A Novel Power Generating Technique of PV System Using Solar Panel with Integrated BI-Directional DC-DC Converter

S.Sangeetha,V.Anuja

***Abstract*— Photovoltaic power conditioning requires power conversion and track to counteract the effect of general variance in power output. Photovaltaic generation is the direct conversion of solar energy into direct current electricity. The use of photovoltaic is to increase the power generation. In this proposes a PV generation system which can be used as the input source. The power which is generated by the PV is not sufficient to drive the load. An integrated bi-directional, buck-boost resonant converter is implemented. Boost mode is integrated to achieve high voltage conversion ratio in forward direction. In reverse direction buck mode is integrated to improve the current. This method is implemented with low component count and isolation transformer.**

***Index Terms*— Photovoltaic, Buck-Boost Mode, Isolation transformer , Bi-directional.**

I. INTRODUCTION

Renewable sources of energy are increasingly valued world wide, because of energy shortages and environmental contamination. Renewable energy system, generate low voltage output. Thus Dc/Dc converters are widely employed in many renewable energy applications, including fuel cells, wind power and photovoltaic system. Among renewable energy systems, photovoltaic systems are expected to play an important role in energy production. Such system transform light energy into electrical energy. PV Power Conditioning System (PCS) design process is necessity of galvanic isolation between the PV panel and the electric utility system. Ungrounded grid connector PV array is permitted by many electric codes, galvanic isolation can be preferred for various reasons. They are improved voltage boost ratio, reduced ground leakage current and overall safety improvement during fault conditions.

PV Panels connected in parallel can be much more productive in low-light and partially shaded conditions than a series connected system. These concerns make the single-panel PV converter, an attractive option from a strictly performance based analysis. The Dc-Dc Converter stage implements Buck-Boost optimization, to regulate dc-link voltage by sending power to the utility grid. Conversion promoted the proceeding technical development. In the distributed PV power conditioning system, the isolated dc-dc stage must operate efficiently at full power, while maintaining high performance at light load across a range of PV voltages. In order to maintain high efficiency under low power conditions, it is necessary to minimize the amount of circulating energy in the system.

An alternate definition of this characteristic would be producing a system with a high “Power factor” at the isolation transformer. Light load efficiency is mitigating the device switching loss. Reduction of the control and gate drive complexity allows for lower fixed losses due to auxiliary power.

The dc-dc conversion stage is a simple continuous-conduction mode (CCM) flyback converter. It has the benefit of simple construction and low circulating energy. Improvements in flyback efficiency can be made using zero-voltage transition.The transformer leakage inductance as resonant element to achieve zero-voltage switch across the main device. The series-resonant converter and LLC resonant converter both are operate on a similar principle and typically use a variable frequency control to adjust the output voltage. When both this converter, is operated near the resonant frequency of the tank circuit, the converter achieves nearly ZVS and ZCS with very low circulating energy and high efficiency.

II. PROPOSED SYSTEM

Photovoltaic are fast increasing due to their environment friendly nature as well as rapid development of power electronic. PV is the input source of the proposed system. PV panels are used to generate the direct current. The generated power from the PV is low voltage. To increasing the voltage boost converter is used. In boost converter the current will decrease.The generated power DC is fed to inverter, it is used to interface different power sources and generate power to the grid individually. The inverter, convert the direct current into alternative current. The output can be step up or step down by transformer.

With addition of a single inductor transformer controlled using simple fixed frequency PWM with only the need to observe limitation on the maximum and minimum duty cycle. The stepped up alternative current is given to the rectifier, which can convert alternative current into direct current. DC is given to load. The boost converter regulates

Manuscript received March 19, 2014

S.Sangeetha, Electrical & Electronics, DMI College of Engineering, Chennai, India, 9750447707.

V.Anuja, Electrical & Electronics, DMI College of Engineering, Chennai, India, 9789778066.

the effective input voltage to the series-resonant converter, allowing it to run as a DCX with high efficiency.To increase the current, buck converter is used. In this method buck converter is done in reverse direction.

The block diagram of the proposed system is shown in figure 1 and 2. The boost converter function is implemented by the original MOSFETs. A method to understand this is to directly tie the input inductor to the midpoint of both active switching legs simultaneously. In the primary side there is only two active switches.

