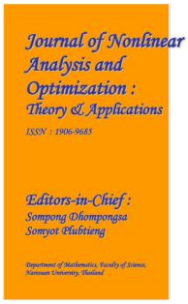
Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1 : 2024
ISSN : **1906-9685**



DESIGN OF NOVEL CONVERTER FOR PV FED BLDC MOTOR WITH DC-DC CONVERTER

Dr.M.Chiranjivi Associate professor Department of EEE Hyderabad Institute of Technology and Management.Hyderabad, India chiranjivimadduluri@gmail.com
G. Shyamlal Btech Scholar Department of EEE Hyderabad Institute of Technology and Management
Hyderabad, India sarweshshyam@gmail.com
G. Vijay Btech Scholar Department of EEE Hyderabad Institute of Technology and Management Hyderabad, India gugulothvijay46@gmail.com
L. Sandeep Btech Scholar Department of EEEHyderabad Institute of Technology and Management Hyderabad, India lakasandeepm@gmail.com
P. Nagarjuna Btech Scholar Department of EEE Hyderabad Institute of Technology and Management Hyderabad, India pallatinagarjuna1234@gmail.com

ABSTRACT –
This paper proposes a system of BLDC motor drive fed through a solar pv. To provide the required power to the motor, a zeta converter is used to boost up the voltage. A Zeta converter is a 4th order DC-DC converter that is built with two inductors and two capacitors and able to work in either step up mode or step-down mode. The proposed system adapts a fundamental functioning of three phase inverter which is switching and this will eliminate the power losses. Fuzzy logic rules are written to control the speed of the BLDC motor. The hall sensor and the reference speed to compared using controller and it is provided as feedback for the three-phase inverter. With increased system efficiency, the proposed drive is built to work in various speed ranges. The proposed system is simulated through Matlab simulating software followed by an experimental setup.

Keywords: MATLAB/Simulink, Fuzzy Logic Controller, solar, BLDC motor, Three phase inverter.

INTRODUCTION:

The usage of motor is increased and most of the industries preferred to use the motor which consumes low input voltage and will need to provide the sufficient output with the higher efficiency. The motor which will use the DC input supply and also an efficient one is BLDC. The ultimate aim in the industries has been to maintain the standard of power quality. The invention of BLDC motors has gained popularity in recent times because of its various characteristics. High energy density, low EMI, high torque ratio, high efficiency, variable speed operation are the unique features of BLDC motor, which increases its significance in the industrial sector.

In the BLDC motor the windings are concentrated on the stator and the permanent magnets are concentrated on the rotor part. The BLDC motor works on the principle of Hall effect. The Hall effect phenomenon can be used to measure the density of current carriers, freedom of movement of carriers also called as mobility, it is also used to detect the presence of current on magnetic field. Zeta converter which is different from the conventional boost converter is added to attain the sufficient input voltage for the motor. Zeta converter will either step up or step down the voltage from Solar PV. A three-phase inverter is a switching element which receives the feedback from the controller as a gate pulse and then the speed is controlled respectively. Fuzzy Logic controller is designed to run the motor with

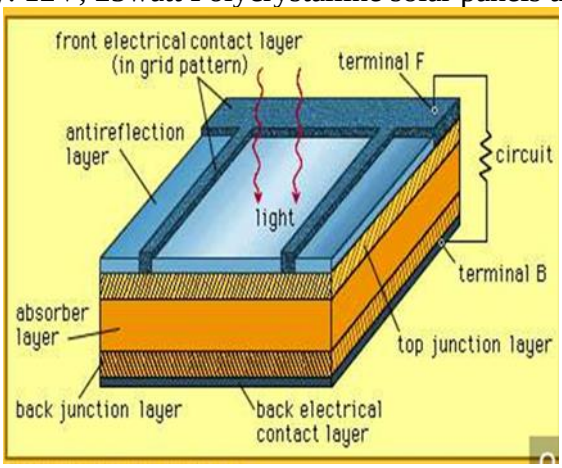
certain rules. The rule sets are written on the basics of the need to run the motor. The membership functions and linguistic variables are designed on the standard terms. Solar energy is the highly efficient type of energy source and it is less harm to the nature. Compared to conventional type solar energy supply is the leading trend in generating electricity. Solor panel is setup to convert solar energy into electrical energy and it is supplied as the input for the control system. The input power supply is allowed to pass through the zeta converter so that it boost up the voltage which is to be supplied to the motor. The speed of the motor is compared with the reference speed and thus the speed is controlled.AC supply is converted to DC and it is step up using zeta converter to provide an input voltage for the motor. PI controller compares the actual speed and reference speed to provide the feedback to the inverter. Hall sensor signal also used in generating the feedback for the inverter. PI controller is the conventional type of microcontroller used in the most application related to speed control. PID controller is used in comparing the speeds. The accuracy will be low while using the PI and PID controllers. In fuzzy logic controller the accuracy will be increased and thus it gives an advancement in the speed control. The BLDC motor is used in many applications. The motor is used in water pumps to make the usage proper. The motor is driven through solar pv as input voltage and its speed is controlled for the water pump application. The proposed system contains design of zeta converter circuit, fuzzy logic rules for regulating the speed of BLDC motor. The control is projected as a simulation setup using MATLAB simulation tool. The advancement and the application is discussed in the conclusion part.

