IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321- 5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

NFTPCOS-18

National Conference on Future Technologies in Power Control and Communication Systems

College of Engineering Perumon, Kollam, Kerala

Vol. 1, Special Issue 2, March 2018

Stand-Alone, Cost Effective Photovoltaic Water Pumping System

Gopika Vijayan[1], Vinod V P[2], Sreejith T[3]

PG Scholar, Dept. Electrical & Electronics Engineering, Sree Buddha College of Engineering, Pattoor, India[1]

Assistant Professor, Dept. Electrical & Electronics Engineering, Sree Buddha College of Engineering, Pattoor, India[2]

PG Scholar, Dept. Electrical & Electronics Engineering, Sree Buddha College of Engineering, Pattoor, India[3]

Abstract: Induction motors are generally utilized as a part of industries because of its ease and least maintenance. In the proposed framework induction motor is utilized for solar based water pumping application. As the vitality utilization is increasing day by day, the vitality generated is alone is not able to supply the whole load prerequisite. Among the available renewable vitality sources, solar vitality is the leading one. The novelty of this paper is the introduction of three phase four switch inverter for reducing the cost and improving the efficiency Utilization of batteries increases the cost and also the life of battery is particularly less when compared to the PV panel. Two Inductor Boost Converter (TIBC) is utilized here to drive the induction motor. TIBC is utilized because it have a high change ratio so the need of transformer turns ratio can be decreased also it contains small number of segments, effortlessness, high productivity, easy transformer transition balance and shared opinion gate driving for both switches suits it for the application. The converter is intended to drive a three-phase induction motor specifically from PV vitality. For tracking maximum available solar power, maximum power point tracking hill climb algorithm is utilized. The utilization of a three-phase induction motor displays a better answer for the commercial dc motor water pumping framework. The advancement is situated to achieve a more effective, reliable, sans maintenance, and cheaper arrangement than the standard ones that utilization dc motors or low-voltage synchronous motors. Since the framework is of minimal effort, it is affordable by the farmers for utilizing it in irrigation reason. It can be executed in any isolated areas since solar vitality is available everywhere. Water is an indispensable factor in day today life. Pumping is required for each commercial working for its smooth working. The proposed framework does not requires any additional power necessity and require less space for installation. So it can be easily executed anywhere required.

Keywords: Induction motor, photovoltaic (PV) power systems, two-inductor boost converter.

I. INTRODUCTION

Water is an indispensable factor in day today life. Humans utilize water for irrigation, industrial, household reason and so forth several motors are utilized to direct out water from the well. Induction motor was utilized as a part of the proposed work because of its diminished cost and low maintenance. As the vitality demand is increasing day by day, the generated vitality is not adequate to meet the whole load. Here comes the importance of renewable vitality hotspots for vitality generation. Among the available vitality assets solar vitality is the leading one and has a proficiency of 18%. This undertaking proposes a stand-alone solar water pumping framework that can be utilized as a part of several parts of India where there is no reach of power for their irrigation reason. A large portion of the commercial framework utilizes low voltage DC Motor for this application thereby avoiding the lift stage between the PV panel and the motor. When compared to induction motors DC motor has less effectiveness and high maintenance. DC motor does not suits for application in remote areas because it requires specialized staff for operating and maintaining these motors which is not a main factor in case of an induction motor. There are conventional water pumping framework utilizing batteries for storing the charge to operate during the evening and other conditions. In the proposed framework the batteries are avoided because it increases the cost of the framework and also they have a decreased life time when compared to other gadgets utilized as a part of the framework. The need of water amid the night and other conditions are compensated by utilizing storage tanks of particular capacity according to the necessity, whose cost is especially low when compared to the battery which is required for the particular application. The lift stage between the battery and the motor was made with the assistance of Two Inductor Boost Converter (TIBC). It has a high transformation ratio there by decreasing the need of high transformer turns ratio.

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II. TIBC BASED WATER PUMPING SYSTEM

The block diagram of the proposed framework is appeared in Fig 1. It consists of a PV panel, modified two inductor boost converter, voltage source inverter, three-phase induction motor and the pump. The voltage from the PV panel is given to the two inductor boost converter, which advance up the voltage to the coveted value. The two inductor boost converter then drives the induction motor via the voltage source inverter. The TIBC consist of a current fed inverter, resonant tank, voltage doubler rectifier and a snubber circuit. The current fed inverter have an inductor at the input, so the framework can be measured to have input current swell as low as required, in this manner eliminating the need of the input capacitor at the panel voltage. Current-fed converters are normally gotten from the boost converter, having an inherent high step-up voltage ratio, which decreases the required transformer turns ratio.

