A COMPARATIVE ANALYSIS OF NOVEL BOOSTING CONVERTER FOR RENEWABLE ENERGY APPLICATION

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Abstract— A hybrid boosting converter(HBC) having collective advantages of regulation competence from its boost structure and enhancement of the gain from its voltage multiplier structure is forthput in this paper. New converter incorporates a bipolar voltage multiplier, prominent symmetrical configuration, single inductor and single switch, high gain capability with wide regulation range, low component stress,small output ripple and obsequious extension, which make it suitable for front-end PV system and some other renewable energy applications. In the proposed work operation principle and voltage ripple are analysed. A 200-W 35V to 415V second order HBC prototype using open loop was designed. In proposed methodnew HBC with PI controller is designed and Induction Motor Drive is connected as the load and verified the performance. The simulation results assure the practicability of the converter

Index Terms- Bipolar voltage multipier (BVM), hybrid boosting converter (HBC), nature interleaving, renewable energy, single switch single inductor.

I. Introduction

Fossil fuels are depleting day by day, therefore it is imperative to find out alternative methods in order to fulfill the energy demand of the world. Renewable energy is becoming more important nowadays. There exist applications of renewable energy which employ hundred of MW (high power) and there are also those which uses hundred of W (low power). Applications can also be classified depending if they are connected to the grid or not, as well known as cogeneration and stand alone systems. This last one is a low power application, specially employed in remote places, where electricity is not available. Usually photovoltaic and wind systems are the source of energy in stand alone systems. Efficient use of energy is very important, since there is no utility line; a battery set becomes essential because energy power is provided in an irregular way from the renewable source; leaving aside this issue a power conversion stage is required in order to make sure a good output power quality. The operation of a dc/dc converter applicable in stand alone systems is discussed in this chapter, which is for using clean energy as it could be a photovoltaic panel or a wind turbine. The system optimizes delivered energy in a smart way, but assuring its availability in the best possible way. Chapter is organized as follows: stand alone systems are described first, later on some converters reported in literature are discussed, and finally operation, energy administration and results of a dc/dc converter for clean-energy applications are presented.

II. Stand alone systems and renewable sources

Energy is not provided from the utility line for the stand alone systems but from renewable source, which depends on weather conditions. So that, in order to make sure there will exist availability of energy, when load required it, a battery set is traditionally considered. Power consumption is restricted to a maximum limit and it also is a finite measurable quantity, to deliver the more amount of energy its use has to be optimized. A block diagram for stand alone systems is shown in Figure 1. Photovoltaic panel, wind turbine system or both can be used as renewable source of energy; reliable energy is provided by a power converter, which is fed from the renewable source and the battery set, it focus mainly to deliver a regulated voltage to the load.

Certainly weather conditions restrict the renewable sources, but output power not only depends on wind speed or solar irradiance when it is employed a turbine system or a photovoltaic panel, also depend on the load. System behaviour for constant weather conditions is shown in Figure 2; traditionally the output power is plotted against its output voltage, but particularly for this graph the load is been changed, because the system depends on it. For different weather conditions similar graph can be obtained but the power varies according it.

When a renewable source is connected to a load not necessarily the maximum output power is consumed, as it is shown between A and B points in Figure 2. A maximum power point tracker (MPPT, point B) is employed in order to optimize the obtained energy; however this is not completely required in stand alone application, due to the load is fixed or bounded and the power system requirements could be lower than the maximum obtainable from the renewable source.

When considering a photovoltaic system and a specific load connected to the stand alone system, there exist two different possibilities: first one occurs if the maximum energy obtained from the panel is lower than the output power (point C) then it is necessary to use a battery in order to deliver the required amount of energy to the load; secondly, it may happen that the maximum energy obtained from the panel is higher or equal than the output power (a point between A and B) then no battery is needed. A power converter must take into account these two scenarios in its operation form in order to provide a constant regulated output voltage no matter weather conditions. Obviously the amount of energy is finite and depends on the battery set and the climatic conditions.

