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BLDC Motor-Driven Solar PV Array-Fed Water Pumping System Employing Zeta Converter

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ABSTRACT: This paper proposes a simple, cost-effective, and efficient brushless dc (BLDC) motor drive for solar photovoltaic (SPV) array-fed water pumping system.A zeta converter is utilized to extract the maximum available power from the SPV array. The proposed control algorithm eliminates phase current sensors and adapts a fundamental frequency switching of the voltage source inverter (VSI), thus avoiding the power losses due to high frequency switching .No additional control or circuitry is used for speed control of the BLDC motor. The speed is controlled through a variable dc link voltage of VSI. An appropriate control of zeta converter through the incremental conductance maximum power point tracking (INC-MPPT) algorithm offers soft starting of the BLDC motor.

KEYWORDS: Brushless dc motor(BLDC), Solar photovoltaic (SPV), Voltage Source Inverter(VSI),Incremental conductance maximum power point tracking(INC-MPTT)

I. INTRODUCTION

One This paper proposes a simple, cost-effective, and efficient brushless dc (BLDC) motor drive for solar photovoltaic (SPV) array-fed water pumping system.A zeta converter is utilized to extract the maximum available power from the SPV array. The proposed control algorithm eliminates phase current sensors and adapts a fundamental frequency switching of the voltage source inverter (VSI), thus avoiding the power losses due to high frequency switching.No additional control or circuitry is used for speed control of the BLDC motor. The speed is controlled through a variable dc link voltage of VSI. An appropriate control of zeta converter through the incremental conductance maximum power point tracking (INC-MPPT) algorithm offers soft starting of the BLDC motor.

The proposed water pumping system is designed and modeled such that the performance is not affected under dynamic conditions. The suitability of proposed system at practical operating conditions is demonstrated through simulation results using MATLAB Simulink.The drastic reduction in the cost of power electronic devices and annihilation of fossil fuels in near future invite to use the solar photovoltaic (SPV) generated electrical energy for various applications as far as possible.

The water pumping, a standalone application of the SPV array-generated electricity, is receiving wide attention nowadays for irrigation in the fields, household applications, and industrial use.
Although several researches have been carried out in an area of SPV array-fed water pumping, combining various dc–dc converters and motor drives, the zeta converter in association with a permanent-magnet brushless dc (BLDC) motor is not explored precisely so far to develop such kind of system.

Here use of solar energy for the operation of the highly efficient BLDC motor . We are feeding the BLDC motor solar energy using a a VSI operating at fundamental frequency . For high efficiency we are using maximum power point tracking algorithm. The VSI is given input voltage using zeta converter.

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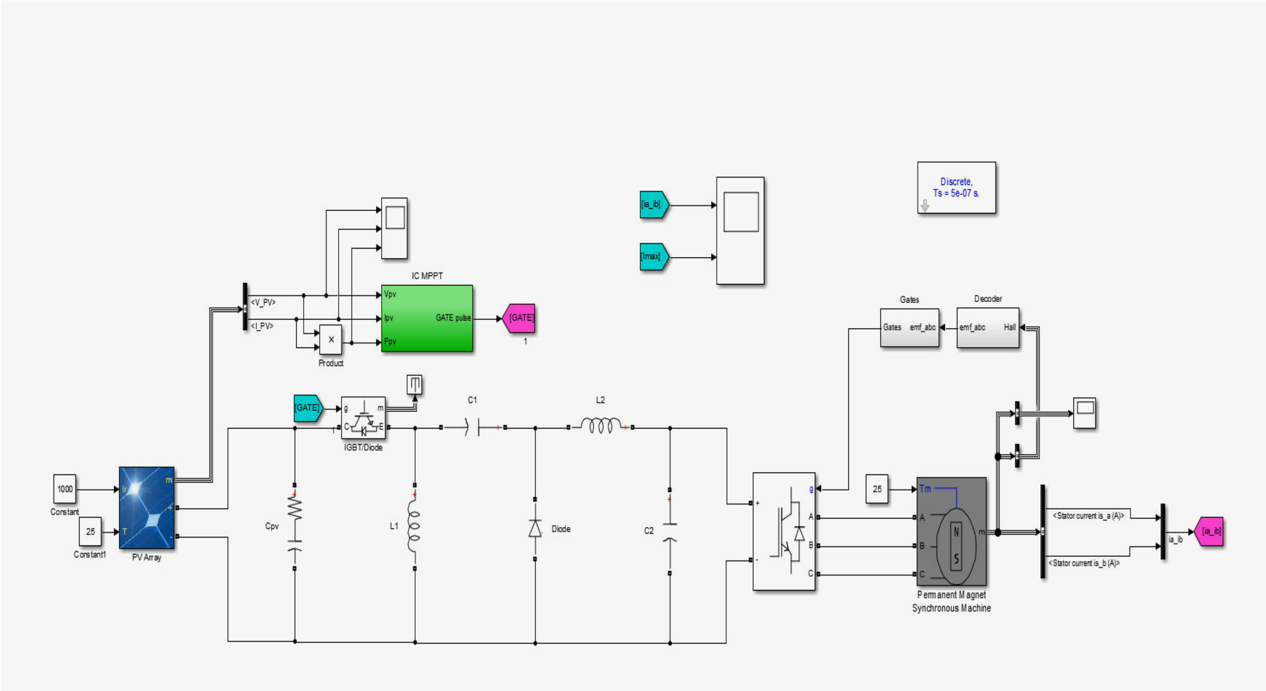


