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EFFICIENT SOLAR-POWERED INDUCTION MOTOR DRIVE FOR WATER PUMPING SYSTEM

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ABSTRACT: Solar energy is a well-known renewable energy source that has the potential to address future energy challenges. This investigation investigates the potential of solar energy to operate water pumping apparatus. Two converters comprise the pump and motor system. Two converters that may be installed are a DC-DC boost converter and a three-phase DC-AC inverter. The inverter is supplied with a consistent supply of power by a boost converter, which increases the voltage from the solar panel. Alternating current (AC) power is supplied to the motor component by the VSI, which functions as a converter. The current three-phase induction motor is a superior option due to its affordability and accessibility. The subsequent phase involves optimizing the power output of a solar panel following its installation. The exorbitant costs of constructing the structures are the cause of this issue. In an effort to optimize operations, Maximum Power Point Tracking (MPPT) is implemented. The induction motor's velocity can be altered by the V/F control system. The entire system design is included, in addition to the MATLAB/SIMULINK model.

Keywords: Maximum Power Point Tracking (MPPT), Photo Voltaic (PV), Boost converter, Voltage Source Inverter (VSI), Induction motor drive, V/F control.

1. INTRODUCTION

A country's success and expansion are contingent upon the availability of energy. Approximately 21% of the global population lacks sufficient access to water to satisfy their fundamental requirements. Typically, the water required by these regions is obtained by transporting it from a distance to rural and remote locations. Another significant concern is that access to electricity may be difficult in certain regions.

Parallel to this, the global energy crisis began to worsen. At some point, conventional energy sources, including coal, nuclear power, and fossil fuels, will exhaust their energy reserves. Alternative energy sources, including geothermal, biomass, solar, and wind power, are currently being implemented to address the imminent energy crisis.The most prevalent form of renewable energy is solar energy. When employed in conjunction with rural water extraction devices, it enhances operational efficiency.

In the past, solar photovoltaic (PV) systems have been associated with subpar performance and exorbitant prices. It

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achieved that level of efficacy approximately 5 to 6 percent of the time. As a result, prices have decreased to align with the 16–17% increase in efficacy that technology advancements have enabled. Many consider solar energy to be the most promising energy source for the near future due to its ease of access, lack of pollution, and minimal maintenance requirements.

The utilization of photovoltaic (PV) systems is increasing as a result of technological advancements. Nevertheless, this has resulted in issues such as uneven performance, lower-than-optimal efficiency, and substantial initial investment requirements. Solar-powered water devices are gaining popularity in remote locations.

For agricultural professionals, there are numerous advantages to installing solar water pumps. The advantages encompass a low environmental impact, high reliability, simplicity of use, low maintenance, and low running costs. The main goal is to improve the panel's power-generating efficiency during placement, even though there are problems like building costs that are too high. Diverse Maximum Power Point Tracking (MPPT) methodologies are implemented to accomplish this objective.

They developed a solar system that utilized a dual-ended induction motor drive and subsequently introduced it to the market. The voltage value of the semiconductor decreases when the terminals of the stator winding are connected to the phase. Nevertheless, the complexity of the control systems and the quantity of devices are both deteriorating concurrently. Afterward, the subject shifts to a water extraction technique that is energy-efficient and capable of operating autonomously. A permanent magnet synchronous motor replaces an induction motor. FOC, or Focus on Customers, is a critical concept in management.

There are substantial expenses associated with this. Frequency control is employed to enhance the efficiency of induction motor transmissions, as indicated by the text. The P&O algorithm is employed to determine the largest integer. Nevertheless, the overall efficacy is diminishing. In order to optimize the performance of induction motors, it is possible to increase the starting ratio by incorporating additional DC-DC converters, such as push-pull converters. One significant issue with the method is that it necessitates transformers with center receptacles, which is not always feasible. In situations where the pace must remain constant, induction motors are frequently employed. They can now operate in environments where inverters regulate rates that fluctuate on a regular basis.

The voltage and frequency that are applied to an induction motor can be adjusted to alter its speed. The drive is more dependable than other commonly available motors due to its ability to operate in a variety of environments, its cost-effectiveness, its ability to produce consistent power, its ease of use, and its wide speed range. Additionally, it requires minimal maintenance. The induction motor is supplied with power from a three-phase electrical source through the use of a converter. Scalar control and vector control are two distinct methods of monitoring a machine. Numerous individuals implement the V/F approach.

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The formula provided above is the fundamental method by which pumps are managed in various environments. Smooth starting, smooth acceleration and deceleration, improved motor reversing and stopping routines, lower harmonics, a higher power factor, and substantial cost reductions are among the potential advantages. There are an infinite number of methods for arranging solar cells. Solar-powered pumps are an effective method for supplying water to agricultural regions. Furthermore, it is capable of performing tasks that are associated with water treatment centers and irrigation.