A. *Boost Mode*

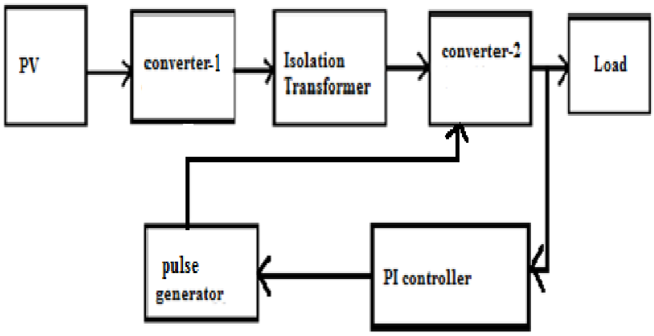

Fig. 1 Block diagram of proposed system for boost mode

When solar rays incident on the PV panel, it generate DC current. The converter-1 convert dc current into ac current. The ac current is fed to isolation transformer. The transformer is used to step-up the voltage by voltage doubler. The step-up voltage is given to the converter-2, it convert ac current into dc. The current is given to the load. From the load error signal is generated, it is given to the PI controller it control the error and it given to the pulse generator, it generate pulse signal to the converter-2.

B. *Buck Mode*

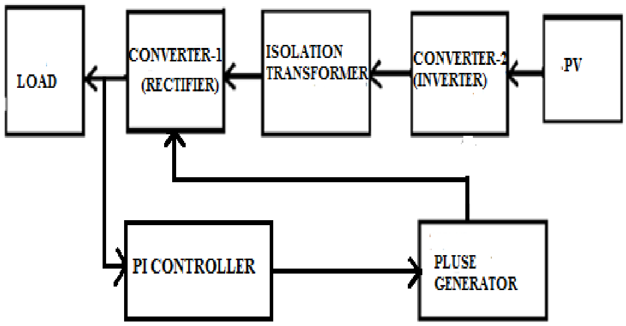

Fig. 2 Block diagram of proposed system for buck mode

Buck mode is similar to the boost mode it is done in reverse direction. In buck mode, the error signal is generated from the load. It is given to the PI controller to control the error and it is given to the pulse generator. The pulse signal is given to the converter-1. In this modes of operation current will be increase.

III. SYSTEM CONFIGURATION

A. *DC-DC Converter*

It convert a fixed –voltage dc source into a variable-voltage dc source. A dc-dc converter can be considered as dc equivalent to an ac transformer with a continuously variable turns ratio. Like a transformer, it can be used to step down or step up a dc voltage source. DC converter are widely used for traction motor control in electric automobiles, cars, and mine haulers. They provide smooth acceleration control, high efficiency, and fast dynamic response. DC converter can be used in regenerative braking of dc motors to return energy back into the supply, and this feature results in energy saving for transportation systems with frequent stops. DC converters are used in dc voltage regulators, and also used in conjunction with an inductor, to generate a dc current source, especially for the current source inverter

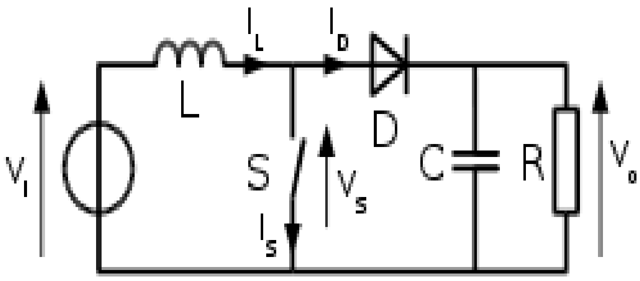

Fig. 3 Boost converter

In a boost converter, the output voltage is always higher than the input voltage. When the switch is closed, current flows through the inductor and the inductor stores some energy by generating a magnetic field. When the switch is opened, current will be reduced as the impedance is higher. The magnetic field previously created will be destroyed to maintain the current flow towards the load. Thus the polarity will be reversed. As a result two sources will be in series causing a higher voltage to charge the capacitor through the diode D.

The inductor will not discharge fully in between charging stages. When the switch is opened, the capacitor in parallel with the load is charged to this combined voltage. When the switch is then closed the capacitor is therefore able to provide the voltage and energy to the load. During this time, the blocking diode prevents the capacitor from discharging through the switch.