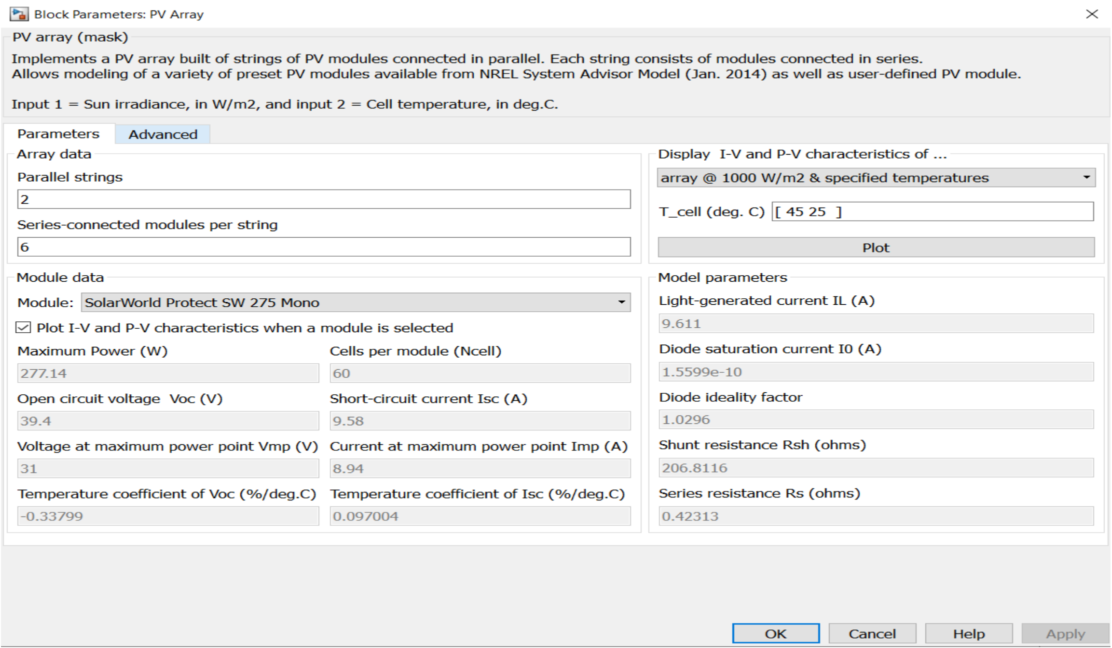
Proposed model of the system

II. OBJECTIVES

- To create a simulation of the proposed model using MATLAB simulink
- To control the voltage levels which are fed as input to the VSI w are using zeta converters.
- The output of the zeta converter is fed to the VSI operating at fundamental frequency.
- The VSI produces a pulsating DC which is then fed to the BLDC motor.

III. METHODOLOGY

DESIGN OF SPV ARRAY



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DESIGN OF ZETA CONVERTER

The zeta converter is the next stage to the SPV array. Its design consists of an estimation of various components such as input inductor L1, output inductor L2, and intermediate capacitor C1. These components are designed such that the zeta converter always operates in CCM resulting in reduced stress on its components and devices.
The ZETA converter provides a positive output voltage for input voltage that varies above and below the output voltage. The ZETA converter also needs two inductors and a series capacitor, sometimes called a flying capacitor. The zeta converter is used for to give the gate pulse for MOSFET which is used the driver circuit in our paper we can see that how the gate pulse is given to it, this converter which is configured with a standard boost converter, the ZETA converter is configured from a buck controller that drives a high-side PMOSFET. The ZETA converter is another option regulating an unregulated input-power supply.