3. HARDWARE COMPONENTS:

The short introduction of distinct modules used in this undertaking is mentioned below:

3.1 SOLAR:

A solar cell (also called photovoltaic cell) is a solid-state device that converts the energy of sunlight directly into electricity by the photovoltaic effect. Assemblies of cells are used to make solar modules, also known as solar panels.The energy generated from these solar modules, referred to as solar power, is an example of solar energy. 12V, 25watt Polycrystalline solar panels are used.

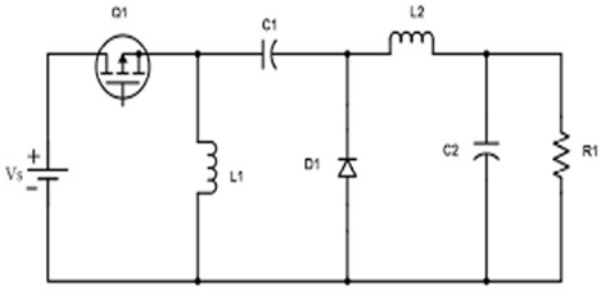


1. Photons in sunlight hit the solar panel and are absorbed by semi conducting materials, such as silicon.
2. Electrons (negatively charged) are knocked loose from their atoms, allowing them to flow through the material to produce electricity. Due to the special composition of solar cells, only allow the electrons to move in a single direction. The complementary positive charges that are also created (like bubbles) are called holes and flow in the direction opposite of the electrons in a silicon solar panel.
3. An array of solar panels converts solar energy into a usable amount of direct current (DC) electricity.

3.2 ZETA CONVERTER:

Zeta converter works on both step up and step-down condition. Both the input and the output voltage of the zeta converter will be of DC voltage. The construction of zeta converter is simple. It consists of

two capacitor, two inductor, one diode and a one power semiconductor which is used as a switching device. It uses only one switch which is an added advantage. The zeta converter circuit is shown in the figure.



Zeta converter

The zeta converter works on the following two modes of operation.

Mode 1: Switch On

In this mode the switch will be in ON conditions. The diode connected is reverse biased and the inductor draws current from the input source voltage. Thus the inductor gets to store energy by using these current. The capacitor also get charged during this condition. Thus two inductors and two capacitor get charged up during this mode of operation.

Mode 2: Switch Off

In this mode the switch will be in OFF condition. As a result, the diode becomes forward biased, the inductor's stored energy is released to the output load, and the capacitor c2 is likewise discharged Thus it is also called as discharging mode of operation.

Duty Cycle:

The term duty cycle is the ratio of input voltage supplied to the output voltage gained .For zeta converter the formula for duty cycle is represented as,

D= Vout/(Vout+Vin)

In our paper the values for the voltages are follows, Vin=74v

Vout=117v

Thus, the duty cycle ratio of the zeta converter which is calculated in the switch ON mode will be 0.34 or 34%

3.3 Fuzzy logic control:

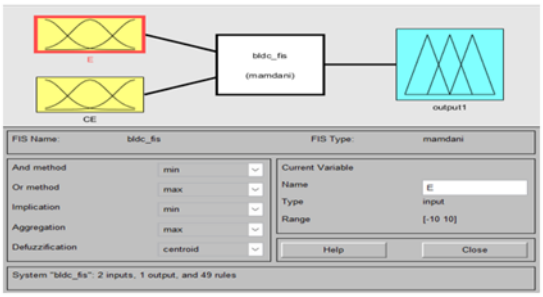


Fig: fuzzy logic block diagram

The most active area of this field's study involves using fuzzy set theory, fuzzy reasoning, and fuzzy logic to control systems (FLC). FLC is used in a variety of diverse industries, including security, biomedical devices, and industrial process control. When contrasting FLC with conventional control methods, FLC has proven to be most successful in handling challenging, poorly defined issues that a competent human operator can handle without being aware of the dynamics at play. Another physical system can be altered so that it exhibits particular desirable characteristics by using a control system, which is an organization of physical parts. Control systems can be divided into two categories: open-loop and closed-loop systems. In open-loop control systems, there is no connection between the input control action and the actual system output. In contrast, the input control action in a closed-loop control

system is dependent on the physical system output. Systems with closed loop feedback are frequently referred to as feedback control systems.

