Efficiency improvement using combined thermal heat exchanger for solar pv based water pump

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Abstract. In this project we are proposing a system which helps to improve the efficiency of Solar PV based agricultural water pump using thermal heat exchanger. We tried to reduce the temperature of the PV panel using thermal heat exchanger and we also installed an IDDB converter. In this way we can increase the voltage and efficiency of the system. Predominant elements of the framework, for example, the impact of sun powered radiation on engine force, ebb and flow, and water release are thought of. The proposed water system technique is more precise and proficient than the regular water system strategies as far as the measure of the water utilized for water system, and the exactness of flooding times dependent on changing neighborhood atmosphere.
Keywords: Solar PV, pump, Heat Exchanger, PV panel

1. Introduction
India is as of now the world's second biggest maker of a few dry organic products, horticulture based material crude materials, roots and tuber crops, beats, cultivated fish, eggs, coconut, sugarcane and various vegetables. India is positioned under the world's five biggest makers of over 80% of horticultural produce things, including many money harvests, for example, espresso and cotton, in 2010. India is one of the world's five biggest makers of domesticated animals and poultry meat, with one of the quickest development rates, as of 2011[1-2].
In both horticulture and residential, water siphoning framework fuelled by sun oriented cell generators are one of the most significant applications. To entrain the siphon through control activity of engines by growing new productive and adaptable modes, this should be possible by warm warmth exchanger is associated on the rear of the PV board. To plan and build up an ARC based high recurrence support converter (Isolated twofold buck help resounding converter) with Fuzzy controller utilizing delicate exchanging strategy for productivity improvement in power change [3]. This converter is proposed to be associated with a horticultural water siphon utilizing sun powered photovoltaic framework as the source. The water conveyed from the siphon is sent used to cool the sun based board.
through cooling cylinders and balances fitted in the board before being conveyed to the development field. In the proposed framework, a disconnected twofold buck support thunderous converter is utilized which help to help up the voltage i.e., it changes over adequate voltage from restricted sunlight based vitality. Fluffy rationale based controller is utilized in the framework. Brushless DC Motor is utilized in the framework. 3 stage Induction Motor is generally is utilized in these sorts thinking about the sun powered vitality vacillation and sun-based vitality improving necessities. Photovoltaic-battery half breed framework feds the vector control of a no concurrent engine, this vector control is talked about in this paper. PV generator, converter of DC-DC, battery, converter of DC-AC, an enlistment engine constrained by a vector and the diffusive siphon are researched in this paper. By irritated and watch (P and O) calculation which incorporated with support converter control, a PV generator can be worked at greatest force. At all confinement conditions, the engine flexibly is likewise guaranteed. The sun oriented photovoltaic based rural water siphoning framework is most appropriate innovation for water system of homesteads. ... The effectiveness of sunlight based water siphon is a lot higher than customary force based water siphon. The greatest stream rate acquired was 69 LPM against 65 LPM for customary force technique [4-5].

Sun based controlled water pumps can convey drinking water just as water for animals or water system purposes [6]. Solar water pumps might be particularly helpful in little scope or network based water system, as huge scope water system requires huge volumes of water that thus require an enormous sun based PV array [7-8]. As the water may just be required during certain pieces of the year, a huge PV exhibit would give abundance vitality that isn’t really required, accordingly making the framework wasteful [9-10]. Therefore the objective is to introduce a system which helps to improve the efficiency of Solar PV based agricultural water pump using thermal heat exchanger. We tried to reduce the temperature of the PV panel using thermal heat exchanger and we also installed an IDBB converter [11-13].

The main objective of this proposed system is to improve the efficiency of the Solar PV based agricultural water pump using thermal heat exchanger.