All non conventional system energy system require particular power converters. seen the power electronic converter is the hart of the entire system , show proper design necessary [7]. ZETA Converter Is mentioned and it is use provide positive output From the input voltage it can be used to increase as well as decrease the voltage. This converter is used for power factor correction applications and short circuit protection .Thus we can use solar photovoltaic cell for the input to the Zeta converter to full fill the requirement of DC input to the converter, as the solar means renewable energy is more popular now a days as the output solar cannot be doubled but due to zeta converter the output of dc voltage can double the output of input voltage and it can be triple by varying Duty cycle.

Thus we are using switching techniques for varying the duty cycle. Thus we are using Driver circuit to give the Gate pulse to the ZETA Circuit For the MOSFET to operate in on state. The Zeta Converter provides Non-inverted output, its ripple less, low voltage diode and Continuous conduction mode. While the load can be use at the output of converter, as the output can be vary we can use large power DC loads.

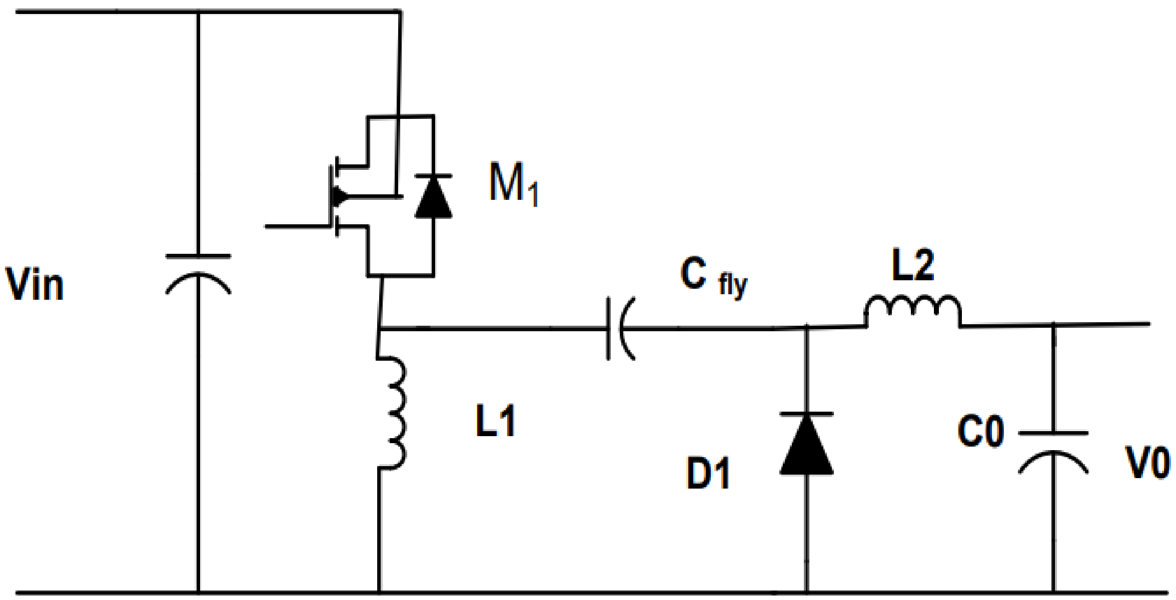

Fig a. Proposed Structure of Basic Zeta converter

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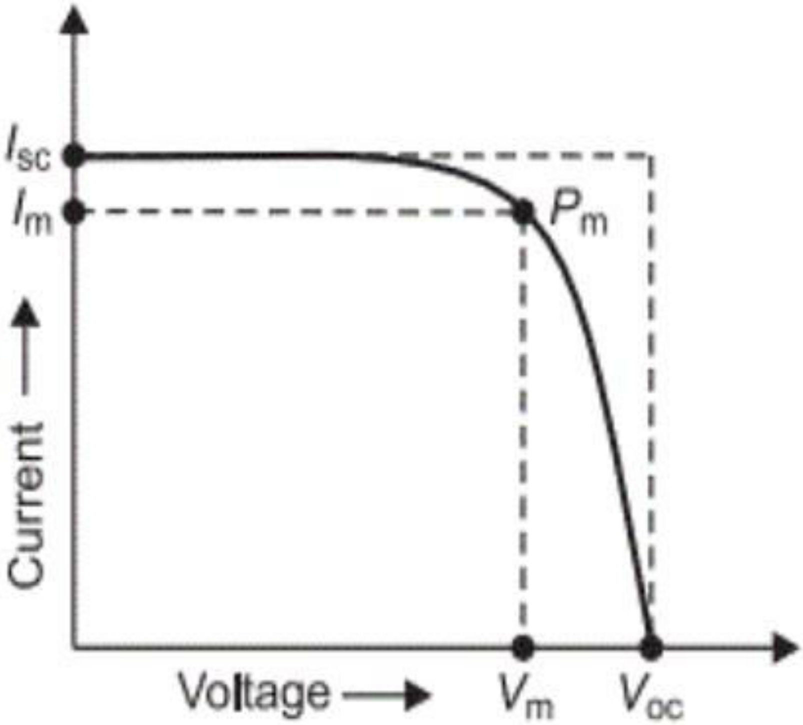
MAXIMUM POWER POINT TRACKING TECHNIQUE(MPTT)