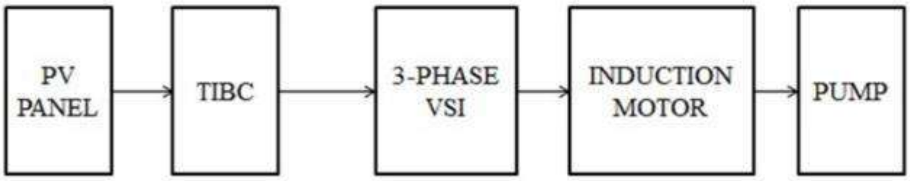

Fig 1. Block Diagram of the Proposed System

Despite everything they have issues with high voltage spikes created because of the leakage inductance of the transformers and with high voltage stress on the rectifying diode. For eliminating this resonant tank is utilized. Resonant topologies are able to use the segment parasitic characteristics, for example, the leakage inductance and winding capacitance of transformers, profitably to achieve zero current switching (ZCS) or zero voltage switching (ZVS) condition to the active switches and rectifying diodes. The main downside of the established TIBC is its inability to work with no load or even in low-load conditions. The TIBC input inductors are charged paying little heed to whether there is no output current, and the imperativeness of the inductor is of late exchanged to the ouput capacitor raising its voltage indefinitely until its breakdown. The input MOSFET cannot be turned off in light of the fact that there is no elective way for the inductor current. With the expansion of the proposed snubber, the TIBC switches can be turned off. Thusly, a hysteresis controller can be set up in light of the dc bus voltage level. Each time a greatest voltage restrain is come to, indicating a low-load condition, this strategy for activity begins. The switches are slaughtered until the point that the point when the dc transport voltage returns to a normal predefined level. Accordingly, the switching misfortunes are diminished in the midst of this time period. The extended two inductor support converter is showed up in Fig 2.
Also compelling smart hill climbing technique to extract maximum power from PV cell is utilized. The flow chart of hill climbing algorithm is appeared in Fig. 3. In this strategy the controller adjusts the voltage by a small amount from the array and measures control; if the power increases, further adjustments toward that path are attempted until control never again increases. This is called the perturb and observe technique and is most normal, although this strategy can bring about oscillations of energy output.

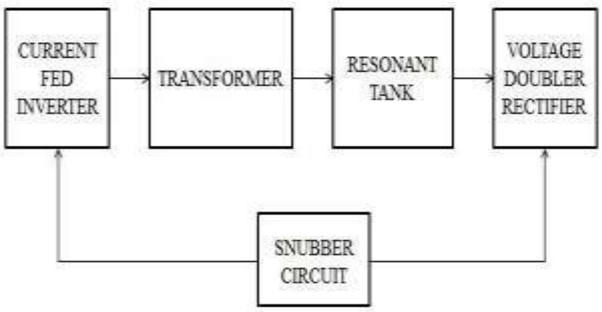

Fig 2. Two Inductor Boost Converter

It is alluded to as a hill climbing method, because it relies upon the rise of the bend of energy against voltage below the maximum power point, and the fall above that point. Perturb and observe is the most usually utilized MPPT technique because of its ease of implementation. Perturb and observe technique may bring about top-level effectiveness, gave that an appropriate prescient and adaptive hill climbing strategy is adopted

