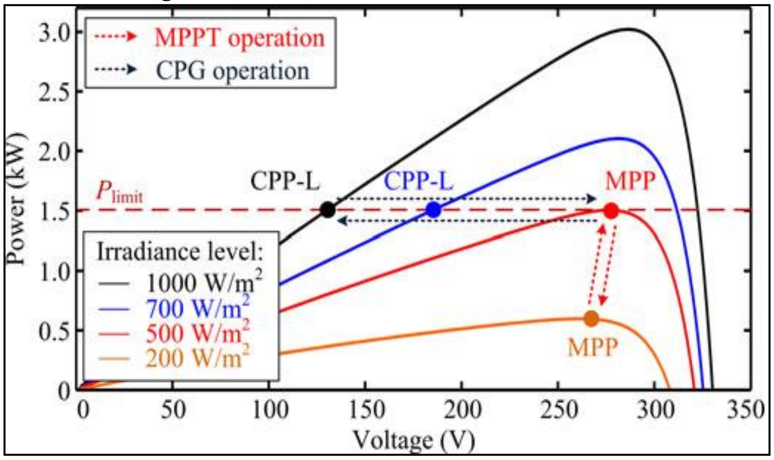

Fig. 1: Operational Principle of the P&O-CPG Algorithm, where the Operating Point is Regulated to the Left side of the MPP Considering Stability Issues

II. Operational principle

The operational principle of the conventional P&O-CPG algorithm is illustrated in Fig. 1. 1) MPPT mode ($P_{pv} \leq P_{limit}$), where the P&O algorithm should track the maximum power and 2) CPG mode ($P_{pv} > P_{limit}$), where the PV output power is limited at P_{limit} [18 19]. During the MPPT operation, the behavior of the algorithm is similar to the conventional P&O MPPT algorithm—the operating point will track and oscillate around the MPP. In the case of the CPG operation, the PV voltage v_{pv} is continuously perturbed toward a point referred to as constant power point (CPP), i.e. $P_{pv} = P_{limit}$. After a number of iterations, the operating point will reach and oscillate around the CPP. Although the PV system with the P&O-CPG control can operate at both CPPs, only the operation at the left side of the MPP (CPP-L) is focused for the stability concern. The control structure of the algorithm is shown in Fig. 2, where v_{pv} can be expressed as $v_{pv} = v_{MPPT}$, when $P_{pv} \leq P_{limit}$ $v_{pv,n} - v_{step}$, when $P_{pv} > P_{limit}$. Where v_{MPPT} is the reference voltage from the MPPT algorithm. $v_{pv,n}$ is the measured PV voltage, and v_{step} is the perturbation step size [20].

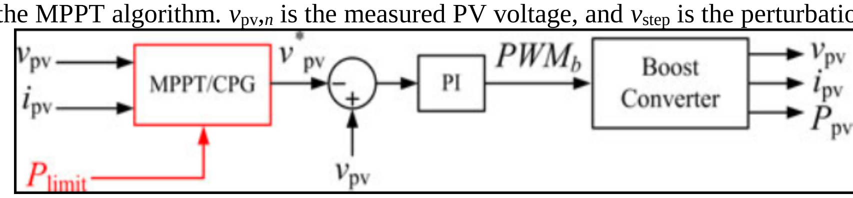

Fig. 2: Control Structure of the P&O-CPG Algorithm, where a PI is adopted

III. Issues of the P&O- CPG algorithm

The P&O- CPG algorithm has a satisfied performance under slow changing irradiance conditions. During a clear day, when the operating point is at the left side of the MPPT, as shown in Fig. 3(a). However, irradiance fluctuation that may happen in a cloudy day will result in overshoots and power losses as shown in Fig. 3(b). Assuming that the PV system is operating in MPPT mode initially and the irradiance level suddenly increases, the PV power P_{pv} is basically lifted by the change in the irradiance as it can be seen from the black arrow trajectory (i.e.,A→B→C) P&O Algorithm Shown in Table 1.As a consequence, large power overshoots may occur [21]. Similarly, if the PV system is operating in the CPG operation (e.g., at CPPL) and the irradiance suddenly drops, the output power P_{pv} will make a sudden decrease. So Some Energy is wasted in this process.

