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Control of Grid Connected Photovoltaic Energy Conversion System

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***Abstract*— This paper presents a control grid command photovoltaic system robust against non-linéaire load. The terminal voltage of photovoltaic arrays is regulated by a DC/DC converter in order to extract the maximum power point–amount of from the photovoltaic generator. The grid interface inverter transfers the energy drawn from the PV module into the grid by keeping common dc voltage constant. The results of the simulation in Matlab / Simulink show improved performance and dynamic behavior of the control grid connected photovoltaic system.**

***Keywords*— Renewable energy, grid interconnection, photovoltaic, non-linear load, inverter, control, performance.**

I. INTRODUCTION

Renewable energy acquires growing importance due to its enormous consumption and exhaustion of fossil fuel. Moreover, solar energy is non-polluting and is the best among all the renewable energy sources (RES) [1]. . In recent years, there has been an enormous interest in many countries on renewable energy for power generation and the integration of a photovoltaic (PV) system into grid has become. However the extensive use of power electronics based equipment an non-linear loads at point common control generate harmonic currents, which may deteriorate the quality of power [2, 3]. However, a photovoltaic generator (PVG) is requested. The PVG is composed by the cells connected like series and parallels according to the required power. But, the operation point of PVG is sensitive in variable atmospheric conditions: lead, illumination and temperature) [4]. Consequence, it is impossible to use all solar energy when, it is not controlled. All photovoltaic systems are interfacing the utility grid through a voltage source inverter [5-8]. Many demands such as power quality are requests. As a consequence, large research efforts are put into the control of these systems in order to improve their behavior.

Renewable energy resources are being increasingly connected in distribution systems using power electronic converters where the inverter (DC/AC) is the key component for successful operation of the grid connected PV system. The solar systems are more and more employed for sector where electricity was not accessible. But, the non-linear loads cause unwanted harmonics in the network and consequently it is necessary to include in the installation dispositive compensation. This work presents a other structure that allows to control the connection a system of renewable energy to the grid and also to compensate the harmonic non-linear load. The simulation results under Matlab/Simulink show the control performance and dynamic behavior of grid connected photovoltaic system.

The paper is arranged as follows: Section II describes the system study. In section III , the model and control for grid-interfacing inverter are developed. A digital simulation study is presented and the results are discussed in section IV. Finally, Section V concludes the paper.

II. SYSTEM CONFIGURATION

The system study consists of renewable energy source connected to the DC/DC converter of a grid-interfacing inverter as shown in Fig. 1. The structure of system consist to a distribution network connected to the consumers of electrical energy via a transformer and a distribution line. The consumer at the end of the line is defined by linear and nonlinear loads whose last usually creates undesirable

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harmonic. Finally, a PVG mainly connected to the network via a DC converter and a filter. Fig 2 shows the power converter structure used to interface the photovoltaic array with the power grid. The DC converter, which will raise the solar voltage to a level suitable for the dc connected to the inverter. The inverter that operates in a current controlled mode which will inject unity power factor current to the grid [9]. The output filter is employed to reduce the ripple components due to PWM switching operation.

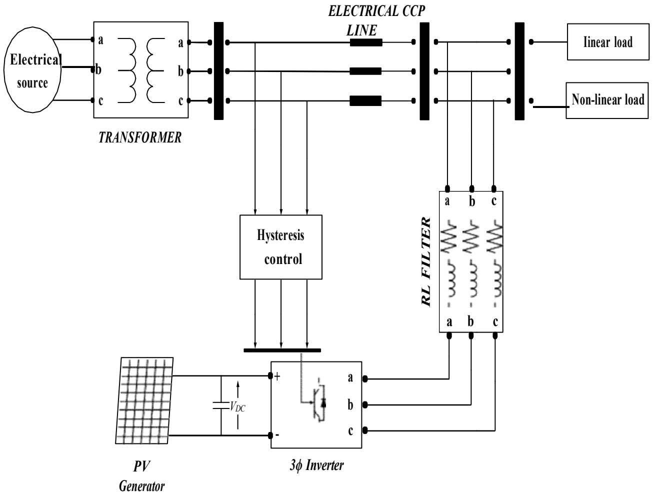

Fig.1 General diagram of grid connected photovoltaic system

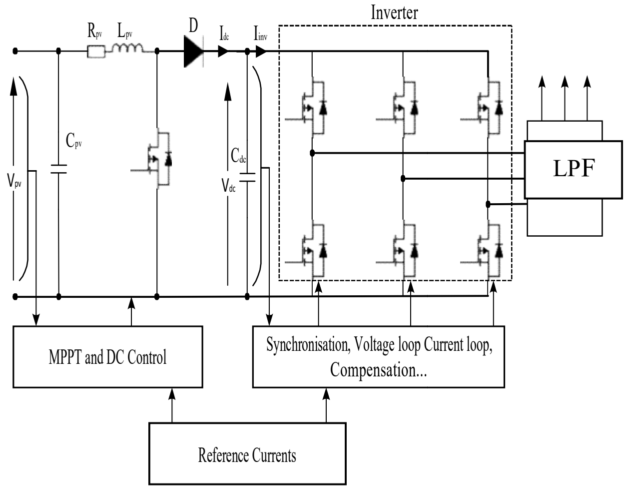

Fig.2 Schematic of renewable energy source connected of distributed generation system