A buck converter operates in continuous mode if the current through the inductor (I_L) never falls to zero during the commutation cycle. When the switch is closed the voltage across the inductor is $V_L = V_i - V_0$. The currentthrough the inductor rises linearly. As the diode is reverse-biased by the voltage source V, no current flows through it. When the switch is open diode is forward biased. The voltage across the inductor is $v_L = -v_0$.

B. PV Souce Modeling

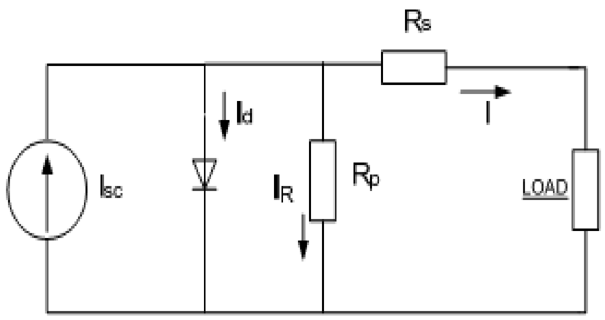

Fig. 5 Equivalent circuit of solar cell

The nonlinear V-I characteristic of a PV generator modeled using current resistor diode. The actual diode characteristic has been divided into three region. The single diode model of the PV generator with linearised diode. The value of V_X and R_D are depends on the operation region of the PV generator.

$$Isc= n_p I_{ph}-n_p I_{sat} *[\exp((q/AKT)(Vpv/ns +Ipv Rs))-1] \quad (1)$$

$$I ph= (I sso + Ki(T-Tr)).S/1000 \quad (2)$$

$$Isat= I rr(T/Tr)3 \exp((q E gap/KA) .(1/Tr-1/T)) \quad (3)$$

IV. OPERATION OF TOPOLOGICAL MODE

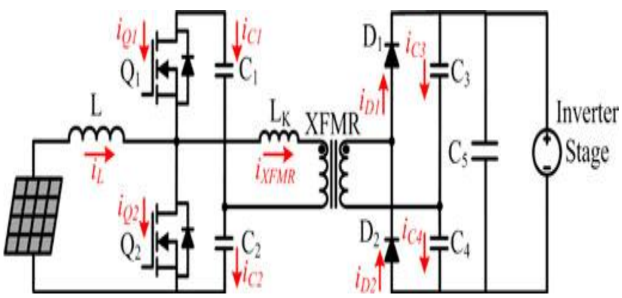

Fig. 6 IBR Converter

Mode 1[t0<t<t1]: When Q_1 is to be turned ON Q_2 will be turned OFF under ZVS condition at t0.The current in the input inductor L flows into the body diode of Q2.The upper input-side capacitor C_1 begins resonating with the transformer leakage inductance L_k and the output-side capacitor,C_3 and C_4 through D_1.Accuaring at the same time the current begins charging of C_1 and C_2.

Mode 2[t1< t <t2]: Q_1 will be operated, when it is only conducting the input inductor current.C_5 continues discharging into the load at this time. Mode 2 turn OFF of Q_1 and Q_2 will turn ON.

Mode 3[t2<t<t3]: After the turn OFF of Q_1, Q_2 will get turn ON. The inductor current is charging the series combination of C_1 and When Q_2 is turned ON, the body diode of Q_1 is commutated the switch loss. At t_2, C_2 resonate with L_K and parallel combination of C_3 and C_4. Once the transformer current resonant back to zero,D_2 blocks the continued cycle.

Mode 4[t3<t<t4]: The inductor current continues to flow through the lower devices, Q_2 is turned OFF. During mode 3 and 4 Q_1 is effectively isolates the upper capacitor from charging and discharging.

V. TRANSFORMER

A transformer is generally a four terminal device that is capable of transforming an alternating current (AC) input voltage into a relatively higher or lower AC output voltage. A typical transformer has two or more coils that share a common laminated iron core. One of the coils is referred to as the primary (N_p turns), while the other coil is called the secondary (N_S turns). Primary coils are defined as coils current is driven by an external alternating-current source, whereas secondary coils are defined as coils voltage is induced by the varying magnetic field produced by the primary coil. The windings of the transformer have negligible resistance, so R_P= R_S= 0, where R_P represents the resistance of the primary winding and R_S represents the resistance of the secondary winding. Thus, there is no copper loss in the winding, and hence no voltage drop. If the secondary is an open circuit, an ideal transformer will not allow the flow of primary current.

