ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Solar Energy Fed BLDC Motor with Four Switch Inverter Using Artificial Neural Networks

D.Durga
M.Tech Student,
Baba Institute of Technology and Sciences,
Visakhapatnam, India.

K.Venkateswara Rao, M.Tech
Assistant Professor,
Baba Institute of Technology and Sciences,
Visakhapatnam, India.

Abstract:

Permanent Magnet Brushless DC (PMBLDC) machines are more popular due to its simple structure and low cost. Improvements in permanent magnetic materials and power electronic devices have resulted in reliable, cost effective PMBLDC drives, for many applications. PMBL motors find applications in diverse fields such as domestic appliances and automobiles due to its low cost and performance. Modeling, simulation and experimentation of drives with new converter configuration and control schemes are essential for making this drive competitive. In this proje, we are introduction method is an sensor control of four switch inverter fed with the Brushless DC motor using Artificial neural network and buck-boost converter is discussed and Simulation model using transfer function of BLDC motor is presented. Simulation work is done using the MATLAB software.

I. INTRODUCTION:

Because of the different advantages of high efficiency, high power density and minimal maintenance, the Permanent Magnet (PM) Brushless DC machine is become increasingly attractive for industrial and electric vehicle (EV) applications. The brushless DC motor (BLDC) is an synchronous electric motor which is powered by direct-current electricity (DC) and has a electronically controlled commutation system; instead of a mechanical commutation system with brushes. It has all good advantage of DC drives and eliminating the drawbacks using electronic commutation. So in this motor current , torque, voltage and rpm are related linearly. Normally from the Hall Effect sensor, the signal for commutation is generated. But using these sensors the size of the BLDC motor will become larger and when space will be a main constraint, BLDC motor fail to meet the same. BLDC Motors are extensively used in domestic and automobile industries. The market is too competitive so cost reduction and better performance will be the prime importance.

Cost reduction in BLDC motor drives can be achieved by two methods one is topological approach and second control approach. In the topological approach, the number of switches , sensors and associated circuitry used to compose the power converter is minimized. Normally for the BLDC Motor drive six switch inverter topology is used. By reducing the no of switches the cost reduction can be achieved. Moreover switching and conduction losses can be reduced. So here Four Switch VSI (FSVSI) topology is attempted. By using the Sensor control. For extensive system testing and evaluation program, detailed computer modeling and simulation is being developed. Modeling of the PMBLDC machine and the controller is essential for evaluating their performance. Each of the simulators allows setting of the input parameters of the drive as well as the setup of certain load torque and speed profiles in order to evaluate the drives. In this project the modeling of BLDCM is explained. The simulation of sensor control of drive is done in Matlab/Simulink. Control with sensor, the controller is used Fuzzy logic Controller. In this project a new methodology is proposed using artificial neural networks.

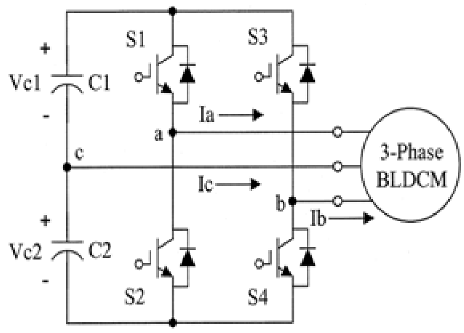


Fig.1.proposed four-switch converter topology for three-phase BLDC motor

2 PRINCIPLE OF A BLDC DRIVE:

A conventional BLDC drive is illustrated in Fig.2.1. It consists of a dc supplied by a rectifier arrangement a dc link capacitor for energy storage , a Voltage Source Inverter (VSI) consisting of transistor switches, and finally,

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

the three-phase output of the inverter is supplied to the motor. Although not explicitly shown, for position sensing purposes, either a Hall position sensor or a optical shutter arrangement is used along with some sort of microcontroller/microprocessor. Although snubbers are not shown, it is a practice to include snubbers to protect the transistor switches from voltage spikes generated by switching. In order to achieve a constant torque that is ideally free from ripple, the desired current be a rectangular ac wave, 120 broad. Torque is given by expression.

$$T_{em} = \frac{e_a i_a + e_b i_b + e_c i_c}{\omega_m} \quad (2.1)$$

e_a =phase-to-neutral back-emf of phase A (in volts)
e_b =Phase-to-neutral back-emf of phase B (in volts),
e_c =Phase-to-neutral back-emf of phase C (in volts),
i_a =Current in phase A (in amperes),
i_b =Current in phase B (in amperes),
i_c =Current in phase C (in amperes) and
ω_m =Angular velocity of the rotor shaft (in radians/second).