The grid synchronizing angle obtained from phase locked loop (PLL) is used to generate unity vector template as [10-12] . The terminal voltage of PV arrays is regulated by a DC/DC converter to track maximum power point (MPPT).

III. CONTROL OF GRID-CONNECTED PV SYSTEMS

The PV system must be capable of tracking the solar arrays maximum power point that varies with the solar radiation value and temperature. The tracking maximum power point (MPPT) requires the measurement of the photovoltaic voltage and current as shown in Figure 2, Previous. The finality of MPPT law is to find the adequate voltage V_{pv}*. The open and closed switches are supposed idealized and commendable by the external control. Fig. 3 represents the structure of grid-interfacing inverter control.

Thus the output of dc-link voltage regulator results in an active (I_{max}) .The multiplication of active current component (I_{max}) with unity grid voltage vector templates (U_a, U_b and U_c) generates the reference grid currents I_{aref}, I_{bref} and I_{cref}. The actual dc-link voltage is sensed and passed through a first-order low pass filter (LPF) to eliminate the presence of switching ripples on the dc-link voltage and in the generate dereference current signals. The difference of this filtered dc link voltage and reference dc-link voltage *Vdc_ref* is given to a discrete-PI regulator to maintain a constant dc-link voltage under varying generation and load conditions.

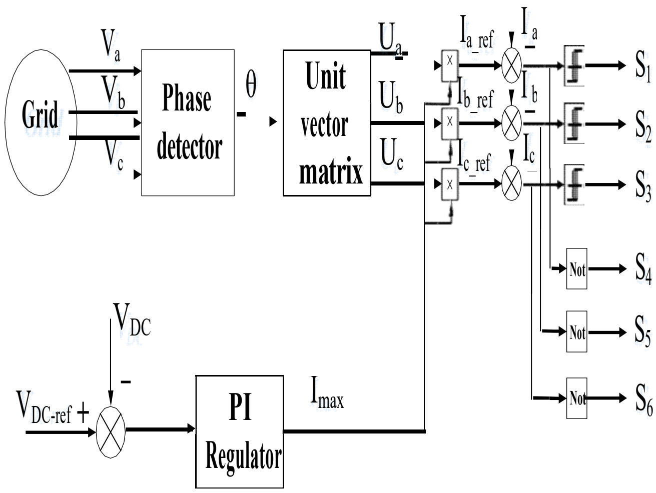

Fig.3 Controls DC voltage and inverter structure

$$\begin{cases} U_a = \sin(\theta) \\ U_b = \sin(\theta - \frac{2\pi}{3}) \\ U_c = \sin(\theta + \frac{2\pi}{3}) \end{cases} \quad (1)$$

$$\begin{cases} I_{aref} = U_a . I_{max} \\ I_{bref} = U_b . I_{max} \\ I_{cref} = U_c . I_{max} \end{cases} \quad (2)$$

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The model inverter is presented by the following equations

$$\begin{cases} \dfrac{dI_{a\_inv}}{dt} = \dfrac{(V_{a\_inv} - V)}{L_{fil}} \\ \dfrac{dI_{b\_inv}}{dt} = \dfrac{(V_{b\_inv} - V)}{L_{fil}} \\ \dfrac{dI_{c\_inv}}{dt} = \dfrac{(V_{c\_inv} - V)}{L_{fil}} \\ \dfrac{dV_{dc}}{dt} = \dfrac{(I_{ad} + I_{bd} + I_{cd})}{C_{dc}} \end{cases} \quad (3)$$

Where, V_{inva}, V_{invb}, and V_{invc} are the three-phase ac switching voltages generated on the output terminal of inverter. These inverter output voltages can be modeled in terms of instantaneous dc bus voltage and switching pulses of the inverter as:

$$\begin{cases} V_{a\_inv} = (P_1 - P_4).\dfrac{V_{dc}}{2} \\ V_{b\_inv} = (P_2 - P_5).\dfrac{V_{dc}}{2} \\ V_{c\_inv} = (P_3 - P_6).\dfrac{V_{dc}}{2} \\ V_{a\_inv} = (P_1 - P_4).\dfrac{V_{dc}}{2} \end{cases} \quad (4)$$

$$\begin{aligned} I_{ad\_inv} &= (P_1 - P_4).I_{a\_inv} \\ I_{bd\_inv} &= (P_1 - P_4).I_{a\_inv} \\ I_{ad\_inv} &= (P_1 - P_4).I_{a\_inv} \end{aligned} \quad (5)$$

IV. Simulation Results

The simulations consisted to trace the shapes of the voltages, currents and powers at various points in the distribution system: the point B1 , between the source and the transformer, B2 between the transport line and the point B3 connection of renewable energy into the grid and consumer (variable load) under the constraint of a variable radiation.