3.4 Three Phase Inverter Design:

The circuit diagram of a three-phase inverter is shown below. The main function of this kind of inverter is to change the input of DC to the output of three-phase AC. A basic 3 phase inverter includes 3 single phase inverter switches where each switch can be connected to one of the 3 load terminals.

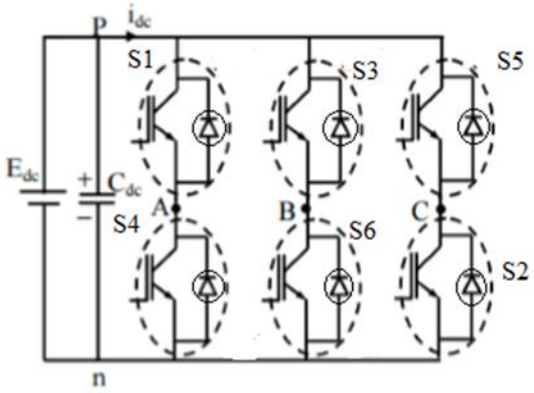


Fig2: Three phase inverter circuit

A three-phase inverter working principle is, it includes three inverter switches with single-phase where each switch can be connected to load terminal. For the basic control system, the three switches operation can be synchronized so that single switch works at every 60 degrees of basic o/p waveform to create a line-to-line o/p waveform including six steps. This waveform includes a zero-voltage stage among the two sections like positive &negative of the square-wave. Once PWM techniques based on the carrier are applied to these waveforms, then the basic shape of the waveform can be taken so that the third harmonic including its multiples will be canceled.

3.5 BLDC motor:

The Brush less DC electric motor are synchronous electric motors powered by direct current (DC) electricity and having electronic commutation systems, rather than mechanical commutators and brushes. The current-to-torque and voltage-to-speed relationships of BLDC motors are linear.

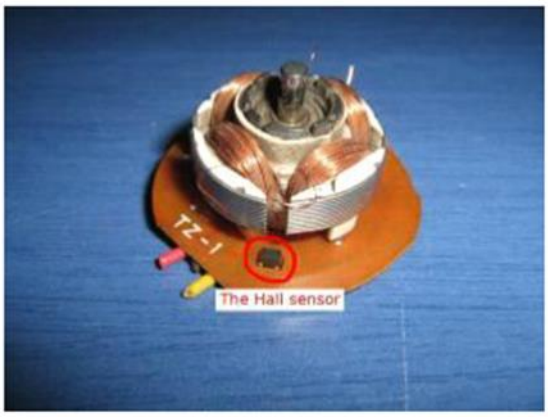


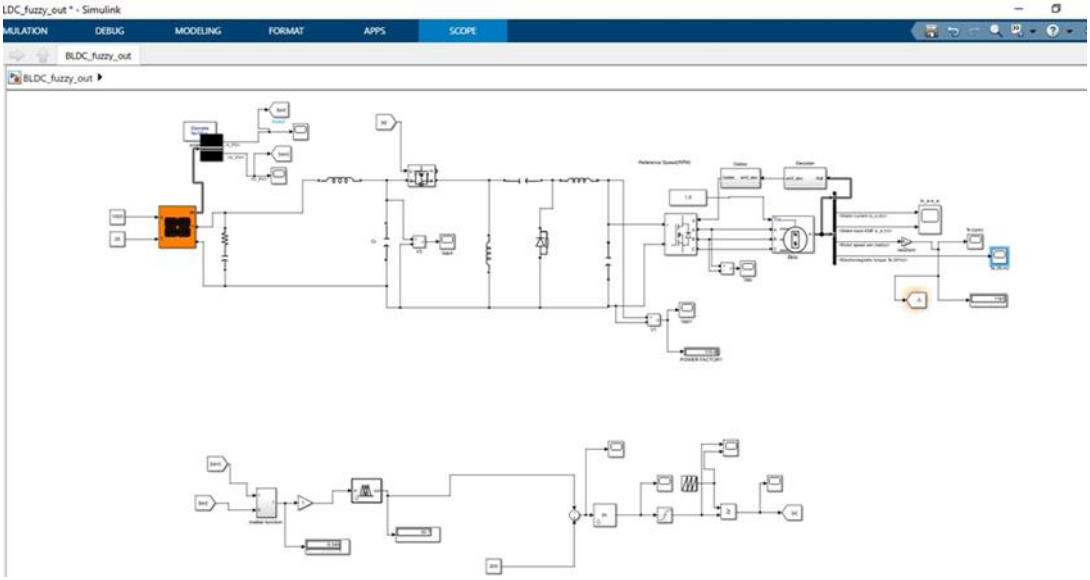
Fig: BLDC Motor

The trick of operation in BLDC motors is the Hall sensor that is attached to the stator. It faces the magnets perpendicularly and can distinguish if the North or South Pole is in front of it.

