An Efficient and Credible Grid-Interfaced Solar PV Water Pumping System with Energy Storage

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Abstract - The increasing demand for sustainable agricultural practices has prompted the exploration of alternative energy sources for water pumping system. In this abstract, it presents a solar powered agriculture water pumping system integrated with a Brushless DC (BLDC) motor. The system harnesses solar energy through photovoltaic panels, converting it into electrical power to drive the BLDC motor. BLDC motors offer advantages such as high efficiency, precise control, and minimal maintenance, making them for agricultural water pumping applications. Key components of the system include solar panels, a power conditioning unit, a BLDC motor controller, and a pump. The solar panels capture sunlight and convert it into direct current (DC) electricity, which is then regulated and optimized by the power conditioning unit. The BLDC motor controller manages the operation of the motor, adjusting speed and torque as needed to meet varying water demand. The system's design prioritizes reliability, efficiency, and ease of maintenance to ensure optimal performance in agricultural settings. The implementation of such systems holds the promise for addressing water scarcity challenges and contributing to agricultural resilience in diverse regions worldwide.

***Keywords: BLDC Motor, Solar (PV) energy storage, Universal bridge, Controller*.**

I. INTRODUCTION

In recent years, the agricultural sector has been increasingly turning towards sustainable and environmentally friendly practices to address challenges such as water scarcity, energy consumption, and climate change impacts. One notable advancement in this pursuit is the integration of solar energy with water pumping systems, particularly in the context of agriculture. Solar-powered water pumping systems offer a compelling solution to meet irrigation and livestock watering needs while reducing reliance on conventional grid electricity and mitigating greenhouse gas emissions. The integration of BLDC motors with solar energy in agriculture water pumping systems involves harnessing sunlight through photovoltaic (PV) panels and converting it into electricity to power the motor. This setup enables farmers to utilize renewable energy sources, thereby reducing operational costs and environmental impact while ensuring reliable water supply for crop irrigation, livestock, and other agricultural activities. This introduction sets the stage for exploring the various aspects of solar-powered agriculture water pumping systems utilizing BLDC motors. It emphasizes the significance of sustainable agricultural practices, the potential of solar energy in meeting water pumping needs, and the advantages offered by BLDC motor technology in enhancing system efficiency and performance. Through further examination, this study aims to elucidate the feasibility, benefits, and challenges associated with implementing such systems, contributing to the advancement of sustainable agriculture and renewable energy integration.

II. LITERATURE SURVEY

Sizing a solar water pump with cost-efficient considerations is essential for making solar irrigation systems accessible to gardeners. Evaluating the advantages and disadvantages of different storage configurations, gardeners can make informed decisions that align with their needs and budget constraints. This research strives to bridge the gap between traditional pumping systems and solar-based solutions in a practical and affordable manner. Remember, when it comes to embracing solar water pump systems, understanding the nuances of energy storage is key to sustainability and cost-effectiveness. Let harness the power of the sun efficiently for a greener future [1]. Providing sustainable energy and water supply to communities like Chele in Angola is essential for their development and well-being. By harnessing the power of renewable energy sources

like solar power, villages can overcome the challenges of limited access to electricity and water. The project to install a stand-alone PV Solar Power Plant in Chele represents a step towards addressing these fundamental needs and improving the quality of life for the villagers. It is imperative to continue investing in renewable energy solutions to ensure a brighter future for remote communities in Angola [2]. The findings of this research emphasize the potential of solar and wind energy as viable alternatives to power water pumps in agricultural settings. By harnessing the power of renewable energy sources, farmers can overcome the challenges of irrigation during the dry season and enhance agricultural productivity. The utilization of solar and wind water pump technology not only offers a sustainable solution but also contributes to environmental conservation efforts. This study underscores the importance of exploring innovative energy solutions for agricultural practices, paving the way for a more efficient and sustainable farming future [3]. The exploration of stator pole surface parameters in switched reluctance motor-based water pump drives offers valuable insights into optimizing system performance. By understanding the influence of pole surface design on key performance metrics, engineers and researchers can fine-tune motor components to enhance efficiency, reduce noise, and improve overall reliability. This in-depth analysis serves as a foundation for future advancements in pump drive technology, paving the way for more efficient and sustainable hydraulic systems. Remember, advancements in technology often hinge on the smallest details, such as the surface design of stator poles in electric motors. By continuously refining these elements, we can unlock new possibilities and drive innovation in various industrial applications [4]. The intent of the paper is to develop a grid interfaced single stage solar water pumping system using switched reluctance motor with PV control technique. Photovoltaic systems being Environmentally friendly energy sources are crucial due to their feasibility which have their own precedence, but there are some issues that need to be considered. Hence need to build maximum efficiency photovoltaic power generation is still probing situation. Attainable and foremost way to solve the drawback is to track sun automatically [5]. The purpose of water distribution networks is to provide water to city residents. Even with climate change and decreasing precipitation, water distribution systems should be built to accommodate consumer demand. A Water Distribution Network (WDN) consists of pipes, valves, pumps, tanks, etc., to transfer potable water from reservoirs to consumer nodes. Internet of things and information and communication technologies (ICT) are applied to water management systems (WMS) to make them smarter and more efficient [6].