Figure 4 represents the shape of radiation regarded during the period of simulation, varying between 950 and 1000, this to get closer to the real case. Figure 5 shows the output voltage of the PV array and its reference value (imposed). Note that the tension perfectly follows its reference with good performances: slight overshoot of about 6% maximum and a response time of 0.18 seconds.

Figures 6,7 and 8 show the voltage waveforms of (a) and current (b) respectively to points B1, B2 and B3. For this, in the evolution of the radiation (see Figure 4), we first connected the linear load to a second. Thus, we notice that the voltages and currents are sinusoidal, without distortion. For against, when you connect the nonlinear load (three phase uncontrolled rectifier) from 0.1 s to 0.2 s , current presentt distortion due to the injection of harmonics by the nonlinear load. Finally from 0.2s to the end of the simulation is to say 0.35s, the renewable energy source is connected to the network, and this action prevents harmonic reaching the network and the current becomes sinusoidal. Fig.9 shown the active and reactive powers for all opérations.

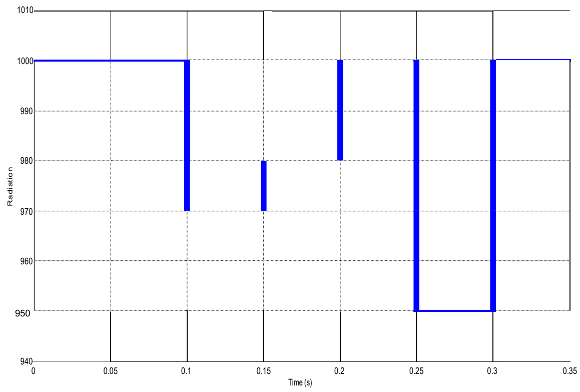

Fig.4 Evolution of radiation

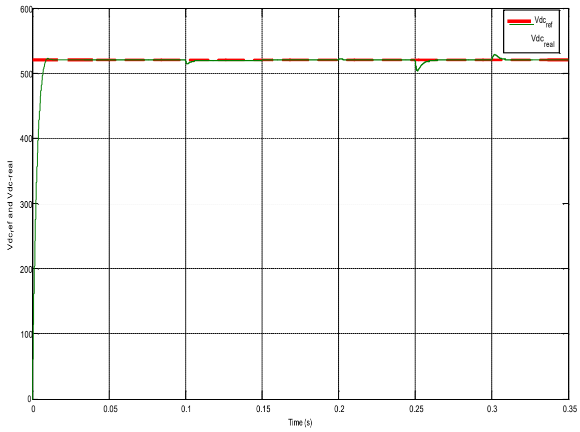

Fig.5 Output voltage of PVG

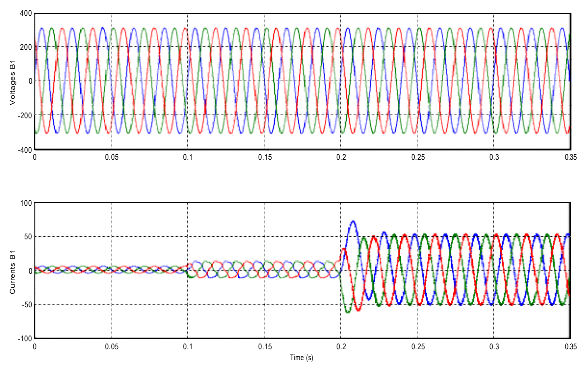

Fig.6 Currents and voltages in B1

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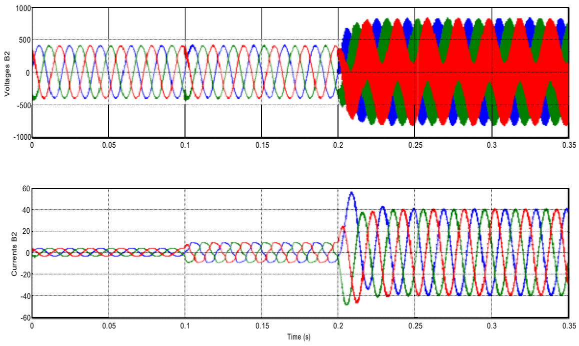

