RESEARCH OF INTEGRATED INVERTER STRUCTURE FOR GRID CONNECTED PHOTOVOLTAIC SYSTEM WITH MAXIMUM POWER TRACKING

Neeraj Priyadarshi,Dr.R.R.Joshi
Department of Electrical Engineering,CTAE, Udaipur

***Abstract*—** An inverter for grid-connected photovoltaic systems is presented in this paper. It can globally locate the maximum power point of the panel over wide insulation and feed the solar energy to the grid. Its structure mainly integrates a previously developed maximum point tracking method and output current shaping function into a buck-boost-derived converter and then inverts the shaped current through a grid frequency bridge to the grid. Instead of having a storage capacitor connecting in parallel with the converter output, series connection is used, so that the required capacitor voltage rating is lower than that in classical inverters. Most importantly, the inverter output current harmonics are less sensitive to the capacitor value. The tracking capability, inversion efficiency, and large-signal responses at different insulations have been investigated. Detailed analysis on the inverter performance has been performed.

***Index Terms*—** DC/AC power conversion, inverters, and photovoltaic systems.

1. INTRODUCTION:

With the continuous consumption of fossil fuel, energy crisis and environmental pollution have become extraordinarily severe to affect human's survival and development. As a result, exploitation and utilization of sustainable energy have become key factors adopted in energy consumption adjustment in every country. Among various sustainable power generation methods, grid-connected photovoltaic (PV) generation has been exploited and utilized around the world. Due to rapid growth in semiconductor and power electronics technology, photovoltaic (PV) energy is of increasing interest in electrical power applications. Photovoltaic resource among all the renewable is considered to be increasingly important for power generation in last few decades. This has resulted not only decreased dependence on fossil fuel but also in emission of greenhouse gases. Photovoltaic for power generation is considered ideal resource in the distributed generation system, which are located at or near to the load point. The advancement of power electronics and semiconductor technologies, the declining cost of solar panels, and the favorable incentives in a number of countries had profound impact on the commercial acceptance of grid-connected PV systems—which have been used in peak shaving, demand reduction, and supply of remote loads. Apart from the solar panels, the core technology associated with these systems is a power-conditioning unit (inverter) that converts the solar output electrically compatible with the utility grid. Most inverters in the mid 1990's consisted of a central inverter of dc power rating above 1 kW. They connect several solar panel strings in parallel via a dc bus. However, the concept has the drawbacks of causing a complete loss of generation during inverter outage and losses due to the mismatch of strings. Later, string inverters, which are designed for a system of one string of panels, were used to lessen the problems and have become popular nowadays. With further system decentralization, concept of "AC-module" was introduced. Every Solar panel has a module-integrated inverter of power rating below 500 W mounted on the backside. This panel inverter integration allows a direct connection to the grid and provides the highest system flexibility and expandability. It also offers the possibilities to overcome problems with respect to high dc voltage level connection, safety, cable losses, and risk of dc arcs, and to achieve high-energy yield in case of system suffering from shading effect, due to the lack of mutual influence among modules' operating points. Typical structures of the AC-module consist of several power conversion stages (Fig.1)

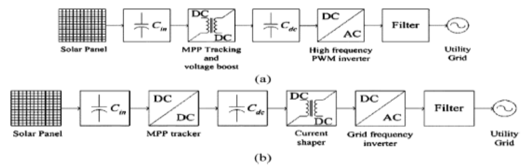

Fig. 1. Typical structures of grid-connected PV systems. (a) With voltage-fed, self-commutated inverter switching at high frequency. (b) With current-fed, grid-commutated inverter switching at the grid frequency.

The front stage has a maximum power point (MPP) tracker for maximizing the output power of the panel, because the maximum power drawn from the panel varies with temperature and insulation. The grid-connected stage uses a full-bridge inverter toward the grid, either self-commutated with a high switching frequency [Fig. 1(a)], or grid-commutated at the grid frequency [Fig. 1(b)]. In the former structure [Fig. 1(a)], the panel voltage is firstly boosted to the grid level together with the tracker. The dc/ac conversion stage, which is usually a pulse-width-modulated (PWM) voltage-source inverter, shapes and inverts the output current. A high-frequency filter is used to eliminate the high-frequency component at the inverter output. In the latter structure [Fig. 1(b)], the tracker, voltage boost, and output current shaping are performed in the front stage. The full bridge is switched at the grid frequency for inverting the shaped output current. Majority works usually emphasize on researching new