fig: BLDC motor with hall effect sensor

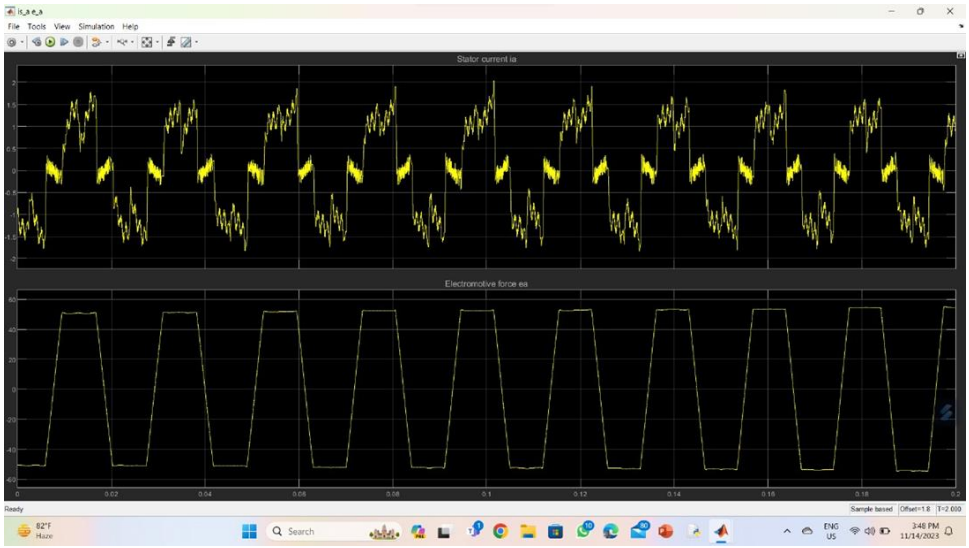
The Hall sensor is this little component under the right electromagnet. When it senses the South pole, it keeps the coils turned off. When the sensor senses no magnetic field (or could be also the South pole), then it turns on the coils. The coils have both the same magnetic polarity which is North. So they pull the opposite pole and torque is then created. If you put a probe to the Hall sensor and watch the signal, then you will discover that during a full rotation of the rotor, the Hall sensor is two times HIGH and two times LOW.

5.RESULT:



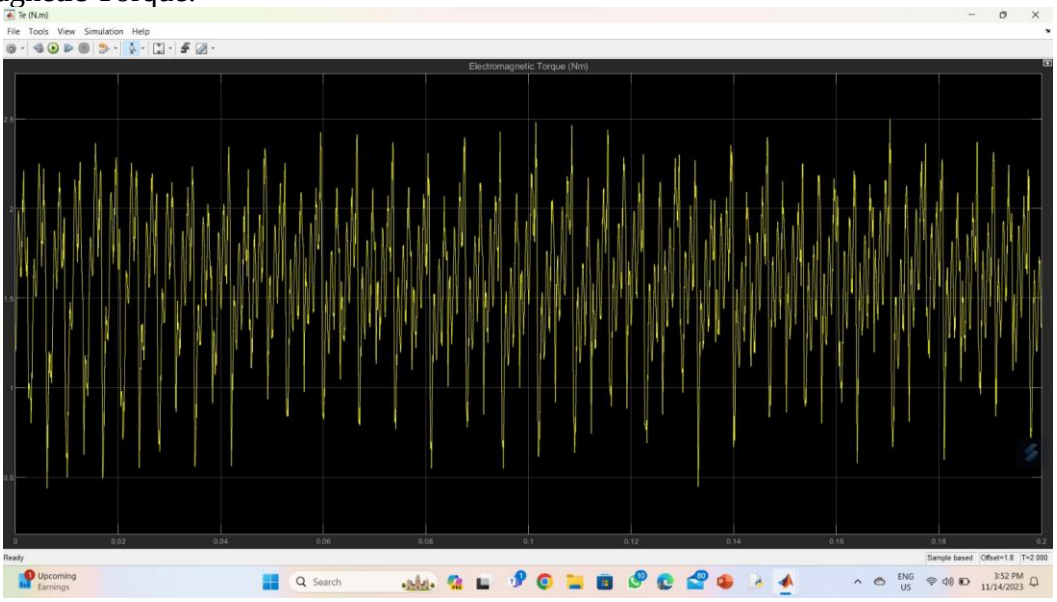
Simulation

Stator current and Electromotive force



Rotor speed:

Electromagnetic Torque:



6.CONCLUSION:

In this proposed system, buck boost type converter named zeta converter is used to fed the BLDC motor. Since there will be fewer power losses and the motor will run moreefficiently, this converter just employs one switch. This workuses a fuzzy rule to maintain the constant speed of a BLDC motor. This BLDC motor speed control is carried out in MATLAB/SIMULINK because it enables the consideration of a variety of dynamic factors, including phase current, voltage, rotor speed, and mechanical torque. Here, fuzzy logic rules have been applied through Mamdani algorithm. Byusing Fuzzy rules-based controller in place of PI controller, itwill improve the accuracy in the speed control waveform.

7. ACKNOWLEDGEMENT:

We would like to thank all the authors of different research papers referred during writing this paper. It was very knowledge gaining and helpful for the further research to be done in future.

REFERENCES:

1. M. M.K, G. S. Warrier, P. Pathivil, S. Kanagalakshmi and R. Archana, "Design and Performance Analysis of Brushless DC Motor Using ANSYS Maxwell," 2019 2nd International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT), Kannur, India, 2019.

2. Singh, S., K. K. S. D. K. Verma, Jaswant Singh, and Naveen Tiwari. "A Review on control of a brushless DC motor drive." Int. J. Future Revolution Comput. Sci. Commun. Eng 4 (2018): 82-97.

3. Banaei, Mohamad Reza, and Hossein Ajdar Faeghi Bonab. "A high efficiency nonisolated buck–boost converter based on ZETA converter." IEEE Transactions on Industrial Electronics 67.3 (2019).

4. Rahman, Mohammad Halimur, Md Abdul Mannan, Muhammad Abdul Goffer Khan, Md Rifat Ul Karim Shovon, and Mohd Muinul Haq Mamun. "Design and Implementation of a Three-Phase Inverter Operated with Different Conduction Modes",in 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), pp. 346-349. IEEE, 2019.

5. Lamkhade, Poonam N., B. J. Parvat, and C. B. Kadu. "Design and implementation of fuzzy logic controller for level control." in 2015 International Conference on Energy Systems and Applications, pp. 475-479. IEEE, 2015.

6. Dubey, Kartika, and M. T. Shah, "Design and simulation of Solar PV system",in 2016 International Conference on Automatic Control and Dynamic Optimization Techniques (ICACDOT), pp. 568-573. IEEE, 2016.

7. Bhavatharini T., D. Maladhi, and G. Mahalakshmi. "Speed control of zeta converter fed BLDC motor." in AIP Conference Proceedings, vol. 2527, no. 1, p. 040006. AIP Publishing LLC, 2022.

8. Hosur, Banashankari,"Design and Simulation of Zeta Converter for Speed Control of BLDC Motor",International Journal of Emerging Technologies in Engineering Research (IJETER) Volume 7 (2019).

9. Acharya, Sriballabh, and Vikas Sharma,"Speed Control of Brushless DC Motor using Zeta Converter",in 2020 International Conference on Smart Electronics and Communication (ICOSEC), pp. 1227-1233. IEEE, 2020.

10 R. Kumar and B. Singh, "BLDC Motor-Driven Solar PV Array-Fed Water Pumping System Employing Zeta Converter," in IEEE Transactions on Industry Applications, vol. 52, no. 3, pp. 2315-2322, May-June 2016, doi: 10.1109/TIA.2016.2522943.

11. V. Bist and B. Singh, "A Brushless DC Motor Drive with Power Factor Correction Using Isolated Zeta Converter," in IEEE Transactions on Industrial Informatics, vol. 10, no. 4, pp. 2064-2072, Nov. 2014, doi: 10.1109/TII.2014.2346689.

12. Sajeevan, Reshma, and K. P. Thomas,"PID Controlled Zeta Converter for PV based DC Supply", 2019 IEEE International Conference on Innovations in Communication, Computing and Instrumentation (ICCI). IEEE, 2019.

13. Singh, Shikha, Bhim Singh, G. Bhuvaneswari, and Vashist Bist, "Power factor corrected zeta converter based improved power quality switched mode power supply",IEEE Transactions on industrial electronics 62, no. 9 (2015): 5422-5433.