Fig.7 Currents and voltages in B2

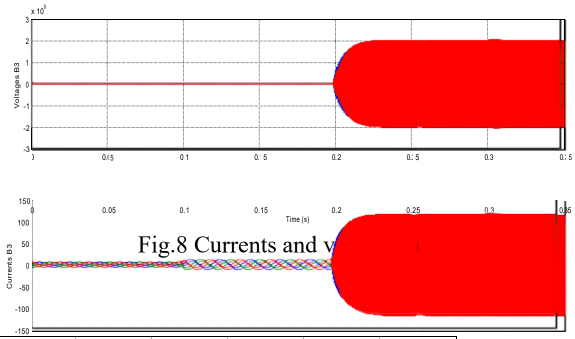

Fig.8 Currents and v

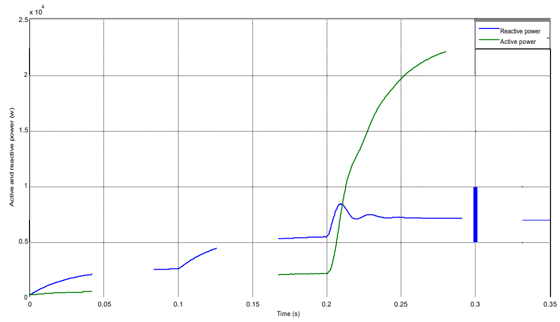

Fig.9 Active and reactive powers

V. CONCLUSION

This paper treats an approach of modeling and control of a grid connected photovoltaic system. The tracking maximum power point controller is used to extract the optimal photovoltaic power, a current and a dc link voltage regulator are used to transfer the photovoltaic power to the grid. The control structure of the connection of system of renewable energy to the grid allows to compensate effectively the harmonic currents and to improve the quality of distribution generator system. The simulated model and the results, obtained for standard operating conditions, are shown the performances of the grid connected photovoltaic.

REFERENCES

[1] Mohamed A. Eltawil, Zhengming Zhao "Grid-connected photovoltaic power systems: Technical and potential problems—A review" Renewable and Sustainable Energy Reviews , Vol 14, pp. 112–129, 2010.

[2] J. M. Guerrero, L. G. de Vicuna, J. Matas, M.Castilla, and J. Miret, "A wireless controller to enhance dynamic performance of parallel inverters in distributed generation systems," IEEE Trans.Power Electron.,vol. 19, no. 5, pp. 1205–1213, Sep. 2004.

[3] J. H. R. Enslin and P. J. M. Heskes, "Harmonic interaction between a large number of distributed power inverters and the distribution network," IEEE Trans. Power Electron., vol. 19, no. 6, pp. 1586–1593,Nov. 2004.

[4] Calais M, Myrzik J, Spooner T, Agelidis VG. Inverters for single-phase grid connected photovoltaic systems—an overview. In: IEEE power electronics specialists conference PESC'01; 2001.

[5] F. Blaabjerg, Z. Chen and S. Kjaer, 'Power Electronics as Efficient Interface in Dispersed Power Generation Systems', IEEE Trans. on Power Electronics, Vol. 19, N°5, pp. 1184 - 1194, 2004.

[6] J. Liang, T. Green, G. Weiss and Q.C. Zhong, 'Evaluations of Repetitive Control for Power Quality Improvements of Distributed Generation', In Proc. of Pesc'02, Vol. 4, Cairns, Qld, pp. 1803 – 1808, 2002.

[7] P. Mattavelli and F. Marfao, 'Repetitive-Base Control for Selective Harmonic Compensation in Active Power Filters', IEEE Trans. on Industrial Electronics, Vol. 51, N°5, pp. 1018 - 1024, 2004.

[8] F. Kanellos and N. Hatziargyriou, 'A New Control Scheme for Variable Speed Wind Turbines Neural Networks', IEEE Power Engineering Society Winter Meeting, Vol. 1, pp. 360 - 365, 2002.

[9] S. Radha Krishna Reddy , Dr. JBV Subrahmanyam, N.Rakesh , " A Novel Approach on Grid Interconnection of Renewable Energy Sources at the Distribution Level with Power-Quality Improvement Features ", International Journal of Wind and Renewable Energy Volume 1 Issue 2 (Page, 137-143), ISSN: 2277-3975.

[10] V. Khadkikar, A. Chandra, A. O. Barry, and T. D. Nguyen, "Application of UPQC to protect a sensitive load on a polluted distribution network," in Proc. Annu. Conf. IEEE Power Eng. Soc. Gen. Meeting,2006, pp. 867–872.

[11] M. Singh and A. Chandra, "Power maximization and voltage sag/swell r34th Annu. Conf. Indus. Electron.Soc., 2008, pp. 2206–2211.

[12] P. Rodríguez, J. Pou, J. Bergas, J. I. Candela, R. P. Burgos, and D.Boroyevich, "Decoupled double synchronous reference frame PLL for power converters control," IEEE Trans. Power Electron, vol. 22, no. 2, pp. 584–592, Mar. 2007.

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