MPP tracker and refining individual converter stage. However, the system complexity is still governed by the multistage structure, as depicted in Fig. 1. This paper proposes a buck-boost-derived converter that integrates the functions of the MPP tracker and current shaper in Fig. 1(b). Low component count and the use of low-voltage-rating capacitor are the key advantages of this converter. The output current harmonics are also less sensitive to the storage capacitor value. Tracking of the MPP is based on the switching frequency modulation scheme (SFMS) . Shaping of the output current is based on controlling the converter’s output pulse duration such that its average value is proportional to the required current reference in each switching cycle. A 30-W laboratory prototype has been built. The tracking capability, inversion efficiency, and large-signal responses at different insulation can be investigated. Detailed analysis on the inverter performance can be performed.

II. OPERATING PRINCIPLES OF THE INVERTER:

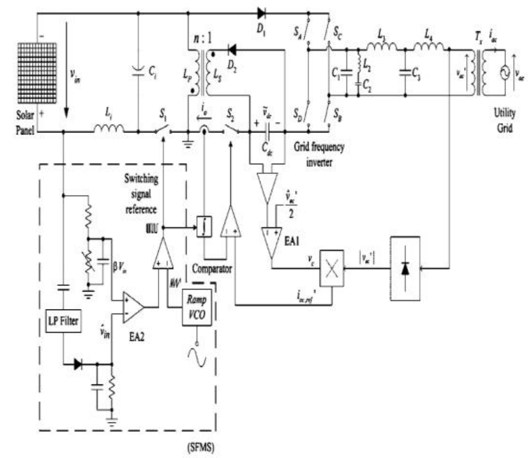

Fig. 2. Circuit schematics of the proposed inverter.

Fig. 2 shows the circuit schematics of the inverter consisting of two stages. The first stage is a buck-boost-derived converter operating in discontinuous conduction mode. It is formed by S1, Lp,D1,S2for tracking the MPP of the panel and shaping the output current . The input filter formed by Li and Ci is used to smooth the panel output current. The MPP tracking method in [11] is used. Its technique is to perturb the switching frequency of S1 and compare the ac component and the average value of the panel voltage to control the duty cycle of S1 . The MPP can be globally located over wide insulation. When is S1 on, S2 and D1 are off. Lp stores energy. When S1 is off, both D1 and S2 are on. The energy stored in Lp and Cdc will transfer to the output. S2 will be switched off when the integrated value of i0 is larger than that of the required output current i’ac,ref switching period Ts . Lp acts as a buffer that temporarily stores panel energy and transfers it to the output in a switching cycle. If the panel power output is higher than the power absorbed by the grid in one cycle, the energy remaining in Lp after switching off S2 will transfer to Cdc through Ls and D2. Since the average voltage across Cdc will be shown to be equal to half of the peak output ac voltage v'ac, it is used to regulate i'ac,ref , and so i0 . Thus, the series connection of Lp and Cdc in transferring energy tothe grid provides the advantages of shaping the current and reducing the voltage stress on Cdc . The second stage is a grid frequency inverter formed by switches SA, SB,SC , and SD,SA and SB are switched on in the positive half cycle of the grid voltage, whilst SC and SD are switched on in the negative half cycle of the grid voltage. For the output filter section, C1 is used to absorb the current difference between i0 and the currents through L2 and L3 when S2 and D1 are on.L2-C2 and L3-C3 have the resonant frequency at the switching frequency of S1 for keeping the line-frequency and attenuating the high-frequency voltage components across C1 and C3.L4 is used to filter the high frequency current components going out to the grid. The transformer Tx is used to adjust the voltage level between the inverter output and the grid voltage.

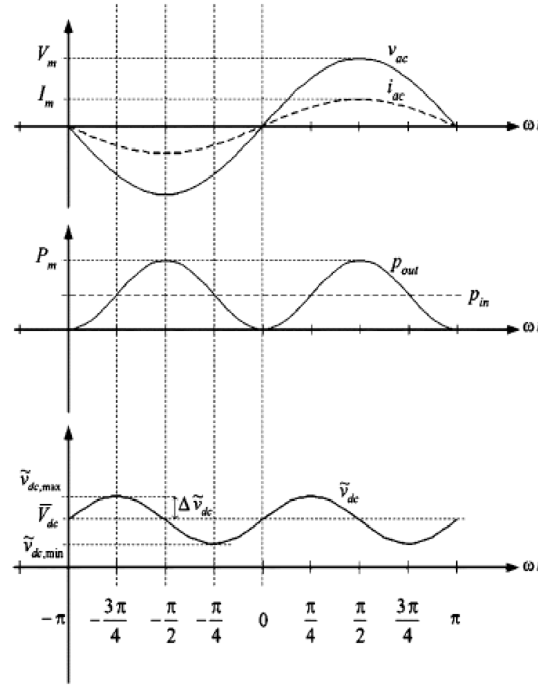

Fig. 3. Relationships among v_{ac}, i_{ac}, $\tilde{v}_{dc}$, p_{in}, and p_{out}.

