Sensor less Control of BLDC Motor using Fuzzy logic controller for Solar power Generation

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Abstract

Brushless dc (BLDC) motors are electronic controlled and have the rotor position for commutating the stator winding current. This paper presents the BLDC motor sensor less speed control system with fuzzy logic implementation. The sensor less method based on the back EMF sensing and the rotor position detection with a high starting torque is suggested. This Paper presents the efficient power generation of Photovoltaic System and deal with the sensor less control of BLDC motor. The controller design of a solar module has established for maximum power. It consists of a solar panel and boost converter for maximum power generations. This boost converter can be operating step up mode with less passive component counts and non-inverted output voltage polarity. The sensor less control of BLDC motor based on fuzzy control and a potential start-up method with a high starting torque are indicated. The rotor position is adjusted at standstill for high starting torque. The stator current can be changed by modulating the pulse width of switching devices during alignment. The controller performance of solar module and corresponding simulation results are verified by using MATLAB/Simulink environment.

Keywords: Brushless DC (BLDC) Motor, Boost Converter (BC), Photovoltaic (PV) Source, Fuzzy Controller.

Introduction:

Brushless dc (BLDC) motor is used in medium and low power application because high efficiency, high flux density, low maintenance, high ruggedness, low EMI problems and speed control. In BLDC motor the stator have winding and rotor having the permanent magnet, no brushes and commutator in the BLDC motor, so it doesn't have the sparking issues as compared to the DC motor so in BLDC motor has low EMI problem [1-2]. The BLDC motor used in the industrial application, home appliance, robot manipulator where speed and torque will be required. To sense the position of rotor by using the hall sensor method. This motor has trapezoidal EMF and used in variable speed drive and has high efficiency. The conventional speed control method has some difficulties but in proposed fuzzy controller is used to get a high efficiency and better dynamic performance [3-5].

The special converters are present but we use the basic boost converter for analyzing the speed control of sensorless brushless dc motor. The boost converter used to boost the voltage from the solar PV array. In boost converter pulse generator is fed to the gate signal of the converter. This paper presented a simplified buck-boost converter having cascading of simplified and controlled active switching arrangement is perfect suitable to extract power from varying solar system. The proposed active power generation of photovoltaic is used to provide a continuous and control of power across DC-Link of inverter fed Brushless DC Motor [6-10].

Photovoltaic fed Four-switch DC-DC converter is interfaced with inverter scheme for providing continuous and controlled voltage to inverter DC link. Classical approach of four switch buck-boost converter and current fed solar converter scheme is suitable a choice for photovoltaic fed motor drives system and also to overcome the drawbacks of converter system is in literatures. But those are still having some limitation in low current generation, low voltage generation, photovoltaic shading problem and multi-stage power conversion system [11]-[15].

The first section gives the introduction about the paper. The second section of the paper is about the proposed Sensorless control of BLDC drive. Design of speed controller with fuzzy technique is discussed in the third section. The fourth section deal with the simulation results through MATLAB environment. The final section presents the conclusion and future work.

2. Proposed Sensorless Control of BLDC motor

The PV power is generated to run the BLDC motor. A single diode equivalent circuit basis photovoltaic model is sophisticated in this paper because it is having simple structure, reliable in operation and easily adjusting parameters when this interfacing with power converters over classical multi diodes structures. In this paper, advances in power generation is includes such as good module of PV, choice of suitable power converter medium with respect to efficiency and derivation of adequate algorithm for maximum power extraction is shown in Fig.1.