A profile for each phase of the motor with respect to the corresponding back-emfs as a function of the rotor position is shown in Fig.2.2.At each rotor position, a constant current multiplies the constant part of the back-emf; hence the sum of products of a phase back-emf and the corresponding phase current is constant. The desired current profile is achieved by supplying the BLDC motor from a VSI or a Current Source Inverter (CSI). When using a VSI, the desired current profile is achieved by controlling the switching of the transistors .

3.FOUR-SWITCH THREE-PHASE BLDC MOTOR DRIVE

A BLDC motor needs quasi square current waveforms which are synchronized with the back-EMF to generate constant output torque and have 120 conduction and 60 nonconducting regions. Also, at every instant only two phases are conducting and the other phase is inactive. However as mentioned earlier in the four-switch converter, the generation of 120 conducting current profiles are inherently difficult. This can be explained as follows:In the four-switch configuration, there are four switching status as shown in Fig. 2.1, such as (0, 0), (0, 1), (1, 0) and (1, 1) in which the motor load is replaced by a resistive load and the switches are replaced by simple ideal switches.

"0" means that the lower switch is turned on and "1" the upper switch is turned on. The two switches never turn on and off simultaneously. In the case of the six-switches converter, switching status (0, 0) and (1, 1) are regarded as zero-vectors, which cannot supply the dc-link voltage to the load, so that current cannot flow through the load. However, in the four-switch converter, one phase of the motor is always connected to the midpoint of the dc-link capacitors, so that current is flowing even at the zero-vectors, as shown in Fig.2.3(a) and (b). Moreover in case of (0, 1) and(1, 0) the phase which is connected to the midpoint of dc-link capacitors is uncontrolled and only the resultant current of the other two phases flow through this phase. If the load is ideally symmetric there is no current in the (0, 1) and (1, 0) vectors. As a result of the operation using four switching vectors one can depict the phase voltage or current waveforms, it is noted that obtaining the 120 conduction and 60 non conducting period current profile is inherently difficult based on the "asymmetric voltage PWM."It means that conventional PWM schemes for the four-switch induction motor drives cannot be used directly for BLDC motor drives.Therefore in order to use the four-switch converter topology for the BLDC motor drive, a new control scheme should be developed.

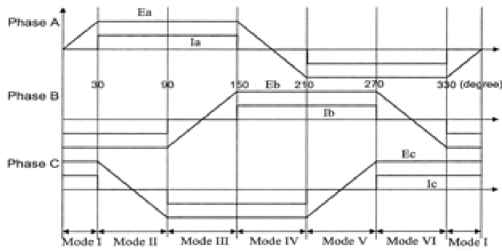


Fig.2.Back emf's,current waveforms and Hall position sensors for a BLDC

4 DETAILED CURRENT EQUATIONS ACCORDING TO THE OPERATING MODES

Mode I (0°<θ<30°)	$I_b + I_c = 0$ and $I_a = 0$
Mode II (30°<θ<90°)	$I_a + I_b = 0$ and $I_c = 0$
Mode III (90°<θ<150°)	$I_a + I_c = 0$ and $I_b = 0$
Mode IV (150°<θ<210°)	$I_b + I_c = 0$ and $I_a = 0$
Mode V (210°<θ<270°)	$I_a + I_b = 0$ and $I_c = 0$
Mode VI (270°<θ<330°)	$I_a + I_c = 0$ and $I_b = 0$

(A)Operational Principle of Direct Current Controlled PWM:

From the motor point of view even though the BLDC motor is supplied by the four-switch converter, ideal

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

back-EMF of three-phase BLDC motor and the desired current profiles can be described. From the detailed investigation of the four-switch configuration and back-EMF and current profiles we could come up with a PWM control strategy for the four-switch three-phase BLDC motor drives as follows:Under a balanced condition, the three-phase currents always satisfy the following condition:

$$i_a + i_b + i_c = 0$$

Then, (2.2) can be modified as

$$I_c = -(I_a + I_b)$$

In the case of the ac induction motor drive, at any instant there are always three phase currents flowing through the load, such as

$$I_a \neq 0, I_b \neq 0, I_c \neq 0$$

However, in the case of the BLDC motor drive, is not valid anymore. According to the operating modes one can derive the following current equations from Table I implies that due to the characteristics of the BLDC motor, only two phases (four switches) needed to be controlled, not three phases. Therefore, based on Table I, one can develop a switching sequence using four switches as follows:

DC to DC converter:

In electronics engineering, a DC to DC converter is a circuit which converts a source of direct current from one voltage to differet dc voltages. It is a class of power converter.