III.CONCLUSION:

This paper has discussed the implementation and performance of an integrated inverter for photovoltaic systems. The inverter provides the function of tracking the MPP of the panels and shaping the output current over wide insulation level. A 30-W laboratory prototype has been built. The tracking capability, inversion efficiency, and large-signal responses at different insulations have been investigated. Theoretical predictions have been confirmed with the experimental results of the prototype.

IV.REFERENCES:

[1] G. Foley, "Photovoltaic applications in rural area of the developing world," Tech. Rep., World Bank, New York, 1995.

[2] C. J. Hatiziadoniu, F. Chalkiadakis, and V. Feiste, "A power conditioner for a grid-connected photovoltaic generator based on the 3-level inverter," *IEEE Trans. Energy Conv.*, vol. 14, no. 4, pp. 1605–1610, Dec. 1999.

[3] K. Y. Khouzam, "Technical and economic assessment of utility interactive PV systems for domestic applications in South East Queensland," *IEEE Trans. Energy Conv.*, vol. 14, no. 4, pp. 1544–1550, Dec. 1999.

[4] T. Markvart, *Solar Electricity*. New York: Wiley, 1994.

[5] H. Becker, K. Kiefer, V. Hoffmann, U. Rindelhard, and G. Heilscher, "Five years of operational experience in the German 1000-Roofs-PV programme—results of monitoring and system inspection," in *Proc. 14th Eur. Photovoltaic Solar Energy Conf.*, Barcelona, Spain, Jul. 1997, pp. 1677–1680.

[6] H. Oldenkamp, I. De Jong, C. Baltus, S. Verhoeven, and S. Elstgeest, "Reliability and accelerated life tests of the ac module mounted OKE4 inverter," in *Proc. 25th IEEE Photovoltaic System Conf.*, May 1996, pp. 1339–1342.

[7] A. Lohner, T. Meyer, and A. Nagel, "A new panel-integratable inverter concept for grid-connected photovoltaic systems," in *Proc. IEEE Int. Symp. Industrial Electronics*, Jun. 1996, pp. 827–831.

[8] M. Meinhardt *et al.*, "Miniaturized low profile module integrated converter for photovoltaic applications with integrated magnetic components," in *Proc. IEEE Applications Power Electron. Conf. Expo.*, Mar. 1999, pp. 305–311.

[9] M. Calais, J. Myrzik, T. Spooner, and V. Agelidis, "Inverters for single-phase grid connected photovoltaic systems—an overview," in *Proc. IEEE Power Electronic Specialists Conf.*, Jun. 2002, pp. 1995–2000.

[10] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "Power inverter topologies for photovoltaic modules—a review," in *Proc. IEEE Industry Applications Conf.*, vol. 2, 2002, pp. 782–788.

[11] K. K. Tse, M. T. Ho, H. Chung, and S. Y. R. Hui, "A novel maximum power point tracker for PV panels using switching frequency modulation," *IEEE Trans. Power Electron.*, vol. 17, no. 6, pp. 980–989, Nov. 2002.

[12] Y. Chen, K. Smedley, F. Vacher, and J. Brouwer, "A new maximum power point tracking controller for photovoltaic power generation," in *Proc. IEEE Applications Power Electronic Conf. Expo*, Mar. 2003, pp. 58–62.

[13] K. Smedley and S. Cúk, "One-cycle control of switching converters," *IEEE Trans. Power*

Electron., vol. 10, no. 6, pp. 625–633, Nov. 1995.

[14] D. Maksimovic and S. Cúk, "A unified analysis of PWM converters in discontinuous modes," *IEEE Trans. Power Electron.*, vol. 6, no. 3, pp. 476–490, Jul. 1991.

[15] *User's Manual of PSIM 4.1*, Powersim Technologies Inc., 2000.

[16] *IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems*, IEEE Std. 929-2000, Jan. 2000