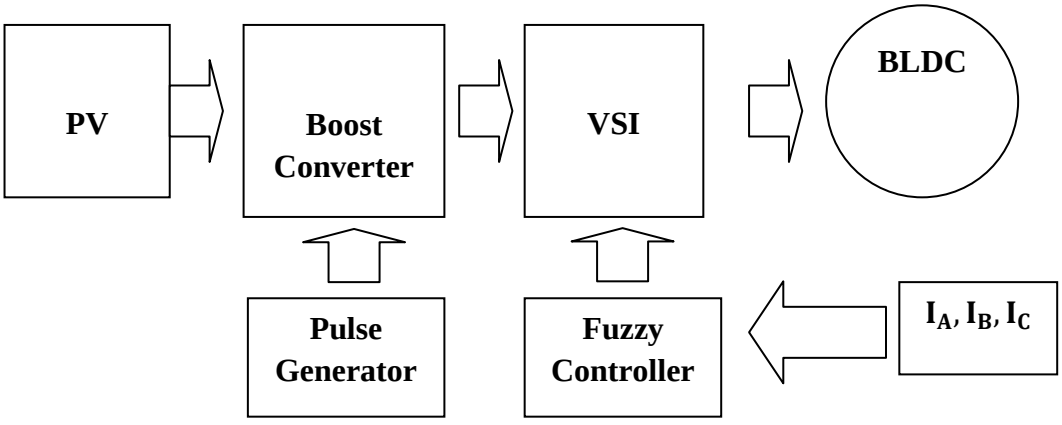


Fig 1: Proposed Block Diagram of BLDC motor For PV application

A photovoltaic system playing role an electricity generation in distributed generation. PV system consists of number of solar cells these are connected in series for generating electrical power with high potential. PV directly converts the electricity from sunlight without any rotational parts. The photovoltaic array process used to refers the photons of light exciting electrons into higher range of energy and permitting as charge carriers for an electric current. The solar cell is defined as unbiased mode of operation in which current by the device completely represent due to the physical energy and every solar cell devices are used in some type of photodiode. Solar cells are building blocks of photovoltaic module, otherwise known as solar panels. The basic equivalent circuit diagram of solar array is shown in figure 2.

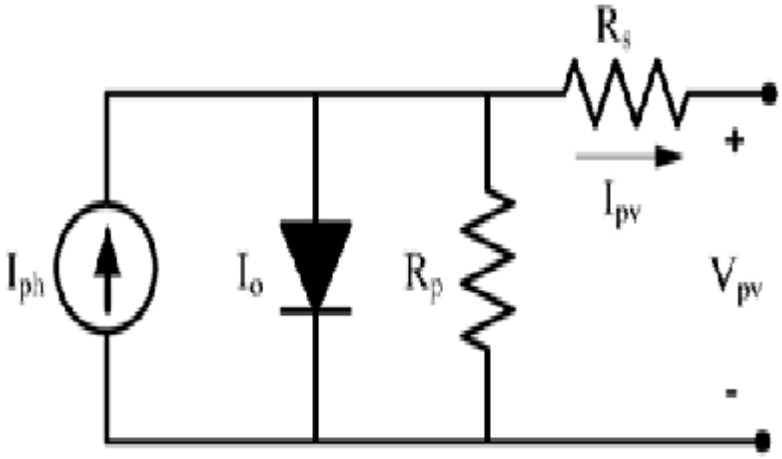


Fig 2: Equivalent circuit diagram of PV cell

$$I_{PV} = N_P \left\{ I_{ph} - I_0 \left\{ exp\left(\frac{q_{V_{PV}}}{nN_sKT} \right) \right\} \right\} \quad (1)$$

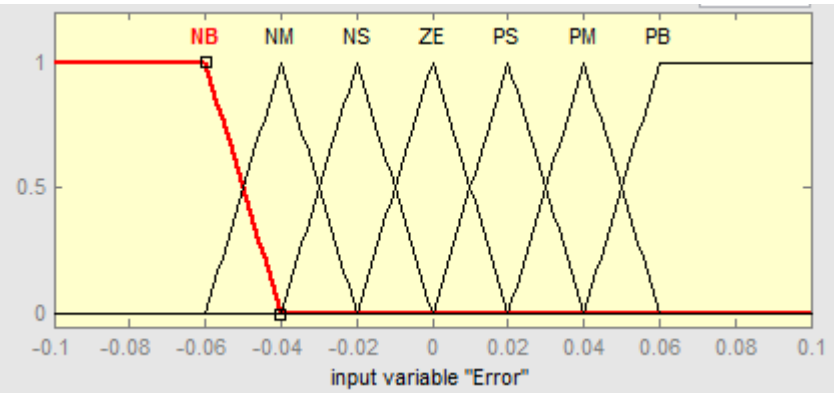
Where in above equation (1) current and Voltage of photovoltaic array is denoted by I_{PV} and V_{PV} respectively, short circuit current of photovoltaic array and saturation current are denoted by I_{ph} and I_0 Respectively. Coulomb constant (q) (1.602×10^{-19}) and Boltzmann constant (k) $(1.38 \times 10^{-23} J/K)$ are applied for derivation of photovoltaic current (I_{PV}).