The ideal transformer induces secondary voltage $E_S = V_S$ as a proportion of the primary voltage $V_P = E_P$ and respective winding turns as given by the equation

$$\frac{V_P}{V_S} = \frac{E_P}{E_S} = \frac{N_P}{N_S} = a \quad (4)$$

The desired output voltage V_{OUT} can be calculated using transformer turn ratio.

$$n = n_{sec}/n_{pri} \quad (5)$$

When determining the transformer design the process be carried under different procedures. The transformer flux density, core size and number of primary turns be

$$V\ Speak = V_{bus}\ T_{sw}/4 \quad (6)$$

The equations were derived by integrating the square of the transformer current over one switching cycle.

VI. PI CONTROLLER

A PI controller is a proportional gain in parallel with an integrator, both in series with a lead controller. The proportional gain provides fast error response. The integrator drives the system to a steady-state error. A proportional integral-derivative is the control loop feedback mechanism used. PI controller attempts to correct the error between a measured process variable and desired set point by calculating and then outputting corrective action that can adjust the process accordingly. The PI controller gain provides fast error response

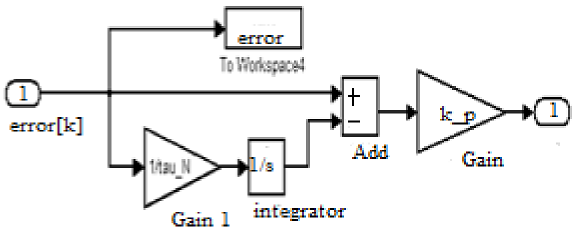

Fig. 7 PI Controller

The PI controller calculation involves two separate modes the proportional mode, integral mode. The proportional mode determine the reaction to the current error, integral mode determines the reaction based recent error. The weighted sum of the two modes output as corrective action to the control element.

VII. Simulation of Proposed System

The simulation of the proposed system with proportional integral controller is carried out in MATLAB . It is simulated with the solar panel, converter, inverter transformer and PI controller.

A. Boost Mode

The input voltage is generated from PV panel which is low voltage. The low voltage is given to the inverter. It consists of two MOSFET M_1 and M_2. The two capacitor c1 and c2 charged equally. When M_1 is turned ON, the voltage of C1 appears across transformer primary, M_2 will turn OFF. When M2 is turn ON, M_1 will be turn OFF. The transformer primary voltage swings to average output voltage. The low level voltage is given to transformer secondary, which will step up the voltage. The alternative voltage is given to the rectifier it convert ac to dc.

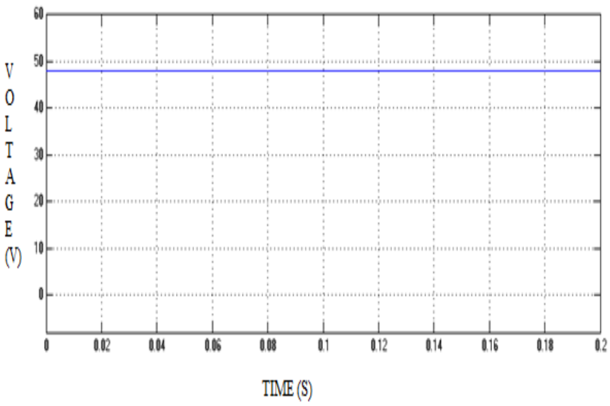

Fig. 8 Solar output voltage

The integrated output of solar panel through the voltage source inverter is experimented as 230v.The generated output is given directly to the step up transformer and it is given to the load.