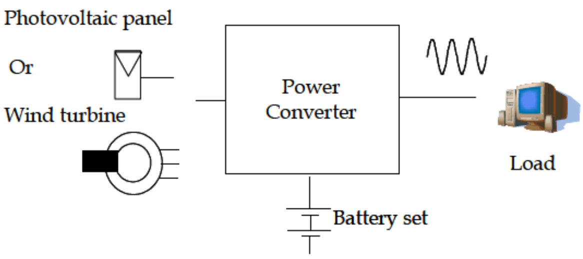

Fig. 1. Block diagram for stand-alone system

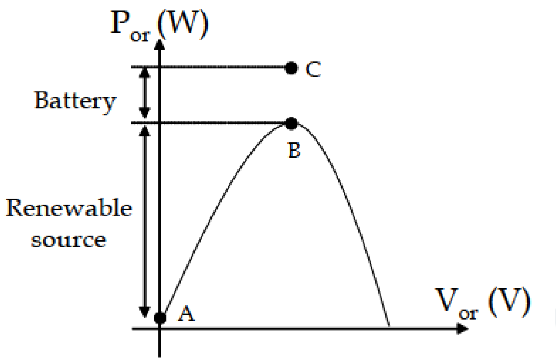

Fig. 2. Characteristic waveforms of renewable sources

III. Power Conversion For Renewable Systems

Power converters normally reported in literature (Carrasco et al., 2006) consider not only different power stages, but also different ways of operation. Some of them are connected to the grid but some others are stand alone systems. Fortunately, two types of converters are typically used no matter configuration: a dc/dc converter and a dc/ac converter. This section describes some topologies reported in literature for renewable systems dealing with photovoltaic and wind systems.

A. Grid connected systems

Grid connected systems deliver the maximum obtainable power to the ac mains from the photovoltaic (PV) and/or wind system (Carrasco et al., 2006); since the provided energy is variable and dependent on weather conditions, the possible released energy is also variable. Algorithms like improved perturbation and observation method (Femia et al., 2009), sliding mode observer technique (Kim et al., 2006), or some others (Park et al., 2006; Kwon et al., 2006) are used to track the maximum power point (MPP). In order to increase the system efficiency is preferred to have low voltage with the solar cell array (Ertl et al., 2002), and also some wind systems generate relatively low voltage. Therefore, converter in these application require boosting type converters, Figure 3 shows different topologies which provide current to the ac-mains. Figure 3(a) shows a topology which considers two stages: a dc/dc boost converter and a dc/ac converter (Kwon et al., 2006). Dc/dc is used for increasing the output voltage at a constant level allowing interaction to ac mains on the inverter stage, which is employed in order to perform the MPPT and deliver a sinusoidal current to the utility line. Converter illustrated in Figure 3(b) has also two stages: multiple isolated dc/dc converters and a multilevel inverter (Ertl et al., 2002); first stage is mainly used for isolation purposes and the next one to provide sinusoidal current to the ac mains. It is normally found in literature systems which combine the power from two or more sources. Kobayashi et al. (2006) suggested a converter which is able to obtain energy from a PV array and the utility mains for telecommunication applications. Particularly for this case there are not energy injected to the ac mains. Walker & Sernia (2004) proposed a cascade connection of dc/dc converter when multiple photovoltaic panels are employed, a single converter for each panel, also different dc/dc converters can be taken into account. Chen at al. (2007) presented a system which uses photovoltaic panels and a wind turbine as main inputs, the photovoltaic voltage is higher than the output voltage and the wind turbine voltage is lower than the output voltage. Figure 4 shows converters which are able to handle photovoltaic arrays and/or wind systems. They are multiple input dc/dc converters, they have the purpose to increase the output power or deliver energy from different renewable sources. Figure 4(a) shows how buck and buck-boost dc/dc converters are integrated to produce a single output voltage (Chen et al., 2006). Specially for this topology one input has to have high voltage (or at least higher than the desired output voltage) and the other one could have a low voltage; the energy can be delivered independently from both inputs.