Perturbation	Change in Power	Next Perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

Table 1: Summary of hill climbing and p&o algorithm

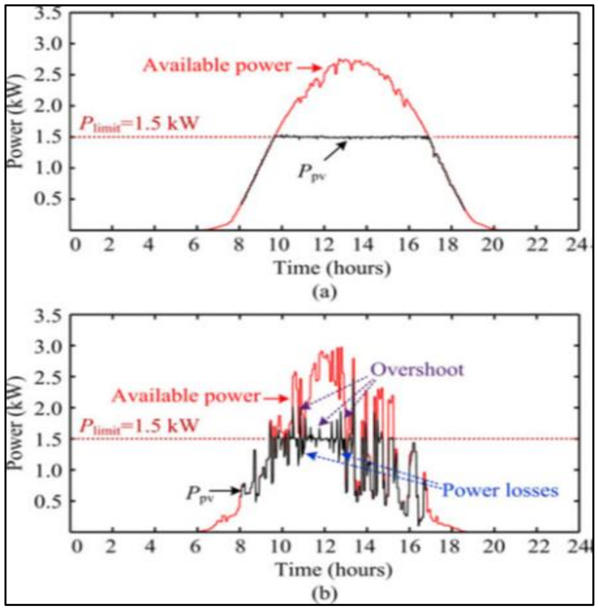

Fig. 3: Experimental Results of the P&O-CPG Algorithm under Two Daily Conditions: (a) Clear Day and (b) Cloudy Day.

IV. INPUT OUTPUT FEEDBACK LINEARIZATION THEORY

The main idea of the input output linearization approach is to design a nonlinear control, which transforms a nonlinear system dynamics into fully or partially decoupled linear subsystems, so that linear control techniques can be easily applied [22,23].Consider a nonlinear multi input multi output system as follows:

$$X = f(x) + g(x).u;\ \ Y = h(x) \qquad (1)$$

Where x is the n x1 state vector, u is the m x 1 control input vector, y is the m x 1 vector of system outputs, f and h are vector fields, and g is an n x m matrix whose columns are vector fields g_i. For obtaining the exact input output feedback linearization, the system outputs y_i must be differentiated until the inputs appear.

Assume that r_i is the smallest integer in a way. In this paper, the current control has been implemented in a rotating synchronous reference frame d, q because the controller can eliminate a steady-state error and has fast transient response by decoupling control Fig [4].A number of techniques are available in the literature for designing the MPPT. Perturb and observe (PO), and incremental conductance method are commonly used techniques in the area of photovoltaic systems. Among the MPPT techniques, the perturbation and observation (P&O) method is the most popular because of the simplicity of its control structure. Yet, in the presence of rapidly changing atmospheric conditions, the P&O MPPT algorithm can be confused due to the fact that it is not able to distinguish the variations of the output power caused by the tracker perturbation from those caused by the irradiance variation. Recently, improved P&O MPPT algorithms for rapidly changing environmental conditions have been proposed by Sera et al. The signal error was designed to reflect the change in power caused by the irradiation variation. Hence, with this information, the proposed algorithm can greatly reduce the power losses caused by the dynamic tracking errors under rapid weather changing conditions [24].

The superiority of the newly proposed method is supported by simulation results. Finally, the stability of the system with the proposed control scheme is investigated by considering the environmental changes. The rest of the paper is organized as follows. Section VI shows the simulation results with the proposed controller under different circumstances. Finally, the paper is concluded in Section VII.

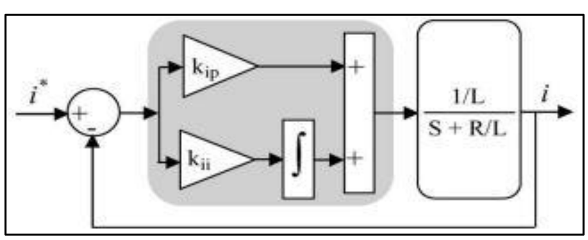

Fig. 4:

A. PI Controller

PI controller is widely used in conjunction with *dq* control, but its implementation in *abc* frame is also possible as described in [25]. The transfer function of the controller in this case and the complexity of the controller matrix in this case, due to the significant off-diagonal terms representing the cross coupling between the phases, is noticeable.

B. Advantages

Using this control method, changes of solar irradiation and temperature do not affect the power factor of the grid [26].It also Regulate the Input Output Current and Voltage.