A PV Panel consists of several photovoltaic cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. Typically, Solar Panel has converting efficiency of 8 to 15 % of the Incident Solar Irradiance into electrical energy.



At the open circuit voltage *VOC* and the short circuit current *ISC*, the power generated is zero.The Maximum power (Pm) is generated at a point where the product Vm*Im is maximum and this point is called as Maximum Power Point. Maximum power point tracking technique is used to improve the efficiency of the solar panel.
There are different techniques used to track the maximum power point, few of the most popular techniques are
1) Perturb and Observe (hill climbing method)
2) Incremental Conductance method
3) Fractional short circuit current
4) Fractional open circuit voltage
5) Neural Network
6) DC-Link Capacitor Droop Control Technique

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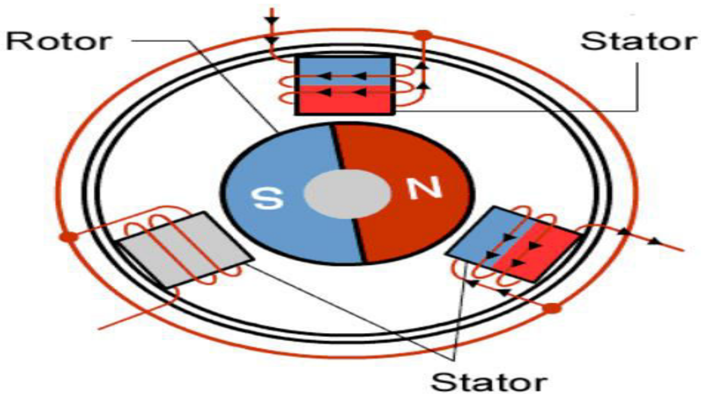
SWITCHING STATES FOR ELECTRONIC COMMUTATION OF BLDC MOTOR

Rotor position θ (°)	Hall signals			Switching states					
	H_3	H_2	H_1	S_1	S_2	S_3	S_4	S_5	S_6
NA	0	0	0	0	0	0	0	0	0
0–60	1	0	1	1	0	0	1	0	0
60–120	0	0	1	1	0	0	0	0	1
120–180	0	1	1	0	0	1	0	0	1
180–240	0	1	0	0	1	1	0	0	0
240–300	1	1	0	0	1	0	0	1	0
300–360	1	0	0	0	0	0	1	1	0
NA	1	1	1	0	0	0	0	0	0

BLDC motor

As their name implies, brushless DC motors do not use brushes. With brushed motors, the brushes deliver current through the commutator into the coils on the rotor. So how does a brushless motor pass current to the rotor coils? It doesn't—because the coils are not located on the rotor. Instead, the rotor is a permanent magnet; the coils do not rotate, but are instead fixed in place on the stator. Because the coils do not move, there is no need for brushes and a commutator.

With the brushed motor, rotation is achieved by controlling the magnetic fields generated by the coils on the rotor, while the magnetic field generated by the stationary magnets remains fixed. To change the rotation speed, you change the voltage for the coils. With a BLDC motor, it is the permanent magnet that rotates; rotation is achieved by changing the direction of the magnetic fields generated by the surrounding stationary coils. To control the rotation, you adjust the magnitude and direction of the current into these coils.