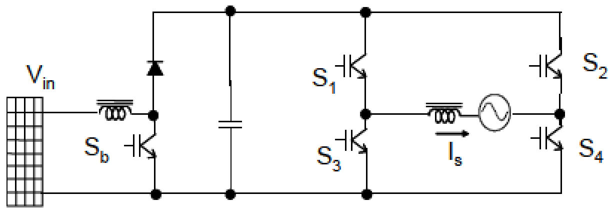

Fig 3 (a) Dc/dc converter and inverter

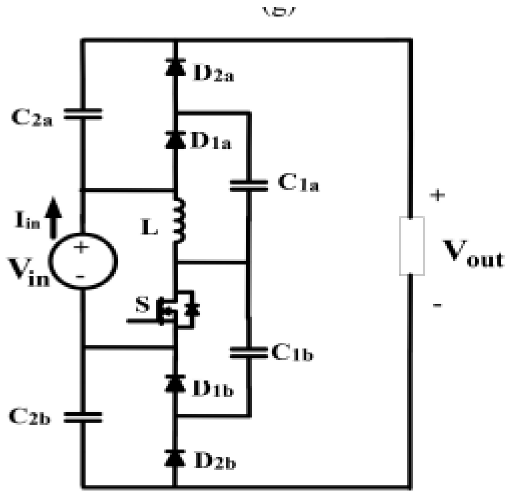

Fig 4: Proposed second-order Hybrid Boost Converter

B. Stand alone systems

Stand alone systems are not connected to utility line, for this type of systems is compulsory to use a battery set in order to provide energy due to weather conditions. Energy is stored in the battery set and when it is completely charged then is ready to feed the load. Traditionally at this time the energy available from PV system is not used until the battery set is charged again. Figure 5(a) shows a converter, which consist of two stages, proposed by Song and Enjeti (2004). The first stage is a dc/dc boost converter that increases the input voltage, but also charges the battery set. The second stage is a dc/ac converter based on an inverter plus an ac/ac converter, which is fed in straight way by the battery set, this feature turns out to be its major disadvantage because the battery is charged continuously and deteriorates its useful life. Figure 5(b) illustrates a dc/dc converter for stand alone applications based on the integration of different dc/dc converters. Energy, which can be administrated by having control on the switches, is delivered in three modes: the first one feeds the load and charge the battery set simultaneously from the renewable source, the second one delivers energy from the sources to the load, and finally, the last one when the battery set provides all the energy to the load. However, it is not possible to deliver energy only from the renewable source for this topology, so that the battery set is always involved, which deteriorate its useful life. A converter, which is able to deliver energy from the renewable source without the use of the battery set, is suggested in next sections. Not only an optimum use of the renewable source and the battery set is achieved with the proposed topology but also similar operating modes are allowed as those proposed by Pacheco et al. (2002). Energy may be delivered by the battery set or the renewable source independently and also simultaneously from both sources with the aid of a smart use of the energy available from the renewable source

IV. A DC/DC CONVERTER APPLICABLE IN RENEWABLE SYSTEM

It is analyzed a topology based on a step-up converter, which also accepts two input voltages Output for this converter can be connected to DC loads or an inverter for AC loads. The system is composed by a dc/dc boost converter and two input sources are located with the aid of some extra components, as it is shown in same figure. An input could be a photovoltaic or wind system, and the other one is a battery set. Converter is capable of being operated in four modes, first and second modes occur when the power becomes just from one input, the third one happens when no energy is available from both sources and finally the last one when energy is demanded from both inputs. These operating modes are employed to feed the load by having an optimization of the energy obtained from the renewable source. Energy is provided completely from the renewable system, if is able to do it, depending on weather circumstances and without using the battery set. Also if there is not enough power, an energy complement may be delivered from the battery set, just in case it is required to do so, then energy is taken from both voltage sources in a complementary way. Finally if there is no available power from the wind system then energy is provided from the battery set only. Operating this way allows optimizing the use of the battery set and also obtainable energy from the photovoltaic/wind system.

A. Operation modes of the converter

Converter is operated in different established modes by switching states of semiconductors involved (S1, S2 and Sm), as described next:

- Power delivered from one of the voltage source.

There exist two possibilities for this operating form. Figure If energy is just delivered by wind system, then the auxiliary switch S1 is turned off and the switch S2 is on, When the wind system cannot provide the required energy to the load, then the auxiliary switch S2 is turned off and the switch S1 is turned on, in this case the energy is delivered only by the battery set .Semiconductor Sm is switching to regulate the output voltage independently of the source used.

- Not energy available from the voltage sources

It is possible not to have energy due to weather conditions and the battery set may be discharged. The two auxiliary switches (S1 and S2) are turned off. As a consequence there is not energy available to regulate the output voltage so that the remaining energy is delivered by the free wheeling diodes.