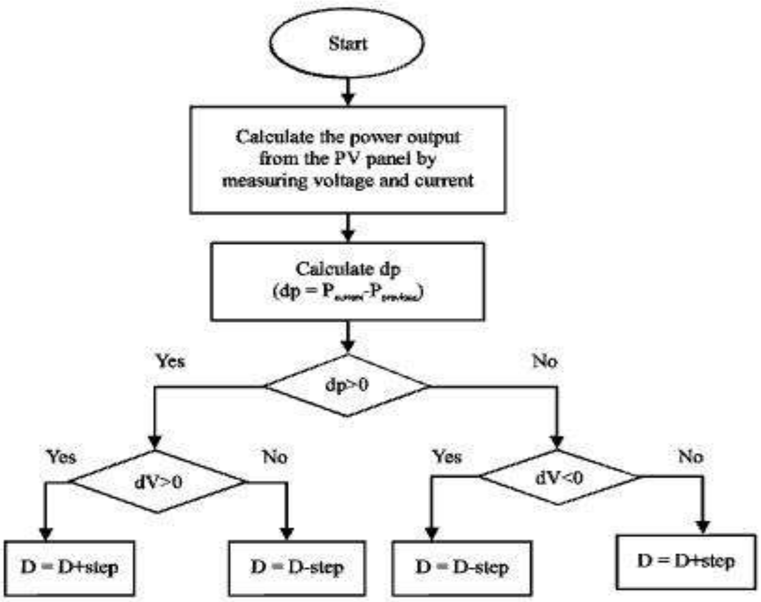

Fig.3. Hill Climbing MPPT Flow Chart

III. THREE PHASE FOUR SWITCH INVERTER

The circuit outline of a 4S3P inverter is appeared in Fig.4. The four switch three phase inverter topology includes four switches that give two inverter yield stages: B and C. The third yield stage, stage An, is related with the midpoint of the two split capacitors. The zero potential point is described as point 0 in Fig.4.

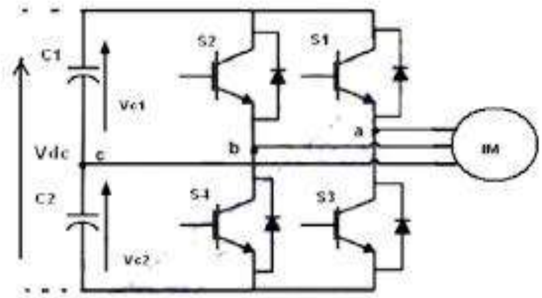

Fig.4 Three phase six switch inverter

The stage to-zero voltages VA0, VB0 and VC0 rely upon the exchanging conditions of S1, S2, S3 and S4, and two dc-interface voltages (Vdc1, Vdc2). The stage to-zero voltages are resolved as takes after:

$V_{AO} = V_{dc2}$

$V_{BO} = S_1(V_{dc1}+V_{dc2})$

$V_{CO} = S_2(V_{dc1}+V_{dc2})$

Where Vdc is the total dc-link voltage. Vdc1, Vdc2 are voltages across two capacitors C1 nd C2, respectively.

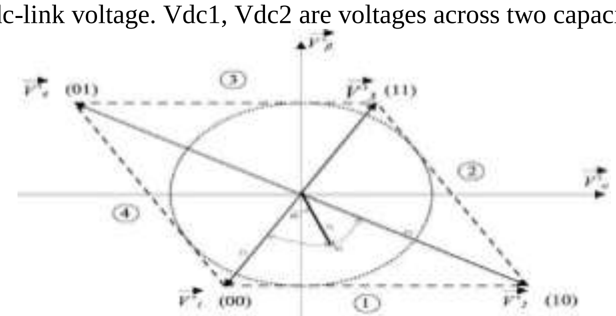

Fig.5 Time durationTs,T1 & T0

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IV. SIMULATION AND RESULTS

With a specific end goal to check the outcomes, the simulation was done on MATLAB software and the outcomes are examined. Fig.6. demonstrates the simulation of Two Inductor Boost Converter. Because of the nearness of high value inductor at the input, the input current swells can be diminished. So the need of high value capacitor at the PV panel can be avoided. The main parts of TIBC are current fed converter, resonant circuit and he snubber circuit. The current fed converters are gotten from boost converter, so they have inherent advance up characteristics so the need of transformer turns ratio can be lessened. Despite the fact that they have several advantages, they have issues associated with high voltage spikes created by the leakage inductance of the transformers and with high voltage stress on the rectifying diodes.