2. Proposed System

In the existing system, due to high temperature there will be a decrease in the voltage in the solar PV panel and it affects the efficiency. In the proposed system, a thermal heat exchanger is connected on the backside of the PV panel. To design and develop an ARC based high frequency boost converter (Isolated double buck boost resonant converter) with Fuzzy controller using soft switching technique for efficiency improvement in power conversion. This converter is intended to be connected to an agricultural water pump using solar photovoltaic system as the source. The water delivered from the pump is sent used to cool the solar panel through cooling tubes and fins fitted in the panel before being delivered to the cultivation field. In the proposed system, an isolated double buck boost resonant converter is used which help to boost up the voltage i.e., it converts sufficient voltage from limited solar energy. Fuzzy logic based controller is used in the system. Brushless DC Motor is used in the system. 3 phase Induction Motor is mostly is used in these types of the existing system. But Induction motor works only on high AC voltage. From solar panel DC voltage is obtaining. By using BLDC motor only one DC-DC converter is needed and works on low voltage.

2.1. Block Diagram Description

The proposed system consists of Solar Panel, Isolated Double Buck Booster, Fuzzy based controller and Brushless DC motor and pump. The block diagram of proposed system is as shown in the figure 1.
2.2. Circuit Description

The figure 2 shows the overall circuit connection of our project. BLDC motor-driven water pump depends on a design appeared in Fig.2. A dc–dc converter is utilized for MPPT of a SPV cluster obviously. Two stage flows are detected alongside Hall signals input for control of BLDC motor, bringing about an expanded expense. The extra control conspire causes expanded expense and intricacy, which is required to control the speed of BLDC motor.

2.3. Methodology

As shown in the figure 2 a thermal heat exchanger is connected on the backside of the PV panel. The thermal heat exchanger is used to cool down the heat on the solar panel. To design and develop an ARC based high frequency boost converter (Isolated double buck boost resonant converter) with Fuzzy controller using soft switching technique for efficiency improvement in power conversion. This converter is intended to be connected to an agricultural water pump using solar photovoltaic system as the source. The water delivered from the pump is sent used to cool the solar panel through heat exchanger fitted in the backside of the panel before being delivered to the cultivation field. In the proposed system, an isolated double buck boost resonant converter is used which help to boost up the voltage i.e., it converts sufficient voltage from limited solar energy. Fuzzy logic based controller is used in the system. Brushless DC Motor is used in the system. 3 phase Induction Motor is mostly is used in these type of the existing system. But Induction motor works only on high AC voltage. From solar panel DC voltage is obtaining. By using BLDC motor only one DC-DC converter is needed and works on low voltage.
2.4. Hardware Description

2.4.1. Solar Panel

The term solar panel is utilized casually for a photovoltaic (PV) module. A PV module is a get together of photovoltaic cells mounted in a casing work for establishment. Photovoltaic cells use daylight as a wellspring of energy and produce direct flow power. An assortment of PV modules is known as a PV Panel, and an arrangement of Panels is an array. Varieties of a photovoltaic framework are gracefully solar power to electrical gear. Diagram of the solar cell to the solar PV system is shown in figure 3.

The most widely recognized use of solar energy assortment outside horticulture is solar water warming frameworks

![Diagram of a solar cell to PV system](image)

**Figure 3** Diagram of a solar cell to PV system

A PV junction box is appended to the rear of the solar panel and capacities as its yield interface. Outer associations for most photovoltaic modules use MC4 connectors to encourage simple weatherproof associations with the remainder of the framework. A USB power interface can likewise be utilized. Module electrical associations are made in arrangement to accomplish an ideal yield voltage or in corresponding to give an ideal flow capacity (amperes) of the solar panel or the PV framework. The directing wires that take the current off the modules are estimated by the amp city and may contain silver, copper or other non-attractive conductive change metals. Sidestep diodes might be consolidated or utilized remotely, if there should arise an occurrence of incomplete module concealing, to augment the yield of module segments despite everything lit up.

2.4.2. Isolated Double Buck Boost Converter

The buck–boost converter is a kind of DC-to-DC converter that has a yield voltage extent that is either more noteworthy than or not exactly the information voltage size. It is equal to a fly back converter utilizing a solitary inductor rather than a transformer. Two distinct topologies are called buck–boost converter. The two can deliver a scope of yield voltages, running from a lot bigger (in supreme extent) than the info voltage, down to right around zero.