USAGE:

DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries. Such electronic devices often contain several sub-circuits with each sub-circuit requiring a unique voltage level different than that supplied by the battery (sometimes higher or lower than the battery voltage and possibly even negative voltage). Additionally, the battery voltage declines as its stored power is drained. DC to DC converters offer a method of generating multiple controlled voltages from a single variable battery voltage, thereby saving space instead of using multiple batteries to supply different parts of the device.

PHOTOVOLTAIC SYSTEM:

3.1 Photovoltaic Effect:

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors are exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels comprising a number of cells containing a photovoltaic material. Materials presently used for photovoltaic include mono crystalline silicon, polycrystalline silicon, amorphous silicon,cadmium telluride and copper indium selenide/sulfide. Due to the growing demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.As of 2010 solar photovoltaic generates electricity in more than 100 countries and while yet comprising a tiny fraction of the 4800 GW total global power-generating capacity from all sources, it is the fastest growth power-generation technology in the world between 2004 and 2009.

Grid-connected PV capacity increased at an annual average rate of 60 percent to some 21GW. Such installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building known as Building Integrated Photovoltaic’s or BIPV for short. Off-grid PV accounts for an additional 3–4 GW.Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaic has declined steadily since the first solar cells were manufactured. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity; have supported solar PV installations in many countries.

The photovoltaic effect is the generation of a voltage (or a corresponding electric current) in a material upon exposure to light. Though the photovoltaic effect is directly related to the photoelectric effect, the two processes are different and should be distinguished. In the photoelectric effect, electrons are ejected from a material’s surface upon exposure to radiation of sufficient energy. The photovoltaic effect is different in that the generated electrons are transferred between different bands (i.e. from the valence to conduction bands) within the material, resulting in the buildup of a voltage between two electrodes. In most photovoltaic applications the radiation is sunlight and for this reason the devices are known as solar cells.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

In the case of a p-n junction solar cell, illumination of the material results in the generation of an electric current as excited electrons and the remaining holes are swept in different directions by the built-in electric field of the depletion region. The photovoltaic effect was first observed by Alexandre-Edmond Becquerel in 1839.

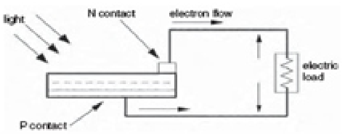


Fig 3.PV effect converts the photon energy into voltage across the p-n junction

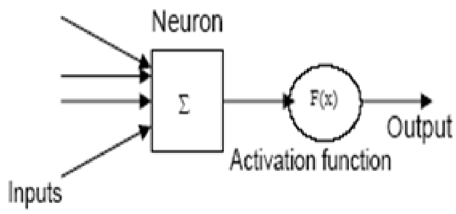
As of October 2010, the largest photovoltaic (PV) power plants in the world are the Sarnia Photovoltaic Power Plant (Canada, 80 MW), the Olmedilla Photovoltaic Park (Spain, 60 MW), the Strasskirchen Solar Park (Germany, 54 MW), the Lieberose Photovoltaic Park (Germany, 53 MW), the Puertollano Photovoltaic Park (Spain, 50 MW), the Moura photovoltaic power station (Portugal, 46 MW), and the Waldpolenz Solar Park (Germany, 40 MW).

FUZZY LOGIC CONTROLLERS:
4.1 INTRODUCTION TO FUZZY LOGIC:

A logic of an approximate reasoning continues to grow in importance, as it provides an in expensive solution for controlling know complicate systems. Fuzzy logic controllers are already used in appliances, washing machine, refrigerator and vacuum cleaner etc. Computer subsystems (disk drive controller, power management) consumer electronics (video, camera and battery charger) C.D. Player etc. and so on in last decade, fuzzy controllers have convert adequate attention in motion control systems. As the later possess non-linear characteristics and a precise model is most often unknown. Remote controllers are increasingly being used to control a system from a distant place due to inaccessibility of the system or for comfort reasons. In this work a fuzzy remote controllers is developed for speed control of a converter fed dc motor. The performance of the fuzzy controller is compared with conventional P-I controller.