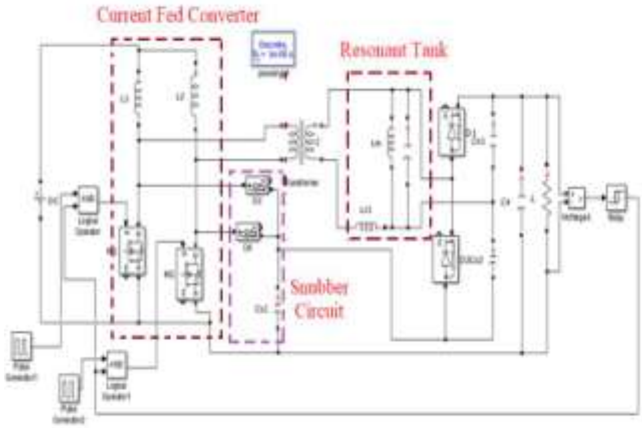

Fig.6. Two Inductor Boost Converter Simulation

During no load and low load condition the yield of the TIBC will be immeasurably high and the TIBC cannot be turned on the grounds that the Inductor current have no elective way to flow. With the introduction of the snubber circuit the MOSFETs can be switched off. At the point when the output voltage outperforms the predefined esteem the output of the transfer will be zero and the door pulse to the MOSFET will be blocked and the MOSFETs can be turned off. The input voltage to the TIBC is 26.6V and the waveform is showed up in the Fig.7.

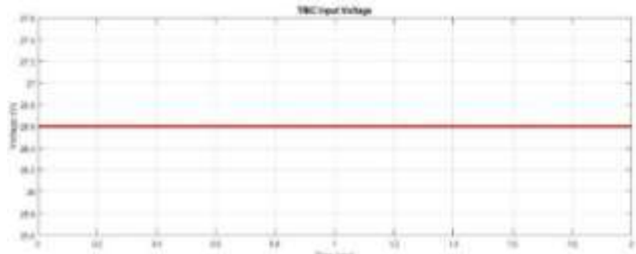

Fig.7. TIBC Input Voltage

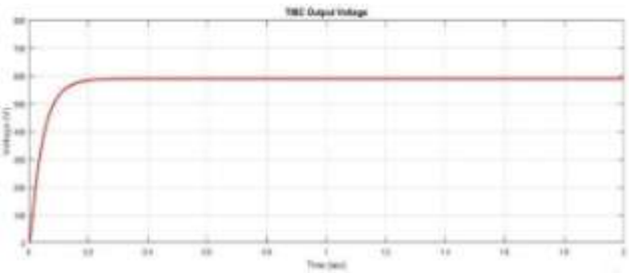

Fig.8. TIBC Output Voltage

The yield of the TIBC is showed up in Fig.8. furthermore, has an esteem 595V. The bus voltage was defined using the minimum necessary voltage for the chosen inverter topology and PWM strategy, as shown in

$$> \quad \times \sqrt{2} = 415 \times \sqrt{2} = 586.8 \quad \cong 600$$

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The Kv gain necessary for the converter can be calculated using

$$> \frac{\times \sqrt{2}}{2} = \frac{415 \times \sqrt{2}}{26.6} = 22$$

D was chosen to be 53% based on the minimum required overlapping and commutation times of the chosen drivers and MOSFETs. The minimum ratio Ns/Np can be determined by

$$\geq \frac{\times (1 - \quad) - 1}{2} = 4.67$$

It have a high conversion ratio, and is able to boost the voltage from 26.6V to 588.6V which is desired by the motor. The simulation of the whole system is done in MATLAB software. Due to the high switching frequency of TIBC converter, the boost stage between the PV panel and inverter is eliminated. Fig.7. shows the MATLAB simulation of the stand-alone solar water pump.

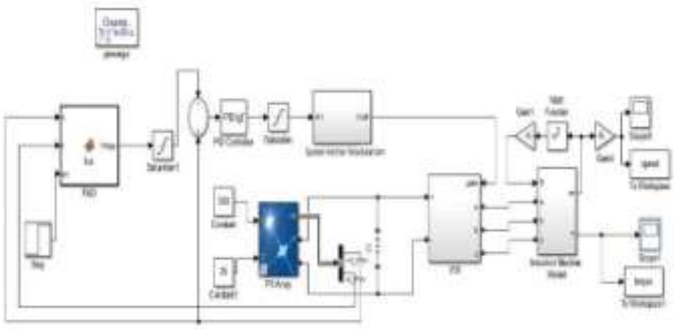

Fig.9. MATLAB Simulation of Stand-alone Solar Water Pump

The voltage from the PV panel is given to the three phase voltage source inverter for converting it to ac. The converted ac signal is used to drive the Induction motor. The torque given to the induction motor is based on the torque characteristics of the pump. The torque equation of the pump is be given as

30

Where T is in KNm

P is in KW

n is in rpm

For a 5 hp motor running at 1500 rpm,

$$= \frac{30 \times 5 \times 746 \times 1000}{\times 1500} = 22$$

Also,

$$= 8.91 \times 10^{-4}$$

Based on the measured PV panel voltage (VPV) and current (IPV), the MPPT estimates a frequency reference to drive the motor, which indirectly serves to regulate the PV voltage by modifying the amount of power transferred to the motor. A volt–hertz controller calculates the output voltage based on the operating frequency.

