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BLDC MOTOR DRIVER SOLAR PV ARRAY FED WATER PUMPING SYSTEM EMPLOYING ZETA CONVERTER

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ABSTRACT:

The growing demand for renewable energy solutions has led to the development of efficient solar-powered systems for agricultural and rural applications. This paper presents the design and implementation of a solar photovoltaic (SPV) array–fed water pumping system using a Brushless DC (BLDC) motor and a Zeta DC–DC converter. The system utilizes a Zeta converter to boost the low and variable output voltage of the solar panel to a regulated level suitable for driving a BLDC motor. A three-phase Voltage Source Inverter (VSI) is used to convert the DC output into AC supply for the motor. A PIC microcontroller generates switching signals for the inverter, enabling efficient motor operation and soft starting. The proposed system offers improved efficiency, reduced starting current, and low power losses. Experimental results demonstrate reliable operation and suitability for standalone water pumping applications in rural and remote areas.

KEYWORDS:

SOLAR PV SYSTEM, BLDC MOTOR, ZETA CONVERTER, WATER PUMPING SYSTEM, RENEWABLE ENERGY, PIC MICROCONTROLLER, VOLTAGE SOURCE INVERTER, EMBEDDED SYSTEMS, ENERGY EFFICIENCY.

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INTRODUCTION

The increasing depletion of fossil fuels and rising energy demand have accelerated the adoption of renewable energy sources such as solar power [1]. Solar photovoltaic (SPV) systems are widely used for standalone applications, especially in rural areas where grid power is unavailable [2]. Water pumping is one of the most important applications of solar energy in agriculture [3].

Conventional water pumping systems use induction or DC motors, which suffer from low efficiency and high maintenance requirements [4]. Brushless DC (BLDC) motors offer advantages such as high efficiency, better speed control, and longer lifespan [5]. However, direct connection of SPV arrays to BLDC motors is challenging due to the variable output voltage of solar panels [6].

DC–DC converters are used to regulate and boost the voltage from solar panels [7]. Among various converter topologies, the Zeta converter provides non-inverted output voltage and continuous input current, making it suitable for solar applications [8]. Voltage Source Inverters (VSI) are used to drive BLDC motors by converting DC into three-phase AC supply [9].

Despite these advancements, efficient integration of SPV systems, converters, and motor drives remains a challenge [10]. This paper presents a solar-powered BLDC motor-driven water pumping system using a Zeta converter to improve efficiency and reliability

MATERIALS AND METHODS:

The proposed system was developed by integrating a solar photovoltaic array, Zeta DC–DC converter, Voltage Source Inverter (VSI), BLDC motor, water pump, and PIC microcontroller into a unified system. The SPV array generates DC power, which is initially low and variable. This output is fed into a Zeta converter that boosts and regulates the voltage from 12 V to a stable 24 V DC supply.

The regulated DC output is supplied to a three-phase VSI, which converts the DC power into AC suitable for driving the BLDC motor. The BLDC motor is mechanically coupled to a water pump for water lifting applications. A PIC16F72 microcontroller is used to generate switching signals for the MOSFET-based inverter, ensuring proper commutation and speed control.

Soft starting of the motor is achieved by controlling the inverter switching frequency, reducing inrush current and protecting the motor. The system operates with a power

flow sequence: SPV array → Zeta converter → VSI → BLDC motor → water pump. All components were integrated and tested to ensure efficient performance and reliable operation under varying solar conditions.

RESULTS:

FIG. 1: SOLAR PV ARRAY FED BLDC WATER PUMPING SYSTEM USING ZETA CONVERTER

The developed solar-powered water pumping system was tested under different operating conditions. The Zeta converter successfully boosted the SPV output voltage to the required level for motor operation. The BLDC motor demonstrated smooth starting and stable operation due to controlled switching frequency.

The system showed reduced inrush current during startup and improved efficiency compared to conventional systems. The VSI provided effective conversion of DC to AC, enabling proper motor commutation. The overall system performed reliably under varying solar irradiance conditions.

The prototype system, as shown in **Fig. 1**, illustrates the integration of the SPV array, Zeta converter, VSI, BLDC motor, and water pump. The results confirm that the system is efficient, cost-effective, and suitable for standalone applications.

DISCUSSION:

The proposed system demonstrates significant advantages over conventional water pumping systems. The use of a BLDC motor improves efficiency and reduces maintenance requirements. The Zeta converter effectively regulates voltage, ensuring stable motor operation even under fluctuating solar conditions. The use of a PIC microcontroller enables precise control of inverter switching, improving system performance. However, the system performance depends on solar irradiance and component efficiency. The complexity of the control system may also increase implementation challenges.Future improvements may include Maximum Power Point Tracking (MPPT) techniques, advanced control algorithms, and integration of energy storage systems

CONCLUSIONS:

This paper presents a solar PV array–fed BLDC motor-driven water pumping system employing a Zeta converter. The system successfully integrates renewable energy generation, power conversion, and motor control to provide an efficient and sustainable solution for water pumping applications.

The results demonstrate improved efficiency, reduced power losses, and reliable operation. The proposed system is suitable for rural and agricultural applications, contributing to sustainable energy utilization and smart irrigation systems.

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