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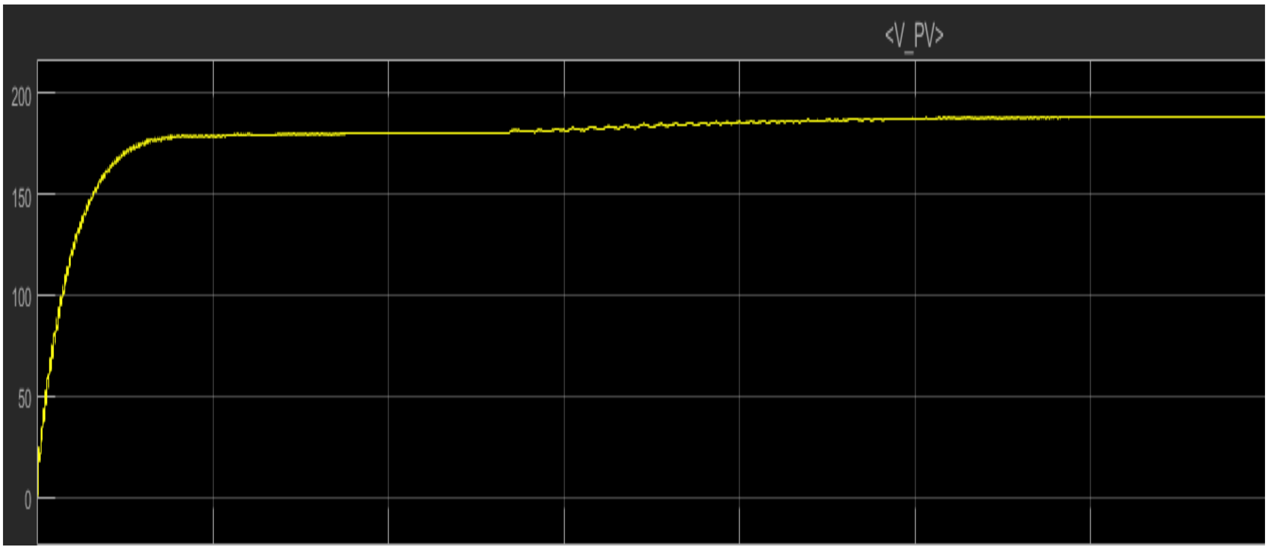
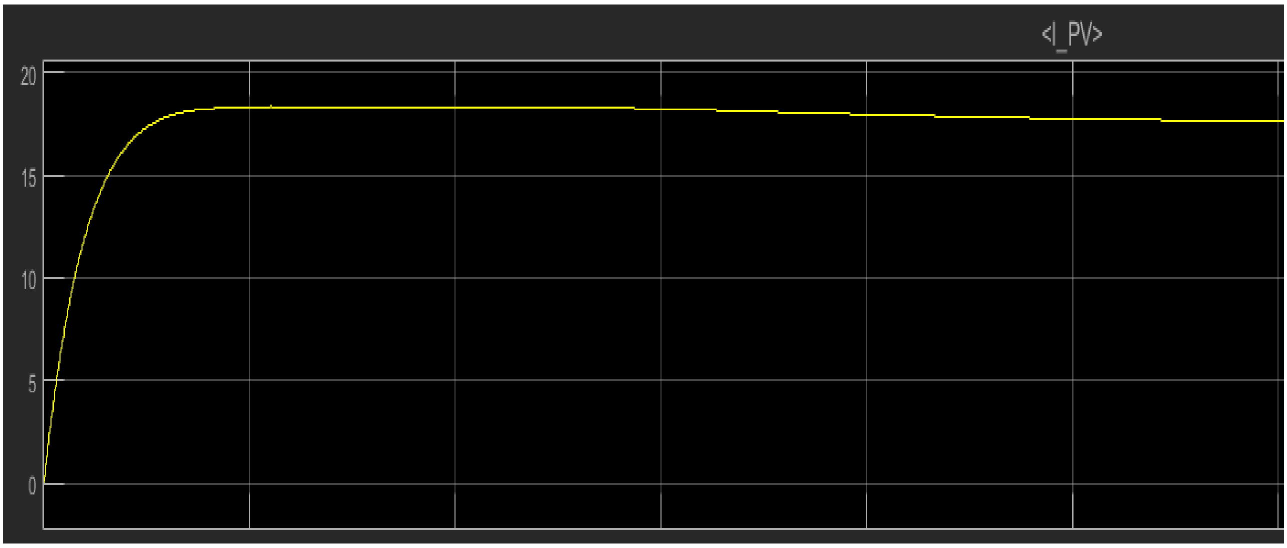
IV. RESULT AND DISCUSSION

The result of the simulation are given as follows:



Voltage generated by the Solar Panel



Current generated by the Solar Panel

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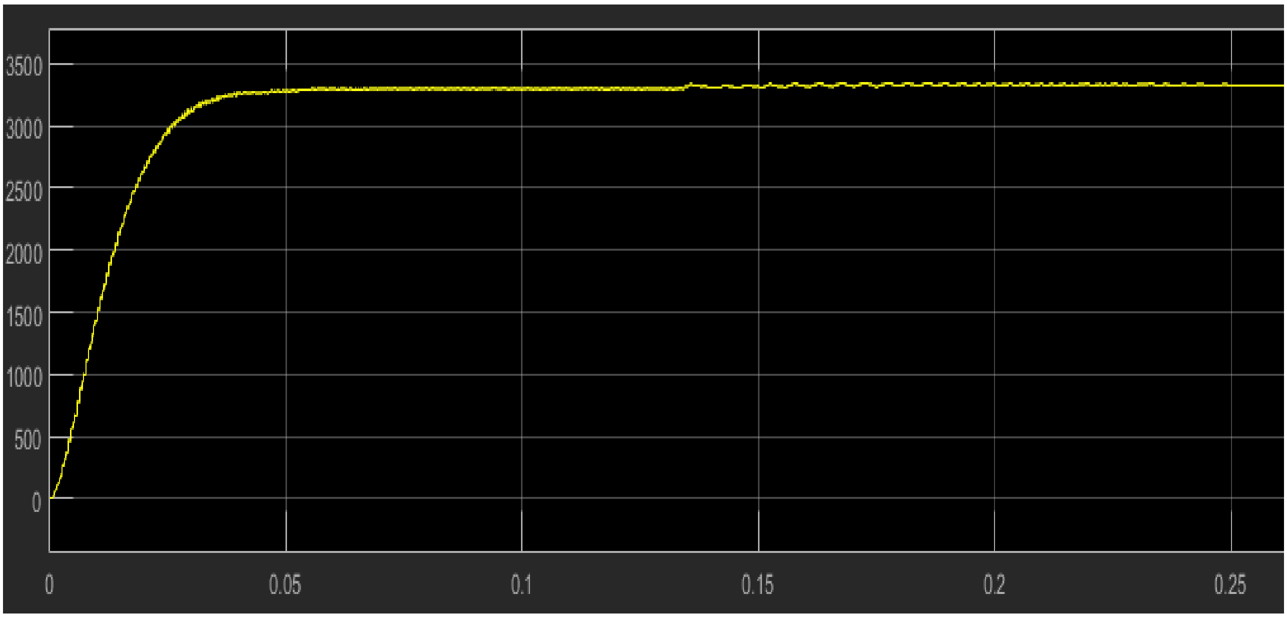
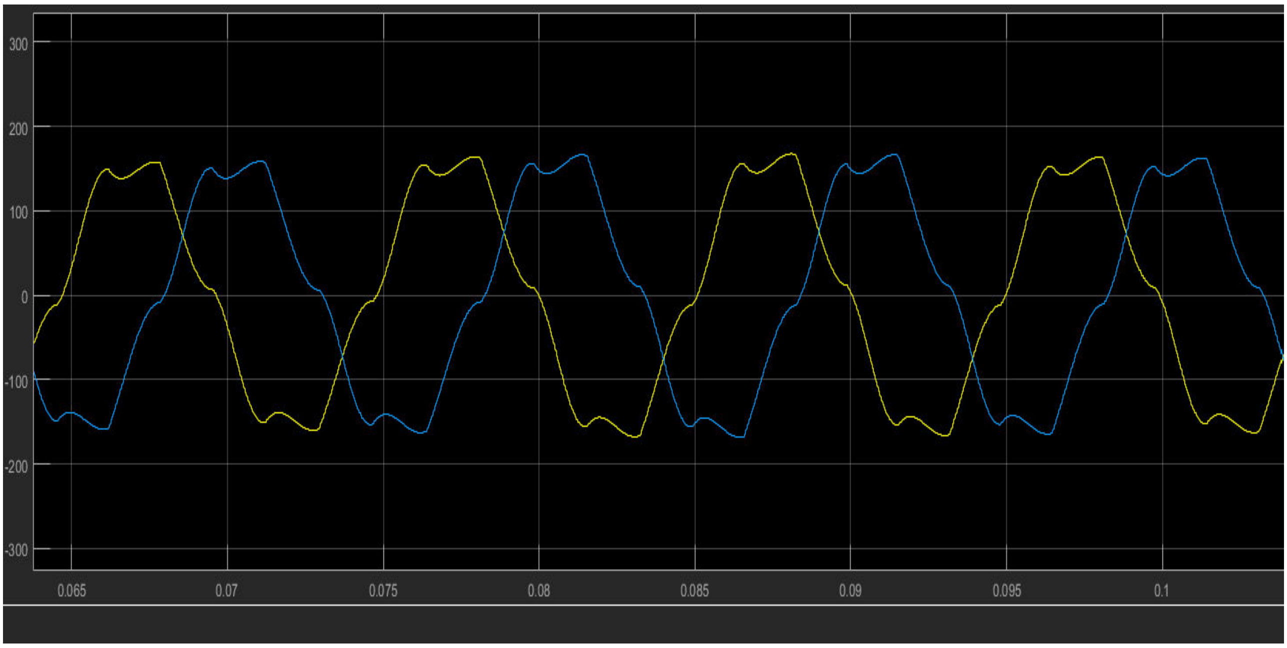