![Schematic diagram IDBB Converter](image)

**Figure 4** Schematic diagram IDBB Converter
Figure 4 shows the output voltage is of the contrary extremity than the info. This is an exchanged mode power flexibly with a comparative circuit topology to the boost converter and the buck converter. The output voltage is movable dependent on the obligation pattern of the exchanging transistor. One potential downside of this converter is that the switch doesn’t have a terminal at ground; this muddles the driving hardware. Be that as it may, this disadvantage is of no outcome if the force gracefully is disconnected from the heap circuit (if, for instance, the flexibly is a battery) in light of the fact that the gracefully and diode extremity can just be turned around. At the point when they can be turned around, the switch can be on either the ground side or the gracefully side.

Figure 5 shows equivalent circuits for the operation of the IDBB converter at different intervals. The output voltage is commonly of a similar extremity of the information, and can be lower or higher than the information. Such a non-transforming buck-boost converter may utilize a solitary inductor which is utilized for both the buck inductor mode and the boost inductor mode, utilizing switches rather than diodes, once in a while called a “four-switch buck-boost converter”, it might utilize various inductors however just a solitary switch as in the SEPIC and Cu k topologies.

2.4.3 Fuzzy Logic Controller
Fuzzy Logic is a specific territory of focus in the investigation of Artificial Intelligence and depends on the estimation of that data which is neither unquestionably evident nor bogus. Figure 6 shows the working of fuzzy logic controller. The data which people use in their regular day to day existences to base natural choices and apply general dependable guidelines can and ought to be applied to those control circumstances which request them. Procured information can be a ground-breaking weapon to battle the undesired impacts of the framework reaction.

Fuzzy logic controllers utilize an entirely adaptable arrangement of if then rules. The arrangement is then applied to suitable participation capacities. Alluding to values which exist in the concealed territory are called valid without question.
Those qualities which exist in the cross brought forth territory are called bogus without question. In the event that all information tumbles aside or the other of the cover territory, at that point Fuzzy Logic likely would be of little advantage. In many applications there are a few focuses which lie in the normal region. Data which exists in the basic territory must be contemplated, put away, and used to evaluate and to characterize the information. This takes into account keen control of the information structure so as to make deduction to an answer. Data which falls in that normal territory can be positioned, matured, and "best estimate" made after assessment of this "dim" data.

Another bit of leeway of Fuzzy Logic controllers is to measure the info signal in an occasionally "boisterous" condition. This clamor, which will in general degenerate the uprightness of the genuine sign, is managed through the good judgment of the skilled administrator. Scientifically, the data must be judged and arranged for use in dynamic. In the event that an administrator set aside the effort to plot the procedure data on a XY facilitate framework, the administrator could outwardly apply a bend fit to the information and concoct a genuinely exact nonexclusive portrayal. Numerically, fitting a bend of lower request would deliver a genuinely off base portrayal. Thusly, a higher request bend fit would be suitable to oblige the boisterous sign. Fuzzy Logic endeavors to imitate what the human reaction would be and apply the most savvy fit to the information. Regular processing depends on Boolean logic, which means everything is spoken to as either zero or one. In certain circumstances this prompts misrepresentation and insufficient outcomes. Fuzzy logic controllers, and by expansion, fuzzy control, tries to manage multifaceted nature by making heuristics that adjust all the more intimately with human view of issues. Fuzzy logic furnishes a method of managing imprecision and nonlinearity in complex control circumstances. Data sources are passed to a "derivation motor" where human or experienced based rules are applied to create a yield.

2.4.4 Brushless DC Motor

A brushless DC electric motor (BLDC motor or BL motor), otherwise called electronically commutated motor (ECM or EC motor) and synchronous DC motors, are coordinated motors fuelled by direct flow (DC) electricity by means of an inverter or exchanging power flexibly which produces electricity through alternating current (AC) to drive each period of the motor by means of a shut circle controller. Diagram of BLDC motor is shown in figure 7. The controller gives beats of current to the motor windings that control the speed and torque of the motor.
The development of a brushless motor framework is normally like a permanent magnet synchronous motor (PMSM), however can likewise be an exchanged reluctance motor, or an acceptance (asynchronous) motor. They may likewise utilize neodymium magnets and be out sprinters (the stator is encircled by the rotor) or in sprinters (the rotor is encircled by the stator).