2. TOPOLOGY DESCRIPTION

The solar water circulation device is assembled as illustrated in Figure 1. It is equipped with a PI processor, a solar photovoltaic grid, a DC-DC converter, an induction motor, and SPWM, which is an acronym for sinusoidal pulse width modulation.

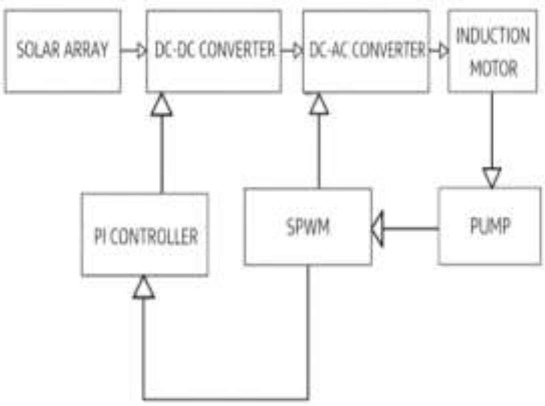

Fig. 1: Block Diagram of the System

Figure 2 illustrates the circuit's fundamental diagram. The device is composed of a power supply inverter, a boost converter, an induction motor drive, and a photovoltaic screen. MPPT algorithms are employed to monitor and maintain the utmost possible power output.The INC methodology generates extraordinary outcomes. The output of the MPPT is connected to the switch actuator of the boost converter. A three-phase inverter changes energy from direct current (DC) to alternating current (AC). The speed of an induction motor can be adjusted by adjusting the V/F ratio.

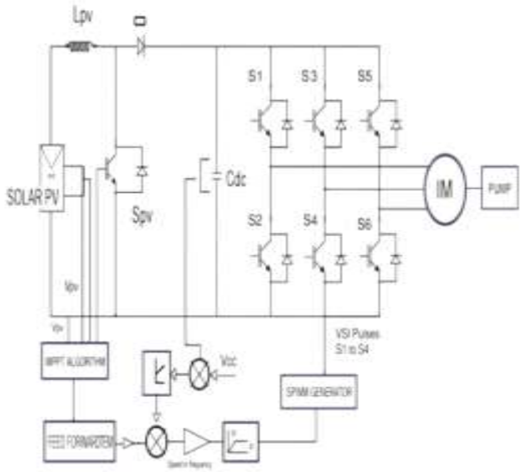

Fig. 2: Circuit Diagram of the System

The screen converts solar energy into usable electricity. This is followed by the transmission of electricity to the boost converter. Incremental conductance is a method of optimizing the power output of a solar array by adjusting the power control to achieve the maximum possible radiation value. The fixed PV panels supply the INC algorithm with voltage and current. The INC method is employed to determine the optimal power and duty ratio for initiating a DC-DC conversion in the presence of fluctuating voltage and current. The computer figures out the boost converter's duty cycle and then changes it. The output voltage of the DC-DC converter is maintained at a consistent and adjustable level by the PI processor. This is accomplished through the utilization of a surge converter.

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The pumps in this system operate in a spiral pattern, and a direct correlation has been established between the power supplied to each pump and its rate of operation. The speed is regulated by a feed-forward component that is composed of the pump working factor and the available photovoltaic power. The pump working factor is determined by utilizing the motor's rated torque and speed. The proportional-integral (PI) engine generates an output by eliminating the velocity component. This can be accomplished by comparing the speed term to the output of the PI controller. This will reduce the system's burden and enhance its dynamic performance.

Sine waves regulate the energy that is directed to the motor and compressor. The SPWM voltage application employs the three-phase VSI. Sinusoidal pulse width modulation is employed to determine the switching logic for the voltage source inverter (VSI) in the voltage-to-frequency (V/f) method of controlling speed. Induction motors ensure a seamless start by managing the initial current through V/f control. Furthermore, this will extend the lifespan of the motor. This procedure involves two comparisons: the first is conducted within the PI control, while the second, as previously mentioned, evaluates the PI result in relation to the speed term. The DC link voltage is initially compared to a predetermined standard value. The inverter generates a consistent power source. Conversely, the PI driver modifies the reference speed to regulate V/f. Once the DC link voltage falls below the reference voltage, the reference speed decelerates. Conversely, the reference speed accelerates when the voltage exceeds the reference value.