III. PROPOSED METHODOLOGY

1. Block Diagram

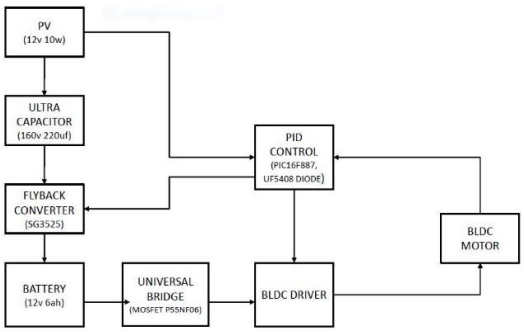


Fig. 1. Proposed Block Diagram

2. Working Methodology

As the name suggests, a BLDC motor-driven water pump is powered by a solar photovoltaic (PV) array. The PV array charges a battery, which in turn powers the BLDC motor. Fig. 1. Shows the block diagram for this proposed system. The BLDC motor drives the water pump, which pumps water from a container and into a piping system. The PV array is connected to a boost converter, which raises the voltage of the PV array to the level required by the BLDC motor. The boost converter is controlled by an intelligent maximum power point tracking (MPPT) algorithm, which ensures that the PV array is operated at its maximum power point. A three-phase AC voltage source inverter (VSI) is used to drive the BLDC motor. The VSI is controlled by a pulse generator, which produces the control signals for the VSI. The pulse generator is also used to control the water pump. A Brushless DC (BLDC) Motor is an electric motor powered by a direct current (DC) source that uses electromagnets in the stator to rotate the motor's internal permanent magnets (or armature) attached to the rotor. The stator's electromagnets are energized by DC power supplied through brushless DC (BLDC) motor drivers, which switch the electromagnets on and off in a specific sequence to make the armature rotate. BLDC motor drivers may be integrated into the motor itself, or they may be external to the motor. External BLDC motor drivers are typically found in industrial applications where high power and/or high speed are required. Internal

BLDC motor drivers are typically found in lower power applications, such as in computer hard drives and small electric motors. The most common type of BLDC motor is the Permanent Magnet (PM) type, in which the stator's electromagnets are replaced by permanent magnets. Solar photovoltaic (PV) arrays are an increasingly common sight on rooftops and in open fields around the world. Solar PV arrays convert sunlight into direct current (DC) electricity which can then be used to power homes, businesses, and other applications. Boost converters are commonly used to increase the voltage of the DC electricity produced by solar PV arrays so that it can be used to power devices or applications that require a higher voltage. For example, the DC electricity produced by a solar PV array may be increased from 12 volts to 24 volts by a boost converter so that it can be used. Boost converters are also used to increase the current of the DC electricity produced by solar PV arrays. For example, the DC electricity produced by a solar PV array may be increased from 5 amps to 10 amps by a boost converter so that it can be used to power a device that requires 10 amps. Solar PV arrays can be used to power a wide variety of devices and applications, including homes, businesses, electric vehicles, and water pumps. They are commonly used to move water from a well or a reservoir to a home or business. Water pumps can also be used to move water from one location to another in an irrigation system. Solar PV arrays can be used to power water pumps, and boost converters can be used to increase the voltage or current of the DC electricity produced by solar PV arrays so that it can be used to power water pumps.