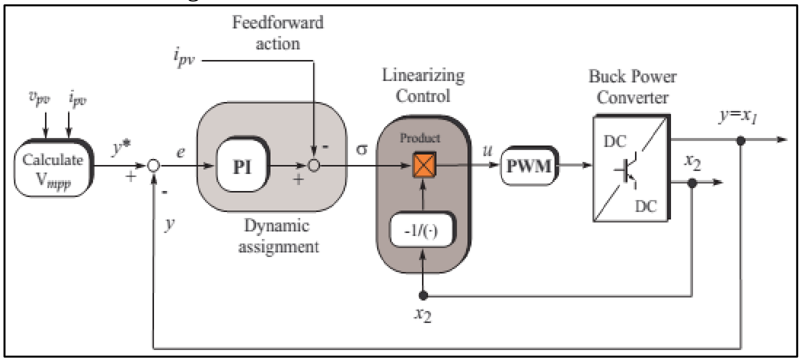

Fig. 5: Linearizing Current Control

V. SIMULATION RESULT

This section presents the simulation results of the conventional PI and PID method in order to validate the performance of the control scheme. Computer simulation has been done using MATLAB/PLECS.PLECS is used for Renewable Sources. It Simulation running time is low When compared the other Software. The full diagram of the control methodology and the modulation is shown in Fig. 6, 7.


Fig. 6: Input Output Voltage and Current.

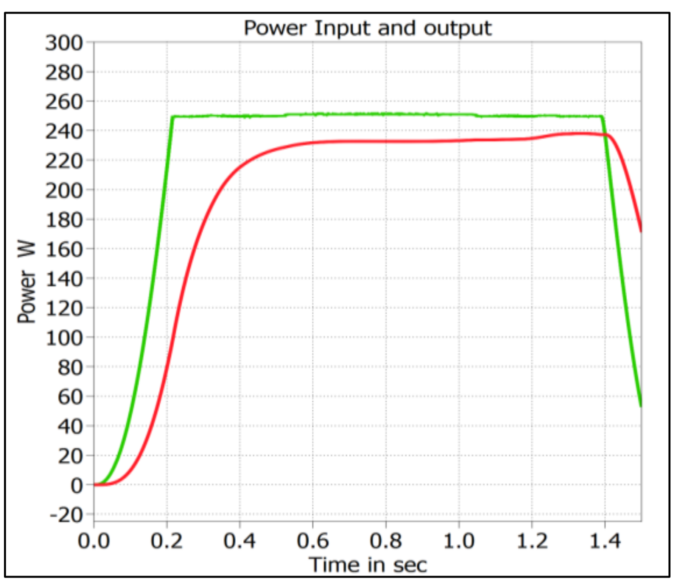

Fig. 7: Input Output Power

VI. CONCLUSION

The control problem of grid-connected photovoltaic arrays is stated as to provide the maximum of power irrespective of the solar irradiance conditions. The main objective of this paper is, to avoid possible mistakes of the classical P&O algorithm due to the fast-changing irradiation. This paper has proposed an improved MPPT controller without PV array power measurement. This MPPT method permits one to differentiate the contribution of increment perturbation and irradiation change in power variation, hence identifying the correct direction of the MPP. The steady-state and dynamic responses illustrated the perfect desired reference tracking controller. Moreover, the output power losses caused by the dynamic tracking errors are significantly reduced, particularly under fast changing irradiation. The proposed control algorithm is simple, robust and easy to implement in real time applications. The MATLAB/ PLECS numerical simulations have shown that the proposed scheme is quite effective at tracking strongly variable irradiance Conditions.

REFERENCES

[1] U.S. Energy Information Administration. International Energy Outlook 2011. (Sep. 2011). [Online]. Available: www.eia.doe.gov/oiaf/ieo/index.html

[2] A. Ahmed, L. Ran, and J. Bumby, “Simulation and control of a hybrid PVwind system,” presented at IET 4th Conf. Power Electron. Mach. Drives,York,2008

[3] A. Ahmed, L. Ran, and J. Bumby, “New constant electrical power softstalling control for small-scale VAWTs,” IEEE Trans. Energy Convers., vol. 25, no. 4, pp. 1152–1161, Apr. 2010.

[4] A. Ahmed, L. Ran, and J. Bumby, “Stalling region instability compensation for constant power soft stalling control,” presented at IETPEMD 2010, Brighton, UK, 2010.

[5] F Giraud and Z Salameh, “Steady-state performance of a grid-connected rooftop hybrid wind–photovoltaic power system with battery storage,”IEEE Trans. Energy Convers., vol. 16, no. 1, pp.1–7, Feb.2001.

[6] T. Esram and P. Chapman, “Comparison of photovoltaic array maximum power point tracking techniques,” IEEE Trans. Energy Convers., vol. 22, no. 2, pp. 439–449, Jun. 2007.

