Implementation of High Efficiency, High Lifetime and Low Cost Converter for an Automatic Photovoltaic Water Pumping Station

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***Abstract*— *A novel idea of photovoltaic (PV) energy based converter for water pumping system without the usage of fuel cells or batteries. In proposed system, the design of a three phase induction motor drive is directly supplied by using photovoltaic system energy. Presence of a three phase induction motor has better performance with optimized efficiency compared to the commercial water pumping system of DC motor. The developed resonant of Two Inductor Boost Converter (TIBC) and voltage quadruple with three phase Voltage Source Inverter (VSI) are based on the current fed multi resonant converter. Low input current ripple and high voltage gain are the features of TIBC. So the classical topology used to improve the system with a constant duty cycle control and a non dissipative snubber circuit along with a hysteresis controller to improve its efficiency. Due to the non existence of electrolytic capacitors the system is required to have a high lifetime and total system cost is low. As a result, in isolated locations the system has an optimistic solution and it provide water to poor societies.*

***Keywords*— Two Induction Boost Converter, Photovoltaic Water Pumping Station.**

I. INTRODUCTION

In this paper, modified two inductor boost converter (TIBC) used for the application of PV water pumping system. Modified TIBC converter require a ratio of large voltage conversion, because lower energy characteristics of the PV panels and low input current ripple, so it does not cause anything oscillation. The proper design makes the converter operate with a constant voltage gain by using a fixed duty cycle and high step up, high efficiency, low cost. It have low losses because snubber circuit used in order to suppress the rate of rise of forward voltage i.e., dv/dt across the thyristor, otherwise the switch gets damaged. Induction motor is preferable for water pumping application.

The speed of the rotor is depending upon the AC voltage and the input supply variation control the speed, so controller measures the output efficiency and gives the control signal to inverter. It generates the AC supply to motor according to the load. Hysteresis controller is used in many industrial applications because it has many advantages like fast and high dynamic performance.

The hysteresis controller used to control the output of Voltage Source Inverter (VSI). The VSI takes voltage as the reference. The AC output voltage is limited below exceed limit. It cannot exceed the DC rail voltage. Therefore the voltage source inverter is step down converter for the input of DC and the output of AC power conversion. For applications over drive is desirable and DC voltage is limited and an additional DC / DC boost operation is required to obtain a desired AC output voltage. Output LC filter is required for providing a pure AC voltage compared with the current source inverter.

II. EXISTING TIBC SYSTEM

This two inductor boost converter is chosen for the application of its low input to high output voltage conversion. The source side of the TIB converter consists of S1 and S2 switches, L1 and L2 boost inductors and transformer. The output side of the boost rectifier consists of diodes D1 and D2, filter capacitors C1 and C2 which connected with load RL. The operation of the circuit can be explained through various time periods.

During mode 1: The switch S2 is closed. This makes the circuit complete, causing the flow of current. Therefore the current flow through the inductor L2, it forward biases the diode D2 charge the capacitor C2, thereby the stored energy discharged by the inductor.

During mode 2: Switches S1 and S2 are turned ON. So the current flow increases at an equal rate through the inductors L1 and L2.
During mode 3: S1 is turned ON and the inductor discharges through capacitor C1.
During mode 4: The circuit operation is repeated.

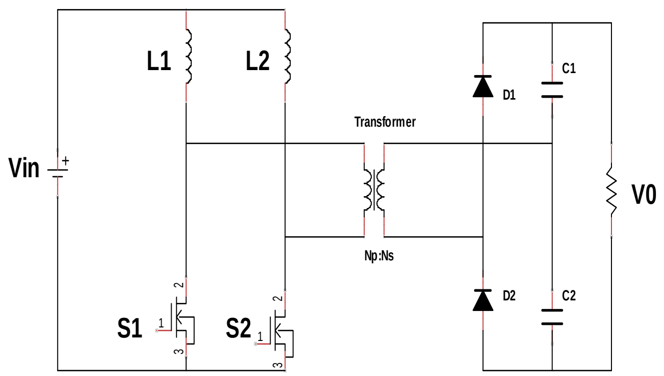

Fig.1 :Two Inductor Boost Converter

In output part of the voltage doubler the transformers act as like an AC Source. Here the two capacitors are connected in series with each other. In voltage doubler the alternating current first pass in clockwise direction and then in anti clock wise direction. In clockwise direction, D1 is forward bias and charge the capacitor C1, capacitor charged with peak voltage of positive cycle. Hence direction of current flow through D1, C1 with load. In anticlockwise direction, D2 is forward bias and charge the capacitor C2, the direction of current flow through D2, C2 with load. C2 charged with peak voltage of negative cycle. The opposite voltages generated to C1, C2.They add up the voltage because both of the capacitor are connected in series with each other. Thus a doubling effect will be produced delivering a voltage which is twice the input.