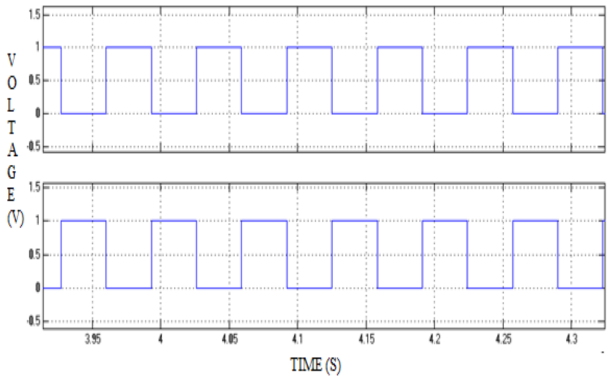

Fig. 9 Gate pulses

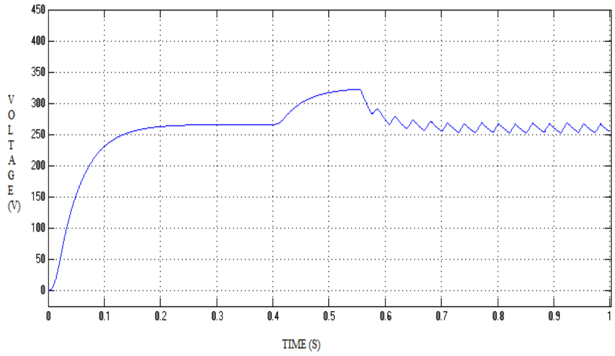

Fig. 10 Output voltage with disturbance

B. Buck Mode

The input voltage is generated from PV panel which is high voltage. The high voltage is given to the inverter. It consists of two MOSFET M_1 and M_2 The two capacitor c1 and c2 charged equally. When M_2 is turned ON, the voltage of C1 appears across transformer primary, M_1 will turn OFF. When M_1 is turn ON, M_1 will be turn OFF. The transformer primary voltage swings to average output voltage. The low level voltage is given to transformer secondary, which will step up the voltage. The alternative voltage is given to the rectifier it convert ac to dc.

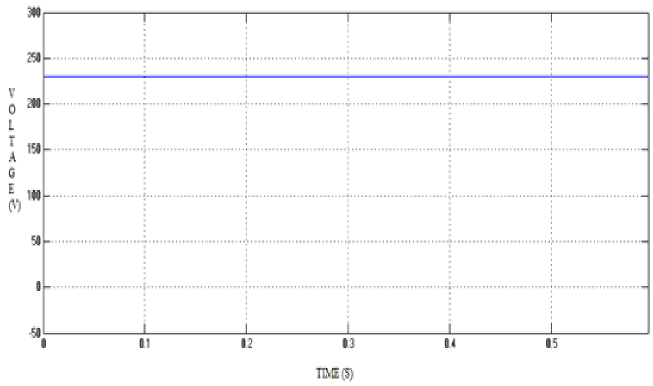

Fig. 11 Solar output voltage

The output of solar panel is experimented as 230V. In which the voltage is step down to improve the current. The generated output of PV fed to the converter and it is given to the transformer to step down the voltage. The error signal is control by PI control the generated signal is given to the load. The output of the load is 48V

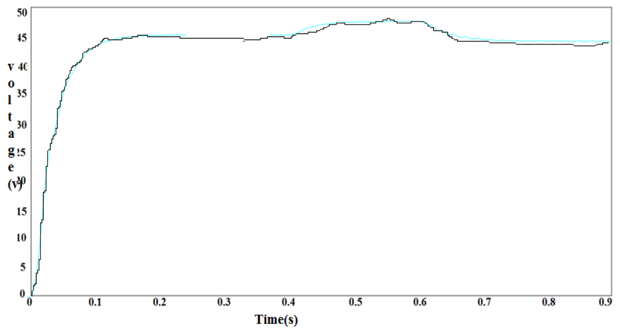

Fig. 12 Output voltage of buck mode

The output voltage is attain constant steady state voltage of 48V.

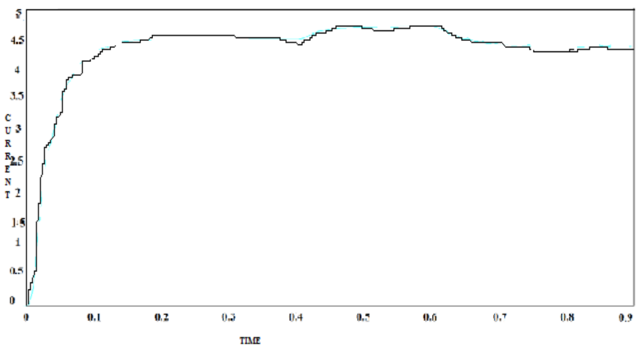

Fig. 13 Output current with disturbance

VIII. CONCLUSION

The bidirectional dc-dc converter has been presented for photovoltaic applications. Distributed PV conversion, a buck boost resonant converter has been proposed. The operating principle of the proposed converter is well introduced. As a solution for providing efficient ZVS in either direction of power flow is achieved with no losses. The adopted capacitor output filter helps in the circulating energy. The circuit analysis is presented and the results are obtained for R load.