The upsides of a brushless motor over brushed motors are high capacity to-weight proportion, fast, electronic control, and low upkeep. Brushless motors discover applications in such places as PC peripherals (circle drives, printers), hand-held force apparatuses, and vehicles extending from model airplane to cars.

2.4.5 Pump
A pump is a gadget that moves (liquids or gases), or once in a while slurries, by mechanical activity, commonly changed over from electrical energy into Hydraulic energy. Pumps can be ordered into three significant gatherings as indicated by the technique they use to move the liquid: direct lift, uprooting, and gravity pumps.

Pumps work by some system (ordinarily responding or turning), and devour energy to perform mechanical work moving the liquid. Pumps work through numerous energy sources, including manual activity, power, motors, or wind force, and come in numerous sizes, from minute for use in clinical applications, to huge mechanical pumps. The below figure 8 shows the diagram of pump.

Mechanical pumps serve in a wide scope of uses, for example, pumping water from wells, aquarium separating, lake sifting and air circulation, in the vehicle business for water-cooling and fuel infusion, in the vitality business for pumping oil and petroleum gas or for working cooling towers and different parts of warming, ventilation and cooling frameworks. In the clinical business, pumps are utilized for biochemical procedures in creating and assembling medication, and as counterfeit substitutes for body parts,
specifically the fake heart and penile prosthesis. At the point when a packaging contains just one spinning impeller, it is known as a solitary stage pump. At the point when a packaging contains at least two spinning impellers, it is known as a double-or multi-stage pump.

3. Result and Discussion

3.1 Simulation

Components specifications are tested in MATLAB Simulink for accuracy. IDBB Converters are modelled in MATLAB Simulink for performance verifications. The model is implemented as shown in Figure 9.

Figure 10 shows the simulation diagram of the BLDC motor. The motor works corresponding to the temperature. When the temperature rises greater than $35^\circ$C the motor automatically turned on and get cool the PV panel. and get cool the PV panel.

![Figure 9 Simulink diagram of an IDBB Converter](image)

![Figure 10 Simulation diagram of hardware](image)
3.2 Output Voltage and Design of Input Inductor

![IDBB Converter Working in Open-loop](image.png)

**Figure 11** IDBB Converter Working in Open-loop

3.2.1 Input Inductor

Figure 11 shows the working of IDBB converter working in open loop.

\[ L_i = \frac{(1-D)^2}{2f_c} R \]

When
- \( D = 0.5 \) then \( V_o = V_s \)
- \( D > 0.5 \) then \( V_o > V_s \)
- \( D < 0.5 \) then \( V_o < V_s \)

3.3 Design Values of Bus Capacitor and Duty Cycle

3.3.1 Duty Cycle

- \( T_{ON} = 60\% \) of \( T \)
- \( T_{ON} = 0.6 \) for boost operation

3.3.2 Output Voltage

Figure 12 and figure 13 shows the output graph of IDBB converter in open and closed loop respectively.

\[ V_o = \frac{D}{1-D} V_s \]

When
- \( D = 0.5 \) then \( V_o = V_s \)
- \( D < 0.5 \) then \( V_o < V_s \)
- \( D > 0.5 \) then \( V_o > V_s \)
3.3.3 Bus Capacitor

$$C_B = \frac{D V_o}{V_r R f_s}$$

Where $V_r$ is the ripple voltage which is normally 1% of $V_o$  
The value of $C_B$ is 80 MFD  
The value of $C_0$ is 150 MFD

3.4 Comparison Result

Table 1 shows the comparison result of the DBB converter with conventional converters.

4. Conclusion

In this project, a new system is made using thermal heat exchanger and IDBB converter on the solar PV based agricultural water pump. By using the thermal heat exchanger the temperature at the PV panel is decreased and by using the IDBB converter the voltage loss is reduced. Thus the efficiency of the system is increased.
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