Power generated by the Solar Panel



BLDC stator current(ia,ib)

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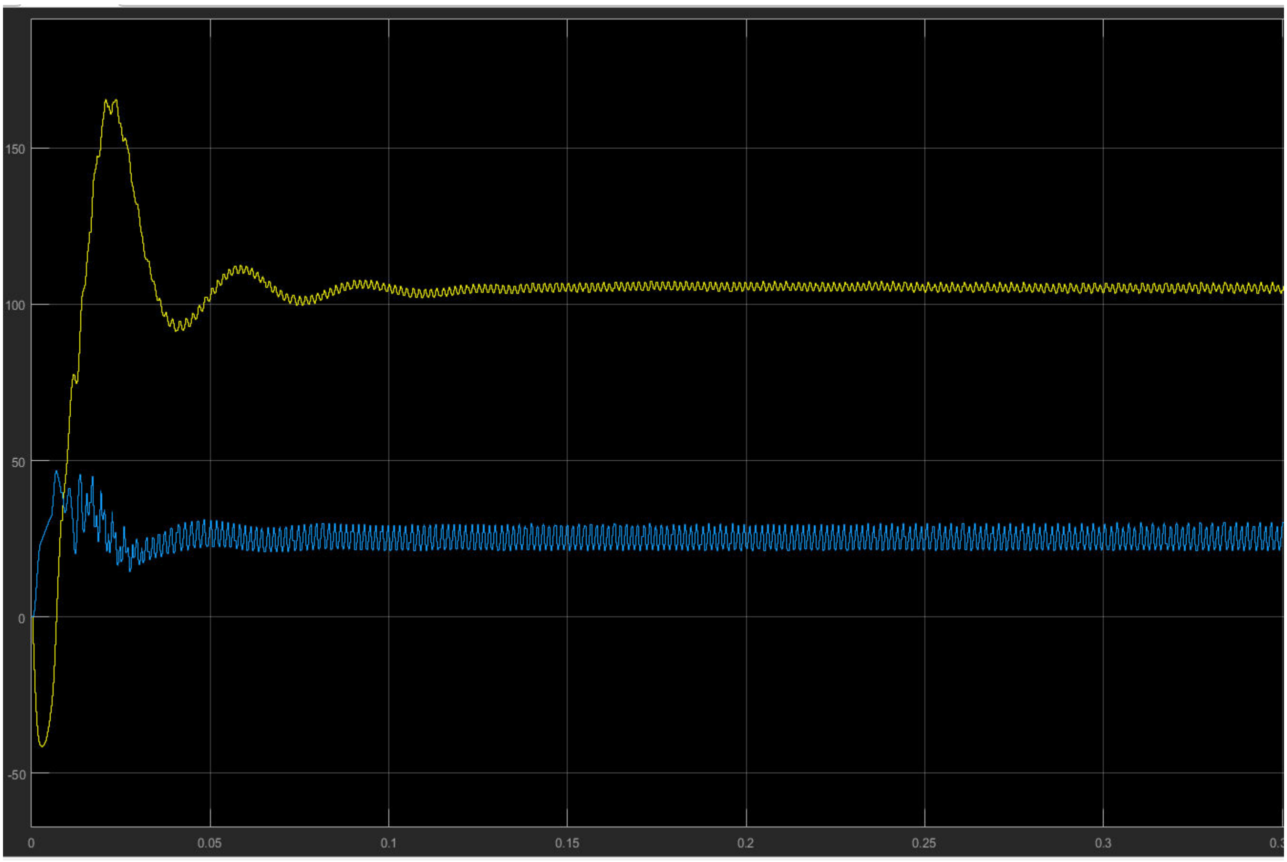

Speed and Torque of the BLDC motor

V. CONCLUSION

The SPV array-zeta converter-fed VSI–BLDC motor-pump has been proposed and its suitability has been demonstrated through simulated results and experimental validation. The proposed system has been designed and modeled appropriately to accomplish the desired objectives and validated to examine various performances under starting, dynamic, and steady-state conditions. The performance evaluation has justified the combination of zeta converter and BLDC motor for SPV array-based water pumping. The system under study has shown various desired functions such as maximum power extraction of the SPV array, soft starting of BLDC motor, fundamental frequency switching of VSI resulting in a reduced switching losses, speed control of BLDC motor without any additional control, and an elimination of phase current and dc-link voltage sensing, resulting in the reduced cost and complexity. The proposed system has operated successfully even under minimum solar irradiance.