- Power delivered from both voltages sources

When wind/photovoltaic system cannot provide all required energy by the load, but still there is available energy, then the system could be operated to demand energy from both sources: the wind/photovoltaic system and the battery set. This mode occurs if S1 and S2 are turned on simultaneously or if they are alternated at different times. This last switching state was used in the converter as illustrated in Figure 7.

V. SIMULATION RESULTS

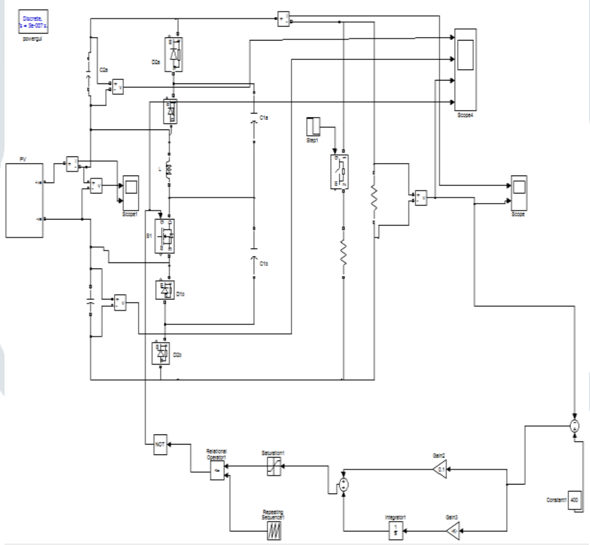

Fig.5MATLAB/SIMULINK circuit for close d loop control of hybrid boost converter with PV system

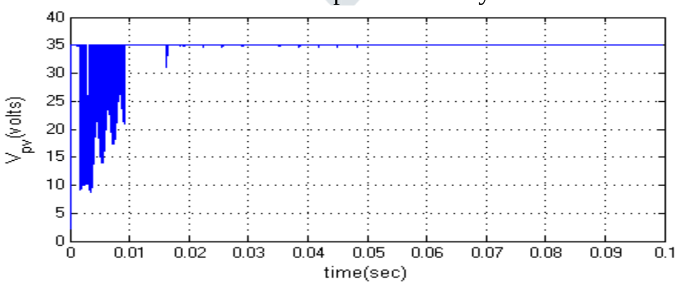

Fig.6 PV Voltage (V)

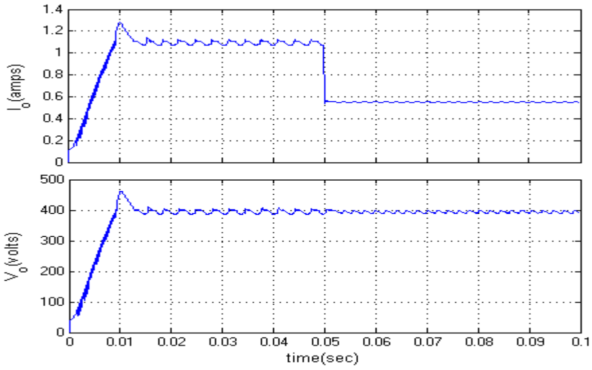

Fig.7 Outputs of Voltage and Current

Sudden Decrease in Load:

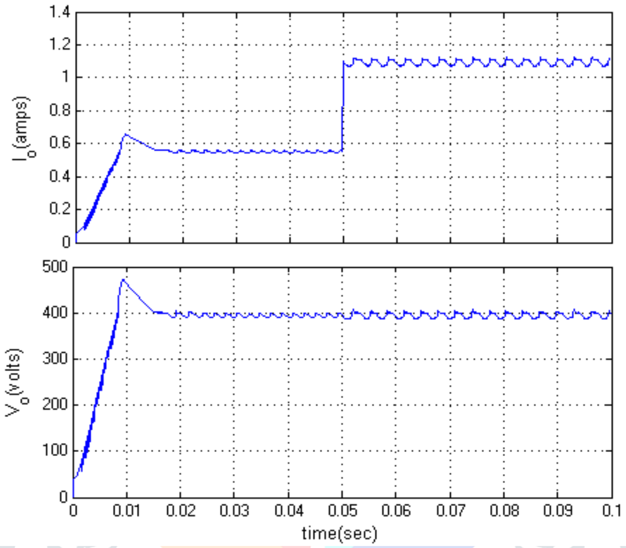

Fig.8 Outputs of Voltage and Current

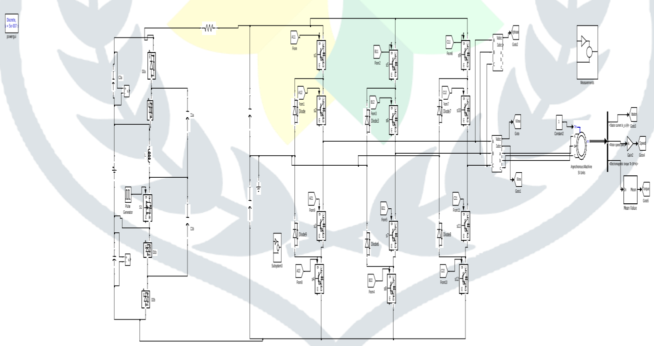

Fig 9: Proposed circuit with Induction Motor Drive

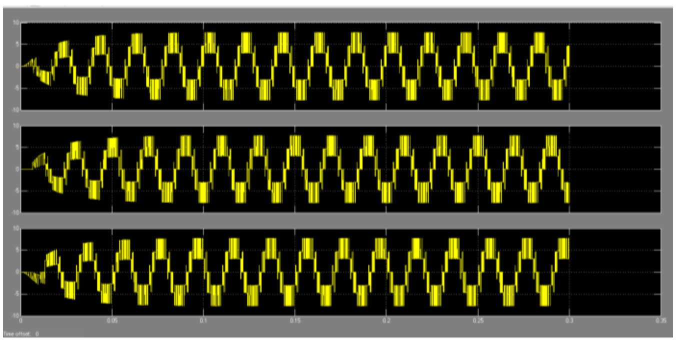

Fig 10: Line Voltage

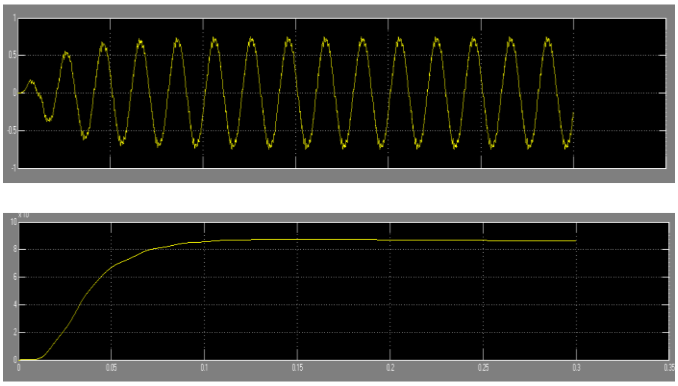

Fig 11: Stator current and torque

VI. Conclusion

Proposed new HBC composed of an inductive core and BVM having closed loop is useful for renewable energy applications. Collective advantages of proposed method are gain boosting technique from the voltage multiplier and voltage regulation capability featuring in nature interleaved operation,wide regulation range,low component stresses,small output ripple,flexible gain extension and high efficiency.Compared with other gain boosting technologies like tapped inductor or transformer based method the proposed topology reduces the complexity which is applicable for mass production and it has a better component utilization factor compared with other single switch single inductor DCDC converters.This work provides operation principle and design considerations.A 200-W35V to 415V second order HBC closed loop prototype was designed which achieved peak efficiency.This converter is suitable for many renewable energy applications. Moreover the PI controllers provide increase in speed of responses and provide applications in many processes. Furthermore the proposed method has lowest capacitor voltage stress which shows the superiority for high power density design and low cost design.