[7] D. Hohm and M. Ropp, “Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed,” presented at IEEE 28th Photovoltaic Spec. Conf., Anchorage, AL, USA, 2000.

[8] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, “A technique for improving P&O MPPT performances of double-stage grid-connected photovoltaic systems,” IEEE Trans. Ind. Electron., vol. 56, no. 11, pp. 4473–4482, Nov. 2009.

[9] E. Koutroulis and N. Voulgaris, “Development of a microcontroller-based, photovoltaic maximum power point tracking control system,” IEEE Trans.Power Electron., vol. 16, no. 1, pp. 46–54, Jan. 2001.

[10] H. Chiu, Y. Lo, C. Yao, T. Lee, J. Wang, and J. Lee, “A modular selfcontrolled photovoltaic charger with interintegrated circuit (I2 C) interface,”IEEE Trans. Energy Convers., vol. 26, no. 1, pp. 281–289, Mar.

[11] S. Azadeh and M. Saad, “Simulation and hardware implementation of incremental conductance MPPT with direct control method using cuk converter,” IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1154–1161,Apr. 2011

[12] F. Liu, S. Duan, F. Liu, B. Liu, and Y. Kang, “A variable step size INC MPPT method for PV systems,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2622–2628, Jul. 2008.

[13] M. Qiang, S. Mingwei, L. Liying, and M. G. Josep, “A novel improved variable step-size incremental-resistance MPPT method for PV systems,” IEEE Trans. Ind. Electron., vol. 58, no. 6, pp. 2427–2434, Jun. 2011.

[14] A. Pandey, N. Dasgupta, and A. K. Mukerjee, “High-Performance algorithms for drift avoidance and fast tracking in solar MPPT system,” IEEE Trans. Energy Convers., vol. 23, no. 2, pp. 681–689, Jun.2008.

[15] Thomas Stetz, Frank Marten and Martin Braun, Member; IEEE “Improved Low Voltage Grid Integration of PhotoVoltaic Systems in Germany” IEEE Transactions on Sustainable Energy.

[16] Ashraf Ahmed Member, IEEE, Li Ran,Senior Member;IEEE ,Sol Moon,and Joung-Hu Park, Member,IEEE “A Fast PV Power Tracking Control Algorithm With Reduced Power Model” IEEE Transactions on Energy Conversion. Vol. 28, No. 3, Sep 2013.

[17] Trishan Essain Student Member;IEEE and Patricle L.chapman,Senior Member;IEEE “Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques”. IEEE Trans VOL. 22, NO. 2, June 2007.

[18] Y. Yang, H. Wang, F. Blaabjerg, and T. Kerekes, “A hybrid power control concept for PV inverters with reduced thermal loading,” IEEE Trans.Power Electron., vol. 29, no. 12, pp. 6271–6275, Dec. 2014.

[19] Y. Yang, F. Blaabjerg, and H. Wang, “Constant power generation of photovoltaic systems considering the distributed grid capacity,” in Proc. Appl.Power Electron. Conf., Mar. 2014, pp. 379–385.

[20] Messai A, Mellit A, Guessoum A, Kalogirou SA. Maximum power point tracking using a GA optimized fuzzy logic controller and its FPGA implementation. Solar Energy 2011.

[21] Ariya Sangwongwanich Yongheng Yang, and Frede Blaabjerg “High Performance Constant Power Generation in Grid Connected PV Systems” IEEE Transactions on Power Electronics,Vol .31, No3 March 2016

[22] Isidori A. Nonlinear control systems. Springer Verlag; 1989

[23] Slotine JJE, Li w. Applied nonlinear control. Printic Hall; 1991.

[24] M.VijayRao1, M.Prashanth Reddy2, B.Sreedhar Reddy3”Voltage-Oriented Control Of a Grid Connected PV System By Modified MPPT Algorithm” Volume I, Issue1 Dec 2013.

[25] D. Sera, T. Kerekes, R. Teodorescu, and F. Blaabjerg, “Improved MPPT method for rapidly changing environmental conditions,” in Proc. IEEE Int. Symp. Ind. Electron., 2006, vol.2, pp.1420 -1425.

[26] V. V. R. Scarpa, S. Buso, and G.Spiazzi, “Lowcomplexity MPPT technique exploiting the PV module MPP locus characterization,” IEEE Trans. Ind. Electron., vol. 56, no. 5, pp. 1531–1538, May 2009.