1) Low circulating energy and reduced switching loss with resonant energy transfer with output diode ZCS.

2) Low potential cost due to minimum number of active devices and less component count.

3) Control complexity provides lower auxiliary power loss .

The PWM technique appropriates the reference voltage by a combination of switching . The high switching frequency involved for less switching losses. DC analysis is used for circuit with time invariant source. All of these features guarantee the high performance of the proposed converter. The resonant converter output voltage doubler simplifies transformer structure and reduce cost. The result was a simple process, requiring only consideration of the resonant period in selecting a valid converter duty cycle.

REFERENCES

[1] Q. Li and P. Wolfs, “Recent development in the topologies for photovoltaic module integrated converters” *in proc. IEEE power electron.spec.conf., 2006, pp. 1733-1737.*

[2] L. Gao, R. A. Dougal, S. Liu, and A. P. Iotova, “Parallel-connected solar PV system to address partial and rapidly fluctuating shadow conditions,”*IEEE Trans. Ind Electrons*.

[3] A. F. Boehringer, “Self-adapting dc converter for solar spacecraft power supply.” *IEEE Trans.Aerosp.electron.,vol. 21, no. 5, pp. 1282-1291, Sep.2006.*

[4] S. Park and S. Choi, “Soft-switched CCM boost converters with high voltage gain for high-power applications,” *IEEE Trans. Power Electron., vol. 25, no5, pp. 1211-1217,May 2010.*

[5] J. Zeng, J. Ying, and Q. Zhang, “A novel dc/dc ZVS converter for battery input application.” *In proc. appl. Power Electron. Conf., 2002, vol. 2.*

[6] M. Fornage, “Method and apparatus for converting direct current to alternating current*,” U.S. Patent 7 796 412, Sep. 14, 2011.*

[7] K. Fathy, H. W. Lee, T. Mishima, and M. Nakaokal, “Boost half bridge single power stage PWM dc-dc converter for small scale fuel cell stack*,” in proc. IEEE Int. Power Energy Conf., 2006, pp.426-431.*

[8] Z. Liang, R. Guo, J. Li, and A. Q. Huang, “A high efficiency PV module-integrated dc/dc converter for PV energy harvest in FREEDM system,” *IEEE Trans. Power Electron., vol. 26, no. 3, pp. 897-909, mar.2011.*

[9] L. Zhang, K. Sun, Y. Xing, L. Feng, and H. Ge, “A Modular grid-connected photovoltaic generation system based on dc bus,” *IEEE Trans. Power Electron.,vol. 26, no. 2, pp.523-531,Feb. 2011.*

[10] J. M. A. Myzik and M. Calais, “String and module integrated inverters for single-phase grid connected photovoltaic system*: A review,” in Proc. IEEE Bologna Power Tech Conf., 2006*.

[11] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, “A review of single phase grid connected inverter for photovoltaic module*,” IEEE Trans. Ind. Appl.,vol.41,no.5,pp. 1292-1306,Sep./Oct.2005.*

[12] Y. F. Huang, Y. Konishi, and W. J. Ho, “Series resonant type soft switching grid connected single-phase inverter employing discontinuous resonant control applied to photovoltaic AC module, “ *in proc. Appl. Power Electron.Conf., 2011,pp.989-994.*

[13] C. E. Kin, G. W. Moon, and S. K. Han, “Voltage doubler rectified boost integrated half bridge converter for digital car audio amplifiers” *IEEE Trans. Power Electron.,Vol.22,no.6,pp.2321-2330,Nov.2007.*

[14] S. Chowdhury, G. A. Taylour, S. P. Chowdhury, A. K. Saha, and Y.H.Song, “Modelling simulation and performance analysis of a PV array in an embedded environment,” *in proc.univ.power eng.conf..2007.pp.781-785.*

[15] L. Nousiainen, J. Puukko,A. Maki,T. Messo,J. Huusari,J. Jokipii, J. Viinamaki,D. T. Lobera,S. Valkealahti, and T. Suntio, “Photovoltaic generator as an input source for power electronic converter” *IEEE Tras.Power Electron., vol. 28,no.6,pp.3028-3038,Jun.2013.*