III. MODIFIED TWO INDUCTION BOOST CONVERTER

A design of proposed system ensures the system cost is low and accessibility with the use of a single PV array. So the proposed system is most preferred to drive low power water pumps with the use of Modified TIBC in the range of 1/3 hp. Solar energy produced by the PV array is fed to the induction motor through a two converters with two stages: one is DC/DC by using TIBC, another one stage is DC/AC by using three phase inverter. The three phase inverter is designed by 6 switches with three legs. It uses a sinusoidal pulse width modulation technique. It used to improve the output voltage level. So the technique is used to verify the proposed system, with high the efficiency and low cost requirements.

Here, the first stage of DC /DC converter is proposed with the use of a modified two inductor boost converter, because of its simplicity, very small number of components, high efficiency, common ground gate driving for both switches, and easy transformer flux balance. These characteristics make it the perfect choice for achieving necessary features. TIBC output DC voltage gain, it also estimate well with other current source converters about conduction losses, transformer utilization, and switch voltage stress. In addition, the input current is transferred by the way of TIBC L1, L2 inductors having its input current ripples be reduced by half and at twice the switching frequency. This last characteristic reduces the oscillations at the PV energy module operating point and makes it without presenting few difficulties to achieve the Maximum Power Point (MPP).
Implementation of the two inductor boost converter is a hard switched overlapped pulse width modulated converter by the way of at least one of the switches in the converter is always ON, creating a path for current flow from the inductor to output. So the multi resonant converter modify the two inductor boost converter by connecting a capacitor at the secondary winding of the transformer. A multi resonant tank is created by the transformer magnetizing inductance, its leakage inductance, so capacitor is also added in resonant tank.
By adding this capacitor by using the transformer parasitic components to form the resonant tank in secondary side, it is the most possible way to achieve zero current switching condition for the switches in input and rectifying diodes in output. Hence it enables the two inductor boost converter to operate at high switching frequencies with higher efficiency.
In secondary side of the transformer with the use of a voltage quadruple rectifier it is also possible to reduce the transformer turns ratio, voltage stress on the MOSFET switches, the necessary ferrite core. As a result, the number of diodes in the secondary side is reduced by half and other benefit is that both MOSFETs and the transformer are cheaper.
In a proposed system the control strategy modification also proposed, when compared to the classical control strategy of

two inductor boost converter control.

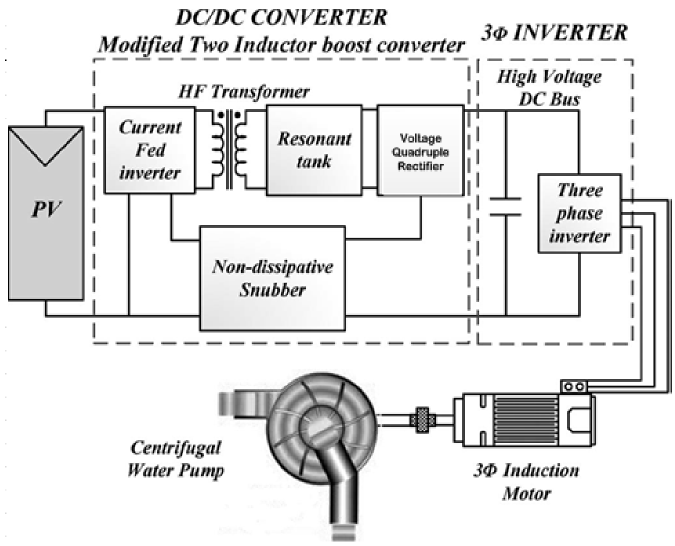

Fig.2 : Simplified Block Diagram Of The Modified TIBC

Photovoltaic water pumping system application, the proper design of converter gain in output makes the converter able to work with a constant voltage gain by using a fixed duty cycle control for the primary MOSFET switches.