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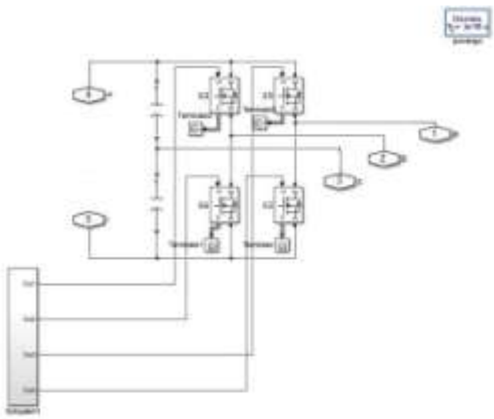

Fig.10. Space Vector PWM

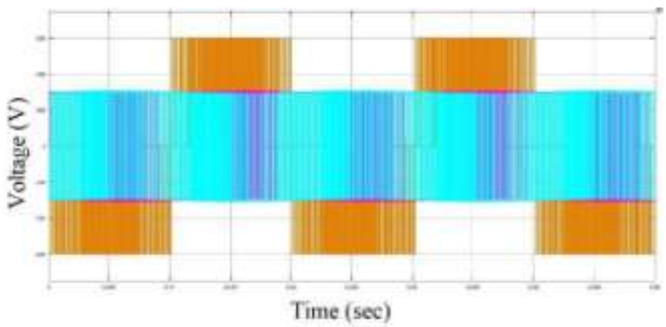

Fig.11. Inverter Output Waveform

The inverter is based on a novel topology (two legs, with two switches per leg) and uses a space vector pulse width modulation (PWM) (SVPWM). The use of this PWM strategy is to improve the output voltage level as compared to sinusoidal PWM modulation. Fig.10 and Fig.11 shows the simulation and generated pulse of space vector PWM respectively. The speed response of the machine is shown in Fig.12, the rated speed of the machine is 1500 rpm. When applying a load of 20Nm the speed reduces to 1400 rpm. As load increases the speed of the machine will decrease. Fig.13 shows the torque characteristics if the machine which has a value around 23 Nm.

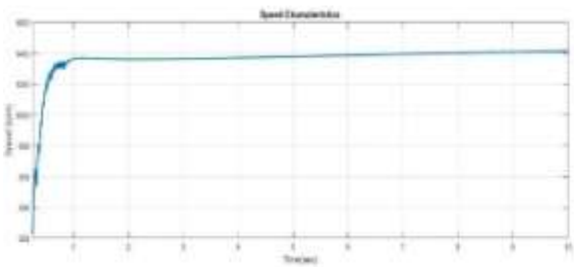

Fig.12. Speed Characteristics

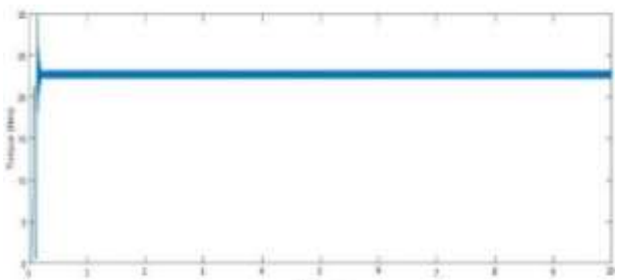

Fig.13. Torque Characteristics

V. CONCLUSION

In this paper an efficient and economical stand-alone solar water pump was proposed. The simulation of the TIBC, three phase four switch inverter and the stand-alone water pump was done on MATLAB software and studied the results.

By the elimination of one complete leg the cost as well as switching loss can be reduced. So the system have high efficiency, low cost compared to any other stand-alone water pumping system.

ACKNOWLEDGMENT

I have an incredible delight in expressing my profound feeling of appreciation to Prof. Vinod. V. P, Assistant Professor Department of Electrical and Electronics Engineering, Sree Buddha College of Engineering, Pattoor for his assistance in this work as a guide. . I am additionally appreciative to my family and companions for their important proposals and consistent support. Most importantly, I offer my profound thanks to Almighty, the preeminent guide for bestowing his blessings upon me for the fruitful finish of this work.

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