III. HARDWARE COMPONENTS

1. PV panel 12v 10w

A 12V 10W PV panel is a photovoltaic panel that generates electricity from sunlight. The "12V" indicates the voltage output of the panel, which means it's designed to charge 12-volt batteries commonly used in off-grid solar systems, such as those in RVs, boats, cabins, and small-scale solar installations. The "10W" specifies the power output of the panel, meaning it can produce up to 10 watts of electricity under optimal conditions. Fig. 2. Shows the presentation for 45 cell solar panel. These panels typically consist of multiple solar cells made from semiconductor materials like silicon. When sunlight passes to these cells, it releases electrons and generating an electric current. This current is then collected and can be used to power various electrical devices or stored in batteries for later use. A 12V 10W PV panel is relatively small and compact, making it suitable for applications where space is limited or where a small amount of power is required. It can be used individually or connected in arrays to increase power output for larger energy needs.

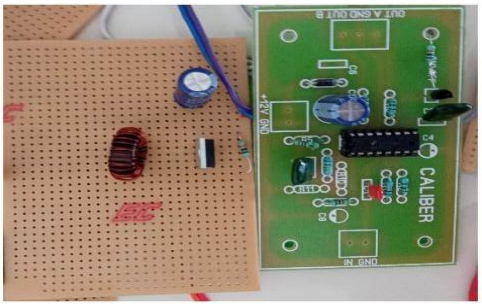


Fig. 2. PV panel 12v 10w

2. Dc/dc converter 12v5ah

A DC/DC converter 12V 5Ah is a device used to convert direct current (DC) power from one voltage level to another. In this case, it takes a 12V input and outputs a voltage at a different level while supplying a maximum current of 5 amps (5Ah). These converters are commonly used in various electronic devices and systems where different voltage levels are required for different components or subsystems to operate efficiently. They can be found in applications such as automotive electronics, telecommunications equipment, renewable energy systems, and more. The 12V 5Ah specification indicates the input voltage and the maximum output current capacity of the converter. It's important to note that the actual output voltage may vary depending on the specific model and design of the converter. Additionally, the efficiency of the converter, which determines how much power is lost during the conversion process, is also a crucial factor to consider when selecting a DC/DC converter for a particular application. Fig. 3. Shows the hardware for DC-DC converter.

3. Battery 12v 6ah

A 12V 6Ah battery is a commonly used rechargeable battery that operates at 12 volts and has a capacity of 6 ampere-hours (Ah). Fig. 4. Shows the batteries use to store energy. It is often utilized in various

applications such as motorcycles, scooters, power wheels, and small electric vehicles, as well as backup power systems for security alarms, lighting, and other low-power devices. These batteries are typically lead-acid or lithium-ion based, offering different characteristics in terms of weight, lifespan, and maintenance requirements. Lead-acid batteries are more affordable but heavier and require periodic maintenance such as topping up with distilled water, while lithium-ion batteries are lighter, maintenance-free, and have a longer lifespan but are more expensive. Overall, a 12V 6Ah battery provides a moderate amount of power for smaller devices and systems, making it a popular choice for a range of applications where portability and reliability are important.

Fig. 4. Battery 12v 6ah

4. Pic16f887

The PIC16F887 is a popular microcontroller manufactured by Microchip Technology. It's part of their PIC16F family, which is known for its ease of use, low power consumption, and wide range of applications. Fig. 5. Shows the PIC16F688 specifically is a mid-range 8-bit microcontroller with features like flash program memory, EEPROM data memory, and a wide range of peripherals. Some key features of the PIC16F688 includes, *Flash Program Memory*: It has a flash program memory of up to 14 KB, which allows for easy reprogramming of the device. *EEPROM Data Memory:* The PIC16F887 also includes EEPROM data memory of up to 256 bytes, which can be used for storing non-volatile data. *Peripherals:* It comes with a variety of peripherals such as analog-to-digital converters (ADC), timers, PWM modules, USART (serial communication), and more. *Low Power Consumption:* It's designed to operate on low power, making it suitable for battery-powered applications or other scenarios where power efficiency is important. *Small Package:* The PIC16F688 is available in various package options, including PDIP, SOIC, and SSOP, making it suitable for compact designs. Overall, the PIC16F688 is a versatile and reliable microcontroller that is commonly used in various embedded systems, consumer electronics, industrial control, and automation applications. Its ease of use, low power consumption, and wide range of peripherals make it a popular choice among embedded developers.