IV. SIMULATION RESULT

The output voltage and input voltage of Modified TIBC is pure DC. Now, the induction motor is driven by using Modified TIBC with VSI.VSI inverter which make the AC output is pure with reduced harmonics and also the efficiency of the induction motor is increased. Modified TIBC convert from DC / DC and its input voltage is presented in figure 3.

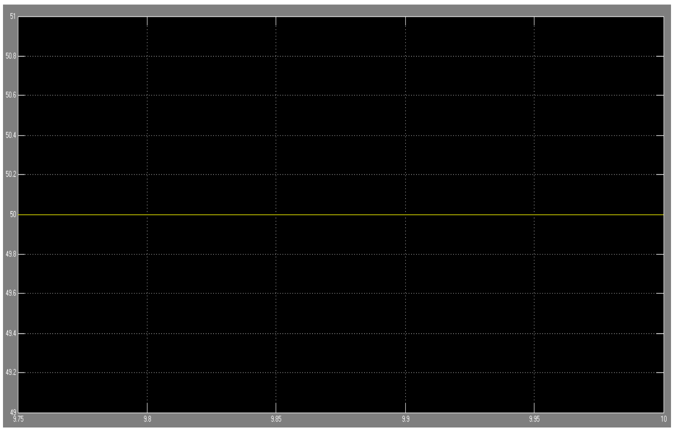

Fig.3: Input DC Voltage

TIBC consists of two inductor, two switches, snubber circuit and transformer with quadruple rectifier. Two inductor with two switches which convert the voltage from DC / AC and its output is presented in 4. Snubber are circuits which are placed across semiconductor devices for protection and to improve performance.

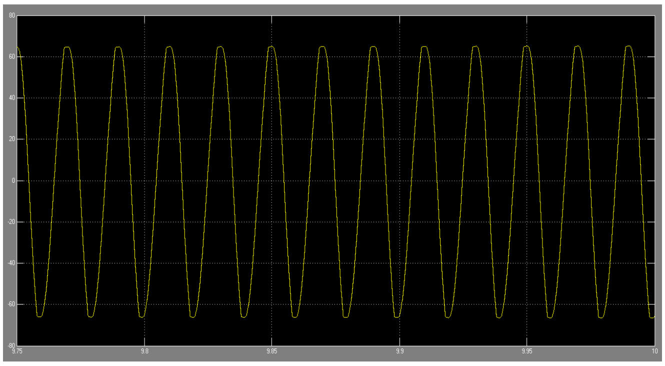

Fig.4 : AC Wave Form From Transformer

Modified TIBC final DC output voltage with open loop simulation results are presented in figure 5.

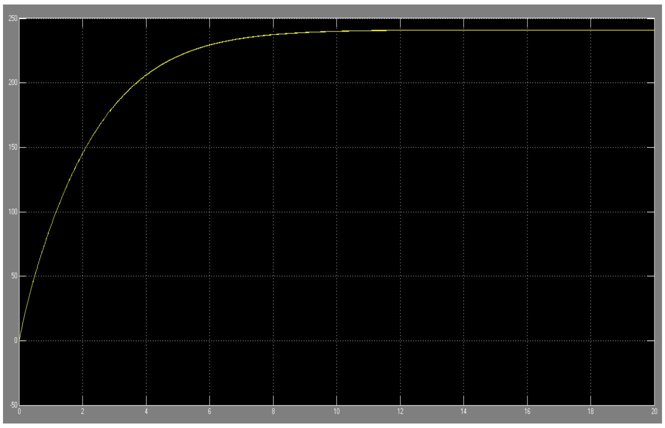

Fig.5 : Output of Open Loop Simulation

V. CONCLUSION

The PV energy with modified two inductor boost converter for water treatment and pumping systems without the use of batteries were presented. The design TIBC with three phase VSI converter used to drive a induction motor directly from solar energy and was conceived to be a commercially viable solution having low cost, high efficiency and robustness.

Multiplier is an important part in arithmetic processors, the current mobile applications and DSP applications need ICs with high speed operations but low power consumption. But in this present system main objective is to achieve high efficiency using multiplier. Voltage quadruple is also one type of multiplier and its give four time gain in output of the converter. In this paper we have presented the system block diagram, control algorithm, and design. The experimental results suggest that the proposed solution could be a viable option after more reliability tests are performed to guarantee its robustness.