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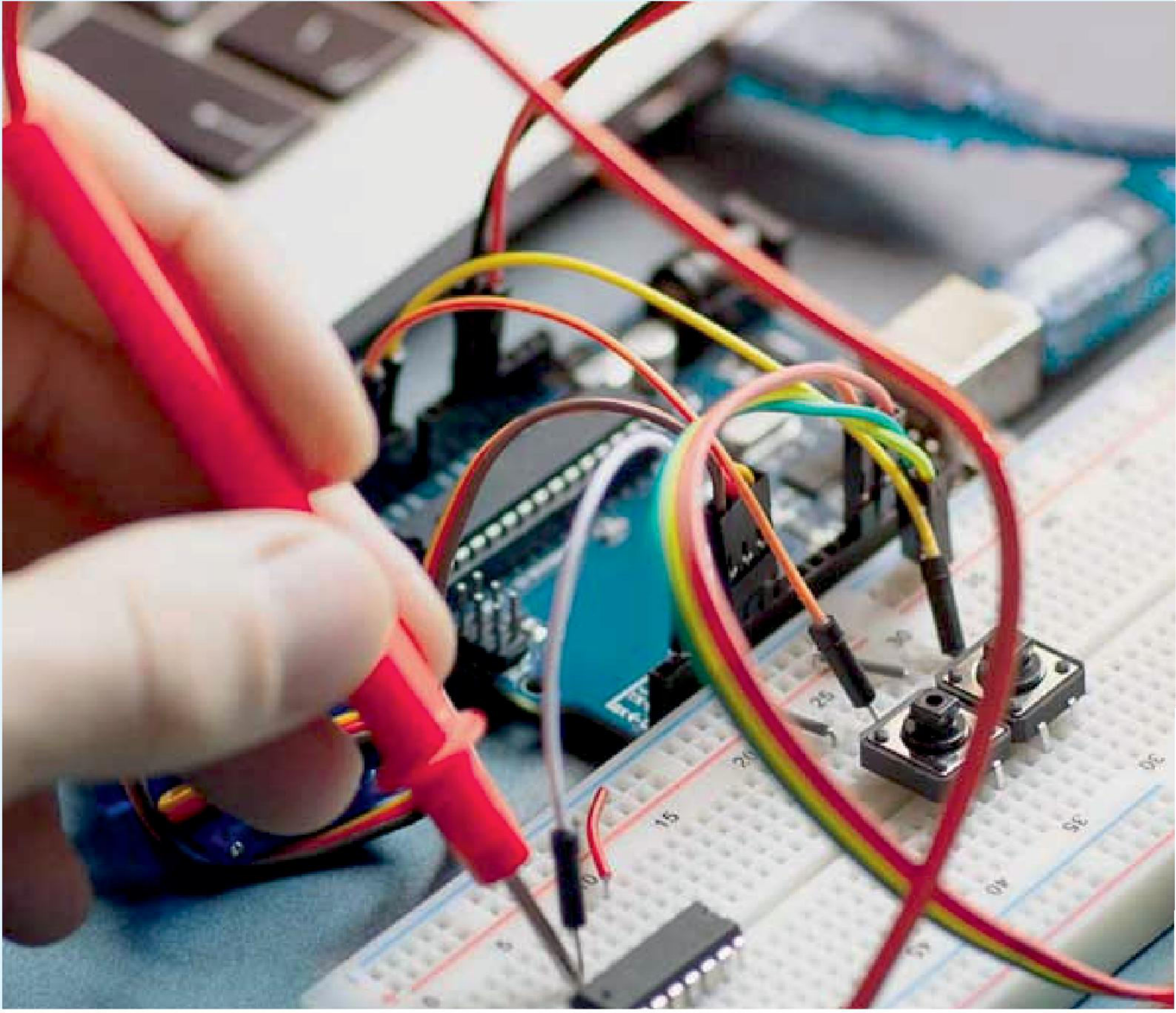

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