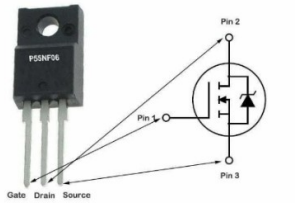


Fig. 5. Pic16f887

5. MOSFET p55nf06

The P55NF06 is a popular N-channel MOSFET commonly used in various electronic circuits due to its low on-resistance and high current-handling capabilities. It is often employed in power management applications such as voltage regulators, motor control circuits, and switch-mode power supplies. With its reliable performance and efficient design, it's a versatile component trusted by engineers for a wide range of projects. Fig. 6. Shows the Gain, Drain and Source.

8. LCD display 16 x 2

Fig. 9. Shows the picture of 16x2 LCD display typically refers to a liquid crystal display with 16 characters per line and 2 lines. It's commonly used in various electronic projects for showing text-based

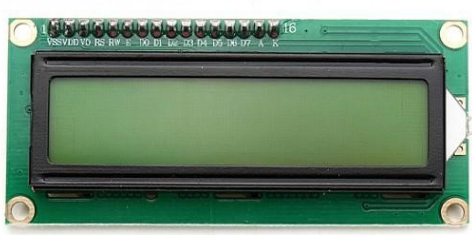


Fig. 9. 16 x 2 LCD display

9. BLDC driver

A Brushless DC (BLDC) driver is an electronic device used to control the speed and direction of a BLDC motor. BLDC motors are commonly used in a variety of applications, including electric vehicles, drones, and industrial machinery, due to their efficiency, reliability, and compact size. The BLDC driver typically consists of a microcontroller or digital signal processor (DSP) that generates the control signals necessary to drive the motor. BLDC drivers often incorporate features such as overcurrent protection, overtemperature protection, and closed-loop feedback control to ensure safe and efficient operation of the motor. They may also support various communication interfaces, such as UART, SPI, or I2C, for interfacing with external control systems or sensors. Overall, BLDC drivers play a crucial role in enabling the widespread adoption of BLDC motors in modern electromechanical systems by providing the necessary control and protection features required for efficient and reliable operation.

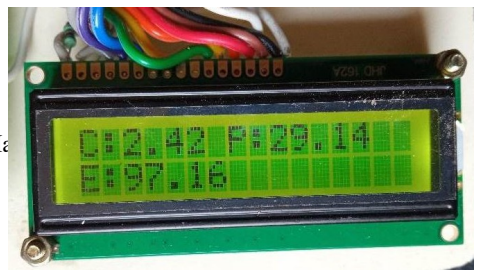
10. BLDC pump

A BLDC (Brushless DC) pump is a type of pump that operates using a brushless DC motor. These pumps are their efficiency, reliability, and quiet operation. Unlike traditional pumps that use brushes to transfer power to the rotor, BLDC pumps use electronic commutation to control the speed and direction of the motor. One of the key advantages of BLDC pumps is their energy efficiency. Because they don't rely on brushes, which can create friction and wear over time, BLDC pumps can operate with minimal energy loss, making them more efficient than traditional pumps. This makes them ideal for applications where energy conservation is important, such as in solar-powered systems or electric vehicles. Fig. 10. Shows the BLDC pumps are also known for their reliability and long lifespan. Without brushes to wear out, these pumps require less maintenance and are less prone to mechanical failure. Overall, BLDC pumps offer a combination of energy efficiency, reliability, and quiet operation that makes them well-suited for a wide range of applications across various industries.

Fig. 10. An Efficient and Credible Grid-Interfaced Solar PV Water Pumping System with Energy Storage Hardware kit.

V. RESULTS AND DISCUSSION

The entire system will be monitored and controlled by a controller, which will ensure smooth and efficient operation. Fig. 11 and Fig. 12. Shows that controller will manage the power flow between the various components, maintaining a balance between energy production, storage, and consumption. This approach presents a reliable and sustainable solution for water pumping in remote areas, highlighting the potential for renewable energy to drive essential systems and reduce carbon emissions. Overall, this concept demonstrates the



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feasibility and benefits of incorporating alternative energy sources in vital systems.

Fig. 11. Voltage readings of Photovoltic (PV), Battery voltage (BV) and Battery Storage percentage (SOC).

VI. CONCLUSION AND FUTURE SCOPE

In conclusion, the proposed grid-interfaced solar PV water pumping system with energy storage offers a sustainable, efficient, and cost-effective solution for remote water pumping needs. By utilizing renewable energy sources, it reduces the carbon footprint and showcases the potential for renewable energy to drive vital systems. Further research and development in this area can lead to the widespread adoption of similar systems, contributing to a greener and more sustainable future.

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