REFERENCES

[1] Carrasco, J.M.; Garcia, L.; Bialasiewicz, J. T.; Galván, E.; Portillo, R. C.; Martín, Ma. A.; León, J. I. & Moreno-Alfonso N. (2006). Power-Electronic Systems for the Grid Integration of Renewable Energy Sources: A Survey, IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, August, 2006, pp 1002-1016, ISSN 0278-0046

[2] Chen, Y.M.; Liu, Y.C. & YuWu, F. (2002). Multi- Input DC/DC Converter Based on the Multiwinding Transformer for Renewable Energy Applications, IEEE transactions on industry applications, Vol. 38, No. 4, July/August, 2002, pp 1096-1104, ISSN 0093- 9994

[3] Chen, Y.M.; Liu, Y.C. & Lin, S.H. (2006). Double-Input PWM DC/DC Converter for High- /Low-Voltage Sources, IEEE Transactions on Industrial Electronics, Vol. 53, No. 5, October, 2006, pp 1538-1545, ISSN 0278-0046

[4] Chen, Y.M.; Liu, Y.C.; Hung, S.C. & Cheng, C.S. (2007). Multi-Input Inverter for Grid Connected Hybrid PV/Wind Power System, IEEE transactions on power electronics, Vol. 22, No. 3, May, 2007, pp. 1070-1077, ISSN 0885-8933 Ertl, H.; Kolar, J. W. & Zach, F.C. (2002). A Novel Multicell DC–AC Converter for Applications in Renewable Energy Systems, IEEE Transactions on industrial Electronics, Vol. 49, No. 5, October, 2002, pp 1048-1057, ISSN 0278-0046

[5] Femia, N.; Petrone, G.; Spagnuolo, G. & Vitelli, M. (2009). A Technique for Improving P&O MPPT Performances of Double-Stage Grid-Connected Photovoltaic Systems, IEEE Transactions on Industrial Electronics, Vol. 56, No. 11, November, 2009, pp 4473-4482, ISSN 0278-0046

[6] Kim, I.S.; Kim, M.B. & Youn, M.J. (2006). New Maximum Power Point Tracker Using Sliding-Mode Observer for Estimation of Solar Array Current in the Grid- Connected Photovoltaic System, IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, August, 2006, pp 1027-1035, ISSN 0278-0046

[7] Kobayashi, K.; Matsuo, H. & Sekine, Y. (2006). Novel Solar-Cell Power Supply System Using a Multiple-Input DC–DC Converter, IEEE Transactions on Industrial Electronics, Vol.53, No. 1, February, 2006, pp 281-286, ISSN 0278-0046

[8] Kwon, J.M.; Nam, K.H. & Kwon, B.H. (2006). Photovoltaic Power Conditioning System with Line Connection, IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, August, 2006, pp 1048-1054, ISSN 0278-0046

[9] Pacheco, V. M.; Freitas, L. C.; Vieira Jr., J.B.; Coelho, E.A.A. & Farias, V.J. (2002). A DC-DC Converter Adequate for Alternative Supply System Applications, Proceedings of IEEE Applied Power Electronics Conference and Exposition, pp. 1074-1080, ISBN 0-7803- 7404-5, USA, March 2002, IEEE, Dallas Park, J.H.; Ahn, J.Y.; Cho, B.H. & Yu, G.J. (2006). Dual-Module-Based Maximum Power Point Tracking Control of Photovoltaic Systems, IEEE Transactions on Industrial Electronics, Vol. 53, No. 4, August, 2006, pp 1036-1047, ISSN 0278-0046

[10] Sira-Ramirez, H. & Rios-Bolivar, M. (1994). Sliding Mode Control of DC-to-DC Power Converters via Extended Linearization, IEEE Transactions on Circuits and Systems Part I: Fundamental Theory and Applications, Vol. 41, No. 10, October, 1994, pp. 652- 661, ISSN 1057-7122

[11] Song, Y.J. & Enjeti, P.N. (2004). A High Frequency Link Direct DC-AC Converter for Residential Fuel Cell Power Systems, Proceedings of IEEE Power Electronics Specialists Conference, pp. 4755-4761, ISBN 0-7803-8399-0, Germany, June 2004, IEEE, Aachen www.intechopen.com A DC/DC converter for clean-energy applications 17

[12] Vazquez, N.; Hernandez, C.; Alvarez, J. & Arau, J. (2003). Sliding Mode Control for DC/DC Converters: A new Sliding Surface, Proceedings of IEEE International Symposium on Industrial Electronics, pp. 422-426, ISBN 0-7803-7912-8, Brasil, June 2003, IEEE, Rio de Janeiro

[13] Walker, G.R. & Sernia, P.C. (2004). Cascaded DC–DC Converter Connection of Photovoltaic Modules, IEEE Transactions on Power Electronics, Vol. 19, No. 4, July, 2004, pp 1130- 1139, ISSN 0885-8933