REFERENCES

[1] M. Chunting, M. B. R. Correa, and J. O. P. Pinto, "The IEEE 2011 international future energy challenge in Proc. IFEC, 2010, pp. 1–24.

[2] A. Hahn, "Technical maturity and reliability of photovoltaic pumping systems," In Proc. 13th Eur. Photovoltaic Solar Energy Conf., Nice, France, pp. 1783–1786.

[3] M. A. Vitorino and M. B. R. Correa, "High performance photovoltaic pumping system using induction motor," in Proc. Brazilian Power Electron. Conf., 2009, pp. 797–804.

[4] G. Teröde, K. Hameyer, and R. Belmans, "Sensor less control of a permanent magnet synchronous motor for PV powered water pump systems using the extended kalman filter," in Proc. 9th Int. Conf. Elect. Mach. Drives, 1999, pp. 366–370.

[5] H. Harsono, "Photovoltaic water pump system," Ph.D. dissertation, Dept. Intell. Mech. Syst. Eng., Faculty Kochi Univ. Technol., Kochi, Japan, Aug. 2003.

[6] D. Linden, Handbook of Batteries and Fuel Cells. New York, NY, USA: McGrawHill, 1984.

[7] D. Tschanz, H. Lovatt, A. Vezzini, and V. Perrenoud, "A multifunctional converter for a reduced cost, solar powered, water pump," in Proc. IEEE ISIE, 2010, pp. 568–572.

[8] M. A. Vitorino, M. B. R. Correa, C. B. Jacobina, and A. M. N. Lima, "An effective induction motor control for photovoltaic pumping," IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1162–1170, Apr. 2011.

[9] S. R. Bowes and A. Midoun, "Suboptimal switching strategies for microprocessor controlled PWM inverter drives," Proc. Inst. Elect. Eng.—Elect. Power Appl., vol. 132, no. 3, pp. 133–148, May 1985.

[10] M. Cacciato, A. Consoli, and V. Crisafulli, "A high voltage gain DC/DC converter for energy harvesting in single module photovoltaic applications," in Proc. IEEE ISIE, 2010, pp. 550–555.

[11] P. J. Wolfs, "A current sourced DCDC converter derived via the duality principle from the half bridge converter," IEEE Trans. Ind. Electron., vol. 40, no. 1, pp. 139–144, Feb. 1993.

[12] P. Wolfs and Q. Li, "An analysis of a resonant half bridge dual converter operating in continuous and discontinuous modes," in Proc. IEEE Power Electron. Spec. Conf., 2002, pp. 1313–1318.

[13] "Power Electronics: Converters, Applications and Design", Mohan, Undeland and Robbins, Wiley, 1989.

[14] Cuk, Slobodan; Middle brook, R. D. (June 8, 1976). A General Unified Approach to Modeling Switching Converter Power Stages (PDF). Proceedings of the IEEE Power Electronics Specialists Conference. Cleveland, OH. pp. pp.73–86.Retrieved 20081231.

[15] Billings, Keith (1999), Switch mode Power Supply Handbook (Second ed.), McGrawHill, ISBN 0070067198

[16] Anders Lind, IFNA PMM (130308) ,V1.0"Forward Converter Design Note". Austria AG 9500 Villach, Austria.(Edition 201303).

[17] Glenn, MisfitToys, Light Year, Cyril B, Dicklyon, et.al."Pushpull converter Source" in "http://en.wikipedia.org/wiki/Push%E2%80%93pull%20 converter?oldid=598461047"

[18] Robert L. Steigerwald, "A Comparison of Halfbridge Resonant Converter Topologies," IEEE Transactions on Power Electronics, Vol. 3, No. 2, April 1988.

[19] Maria Teresa Outeiro and Adriano Carvalho Methodology of Designing Power Converters for Fuel Cell Based Systems: A Resonant Approach "Department of Electrical Engineering, Institute of Engineering of Coimbra, Institute of Systems and Robotics – Porto, Portugal.

[20] Yungtaek Jang and Milan M. Jovanović "Two Inductor Boost Converter with auxillary transformer", Delta Products Corporation Power Electronics Laboratory P.O. Box 12173, 5101Davis Drive Research Triangle Park, NC 27709, 0780374053/02/$17.00 (C) 2002 IEEE