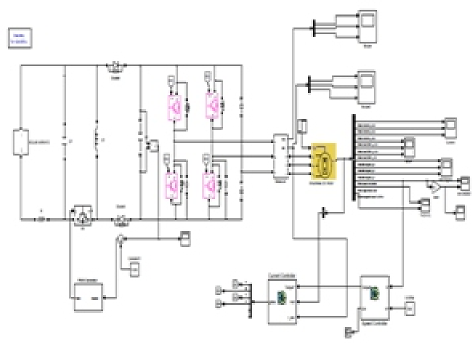
ARTIFICIAL NEURAL NETWORK
5.1 Introduction of ANN:

Numerous advances have been made in developing intelligent systems, some inspired by biological neural networks. Researchers from many scientific disciplines are designing artificial neural networks to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control.Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them. This article is for those readers with little or no knowledge of ANNs to help them understand the other articles in this issue of computer. We discuss the motivations behind the development of ANN, describe the basic biological neuron and the artificial computational model, outline network architectures and learning processes, and present some of the most commonly used ANN models. We conclude with character recognition, a successful ANN application.The artificial neuron is a simple summing unit. It adds its weighted inputs and produces an output which is a function of the sum of all the weighted inputs. It is developed to mimic the performance of the biological neuron in the human brain which forms a powerful information processing system when interconnected with large number of neurons. The imitation of this massive parallelism of this neuron architecture in the human brain leads to the development of the artificial neural networks. Here is simple model of an artificial neuron.



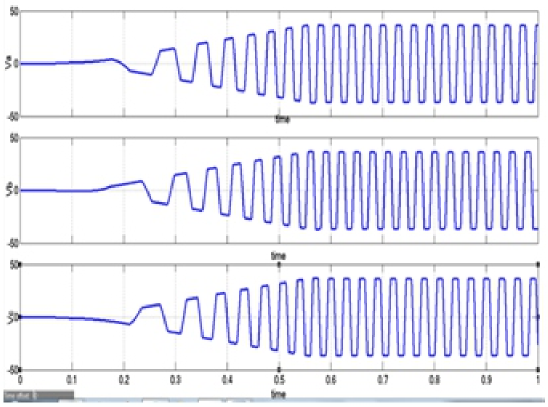
5.1: Simple Artificial Neuron

SIMULINK RESULTS
6.1 BLOCK DIAGRAM WITH FUZZY LOGIC:

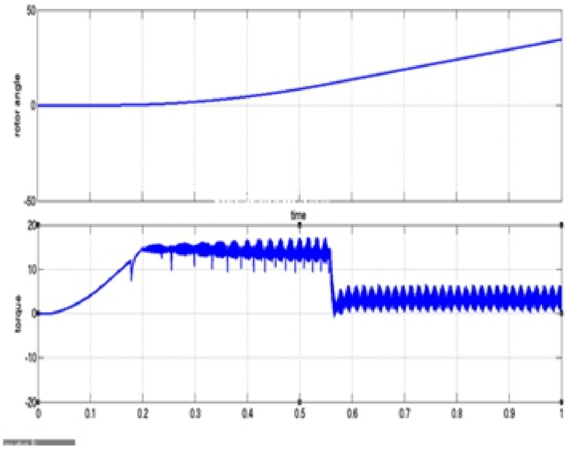


6.2 STATOR CURRENTS FED TO BLDC MOTOR
$I_A, I_B \wedge I_C$

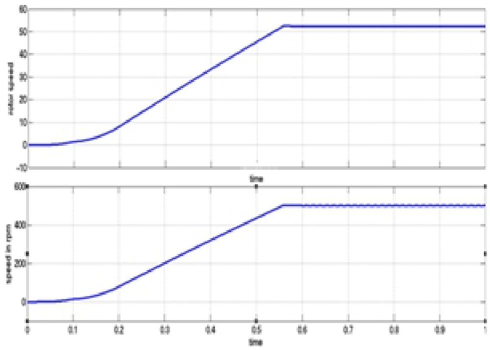
6.3 STATOR BACK EMF $E_a, E_b \wedge E_c$



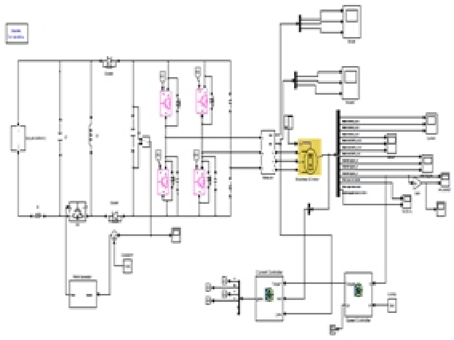
6.4 ROTOR ANGLE AND ELECTROMAGNETIC TORQUE T_E