As a result, the process's initial velocity is determined by the initial measurement. The pace that was previously established serves as a benchmark in the subsequent comparison. This velocity is referred to as the "feed forward speed." The second comparison provides information regarding the speed f* of the induction motor drive, which is regulated by the V/f control method. The device can now function as a single-stage converter by increasing the speed to a specific level. The boost converter generates pulses that are perpetually zero. Upon reaching the cutoff speed, the INC program determines the duty ratio and activates the boost converter's control. The power output is increased by the MPPT method, despite the fact that the initial current is extremely low.

speed Control

The most effective and straightforward method of controlling an induction motor is through V/F control. This method is applicable in a wide range of circumstances due to its adaptability. Induction motors are frequently powered by 50Hz sources. Nevertheless, the pace can be altered by adjusting the frequency. In order to maintain the flux's stability, fluctuations in frequency must be directly proportional to fluctuations in the source voltage. Figure 3 illustrates the block form for the V/F control. This process converts speed to frequency, which is subsequently adjusted to align with the voltage. The power of an induction motor is supplied by a three-phase voltage source transformer.

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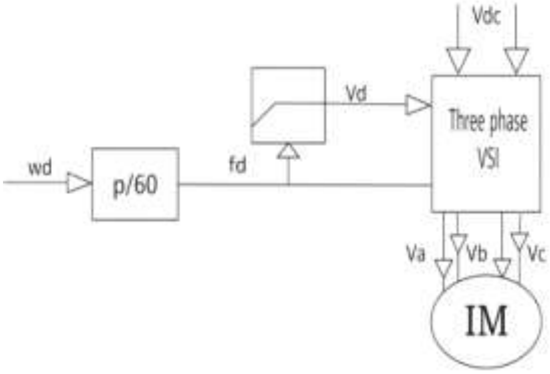

Fig. 3: Block Diagram of V/F Control Method

SPWM Control

The gate signal voltage and the three-phase voltage source inverters can be altered by SAW switching. We can observe that the voltage source inverter (VSI) has a constant direct current (DC) voltage, denoted as Vdc.Two IGBT switches are present in each of the three-phase components of the system, and they are managed by SPWM. One method of controlling the VSI switches is to place a triangle signal adjacent to a sinusoidal signal. The sine wave tells the inverter what frequency it needs to send, while the triangle wave shows the transition frequency.

3. SIMULATION RESULTS

The models of the converters and the entire hydraulic system were connected using MATLAB/SIMULINK software. The fan motor is managed by the three-phase voltage source inverter (VSI). Sinusoidal pulse width modulation (SPWM) is employed to transmit switching signals to the Voltage Source Inverter (VSI). In this section, the waveforms and Simulink model of a three-phase induction motor constructed with Sinusoidal Pulse Width Modulation (SPWM) technology are illustrated.