6.5 ROTOR SPEED IN RAD/SEC AND ROTOR SPEED IN RPM

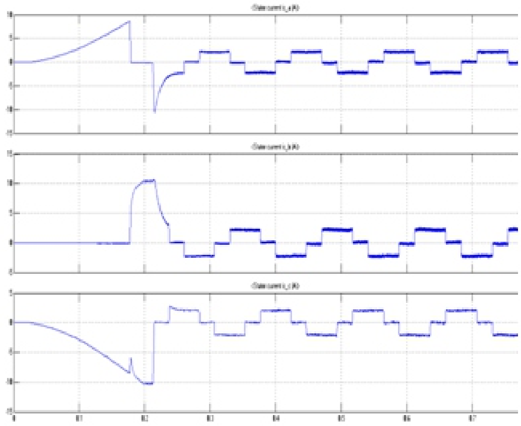


6.6.BLOCK DIAGRAM WITH ANN

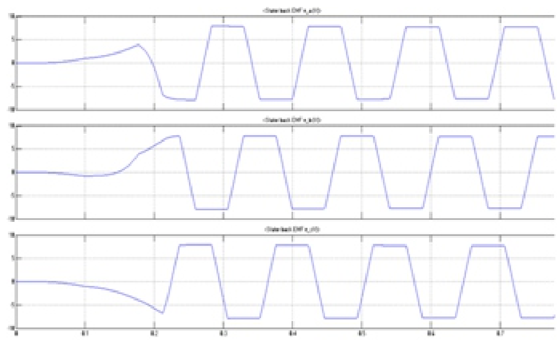


6.7SIMULINK RESULTS OF ANN

6.7. 1.STATOR CURRENTS FED TO BLDC MOTOR
$I_A, I_B \wedge I_C$

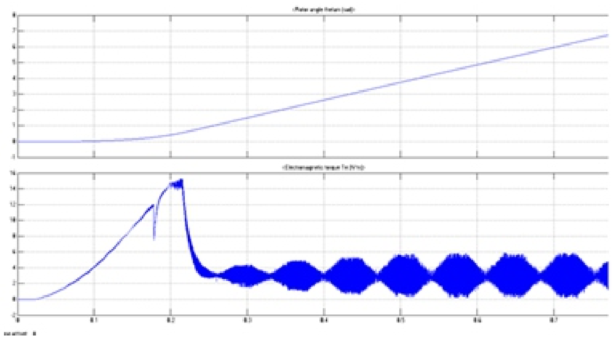


6.7.2. STATOR BACK EMF $E_a, E_b \wedge E_c$

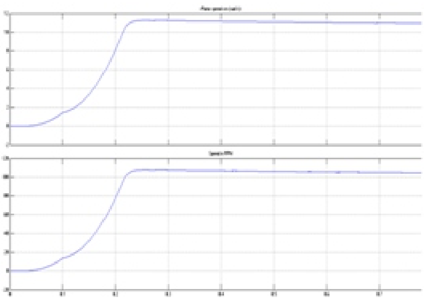


ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

6.7.3. ROTOR ANGLE AND ELECTROMAGNETIC TORQUE T_E



6.7.4.ROTOR SPEED IN RAD/SEC AND ROTOR SPEED IN RPM



7 CONCLUSION:

In this project, the transfer function model is explained .The simulation is performed in MATLAB /SIMLINK motor model fed by four-switch inverter with hysteresis current control first with fuzzy controller, hall effect sensors and then with ANN. The current waveforms are rectangular without any distortion due to the hysteresis control. From the phase voltages the virtual hall effect signals are produced and thus applicable in four switch inverter topology .The new method is proposed for reducing the distortions using artificial neural networks which responds faster and smoother to reference speed changes

8 REFERENCES:

[1]Akhila.R and Nikhil.S ”A comparative study of sensor and sensorless control of four switch inverter fed PMBLDC,”IEEE Trans, 2012.

[2]Pragasan Pillay and R.Krishnan,(1988), “Modeling ofPermanent Magnet Motor Drives”,IEEE’1988,vol35, No.4. PPillay and R Krishnan. ‘Modelling, Simulation and Analysis of a Permanent Magnet Brushless dc Motor Drive.’Conference Record of IEEE/IAS Meeting, 1987, p 8

[3]R. Krishnan, “A novel single-switch-per-phase converter topology for four-quadrant pm brushless dc motor drive”, IEEE Trans. Ind. Appl., Vol. 33, No. 5, pp. 1154-1161, Sep./Oct., 1997

[4]R. Krishnan and P. Vijayraghavan, “A new power converter topology for PM Brushless dc motor drives”, in Proc. IEEE IECON, Vol. 2, pp. 709– 714, 1998

[5]B. K. Lee and M. Ehsani, “Advanced BLDC motor drive for low cost and high performance propulsion system in electric and hybrid vehicles”, in Proc. IEEE Electric Machines and Drives Conf., pp. 246-251, 2001.