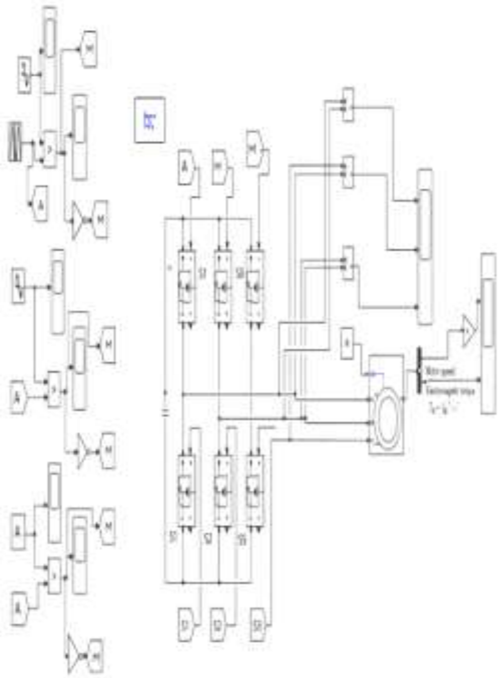

Fig. 4: MATLAB/Simulink Model of the Proposed System

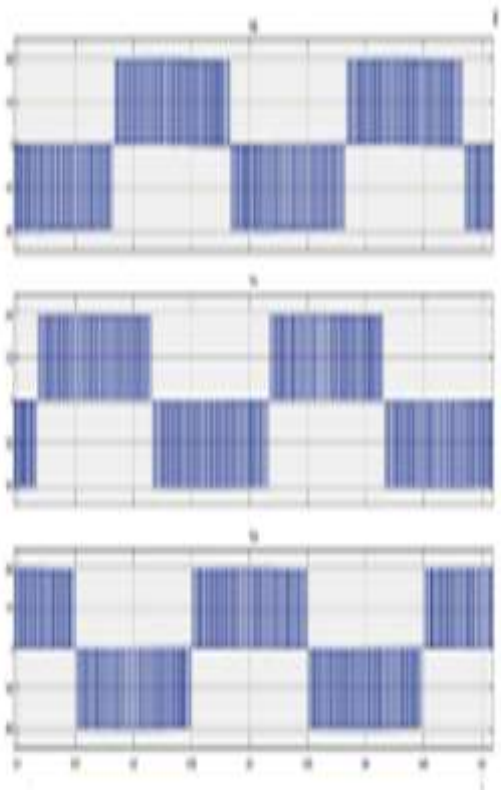

Figure 5. Voltage waveforms of the three-phase inverter

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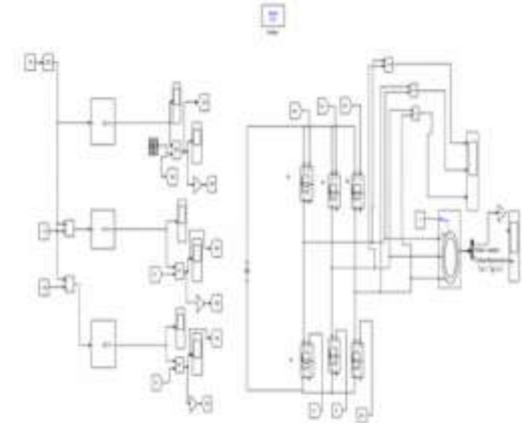

Fig. 6. Induction motor with V/F control

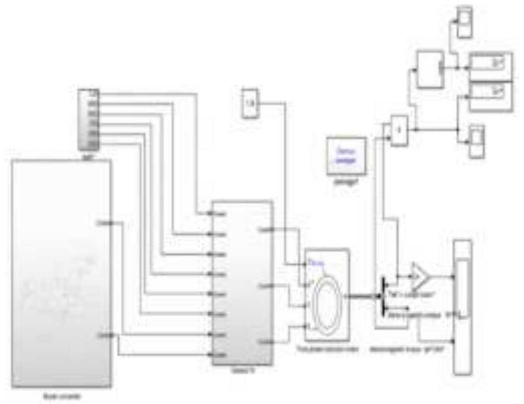

Fig. 7. Simulink model of overall system

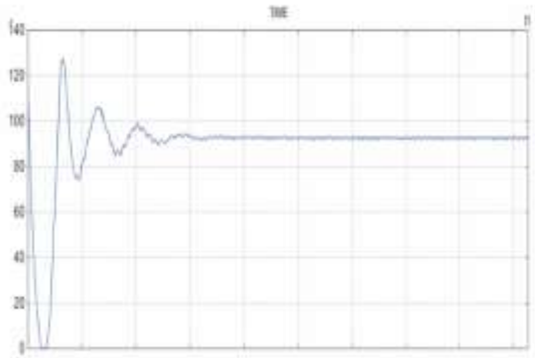

Fig. 8. Rotor speed

The operating frequency must be adjusted in order to reduce the speed using V/F control. The pace of the turning is illustrated in Figure as the frequency decreases to 40 Hz. Starting with a frequency of 50 Hz

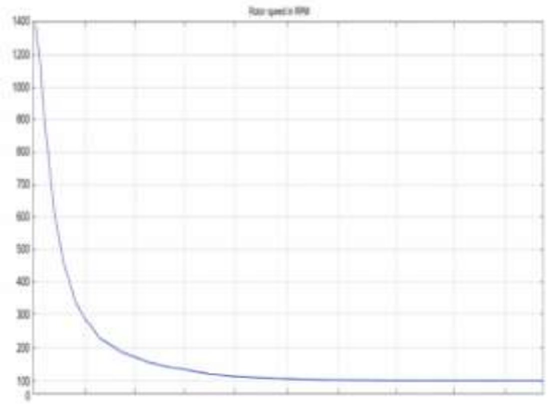

Fig 9 . Change in rotor speed with respect to frequency

4. CONCLUSION

It is recommended that you utilize a solar-powered water purification device that operates independently. Two instruments are employed to optimize the system's functionality, and the solar water pump is subjected to two modifications. The speed at which a pump rotates is determined by a V/F valve, which is powered by an induction motor. Simulations are implemented to demonstrate the system's functionality. In accordance with the test results, the motor consistently maintains the chosen pace. This demonstrates that the V/F method can be employed to effectuate modifications. The best things about this approach are that it can help you avoid losses and that it's almost always carried out perfectly. In this instance, it is imperative to employ an identical quantity of instruments. It is crucial to emphasize that the method is both user-friendly and highly dependable. It is beneficial in areas with limited electricity infrastructure and may mitigate future energy challenges.

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