The construction of brushless DC Motor has coil and permanent magnet for stator and rotor respectively. Stator develops a flux to rotate the rotor by magnetic flux attraction. Hall Effect sensor is used to detect rotor position. Armature is not build with coil but is made of a permanent magnet. Incremental encoder logic is uses for replacing of Hall Effect sensor to find the rotor position. The proposed system is called sensor-less control scheme implemented using phase current sensing system. The speed signal is compared for torque control using Fuzzy logic scheme, resulting in accurate torque and speed performance of brushless DC Motor.

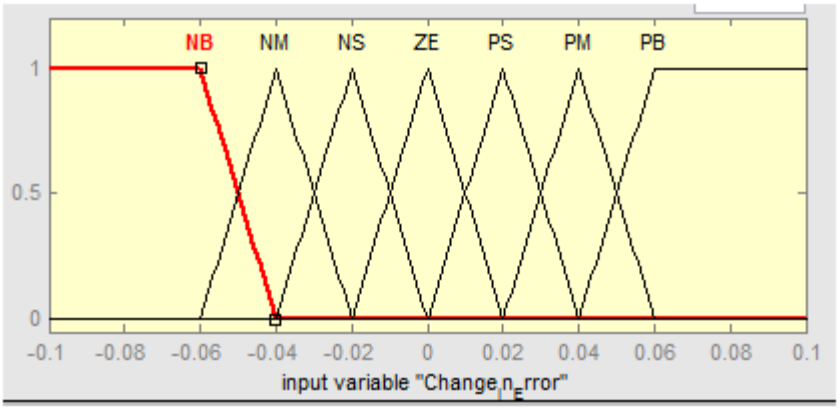
3. Design of speed controller using the fuzzy rule

The proposed method is based on the fuzzy logic sensorless BLDC motor. In boost converter the gate signal is applied by using the pulse generator. The voltage source inverter the gate pulse is applied by the fuzzy rule. The Fuzzy logic control circuit is consists of fuzzification, defuzzification and decision making stage [28] which is shown in Fig.6. The proposed fuzzy logic controller applied in speed control and indirectly controls a torque using d-q reference current generation.

Input variable "error"



"Change in error"



"Output Variable: Speed Estimation"

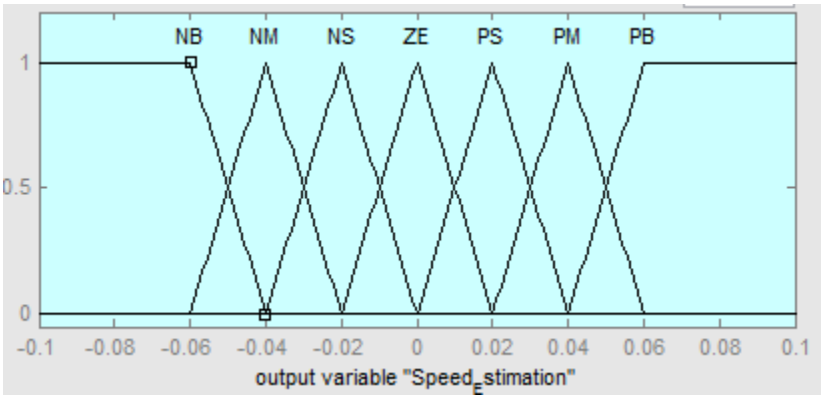


Fig 3: Membership functions of I/O fuzzy sets

4. Simulation Results and Discussion

The proposed circuit and topology is implemented using MATLAB/Simulink and that is shown in Fig.4 using parameters shown in Table I. A maximum extraction of single diode photovoltaic system is implemented on 50V/160W capacity shown in Fig.5 with high efficiency and boost converter (BC) with high step up ratio and capability of present converter performance is shown in Fig.6 across DC-Link.

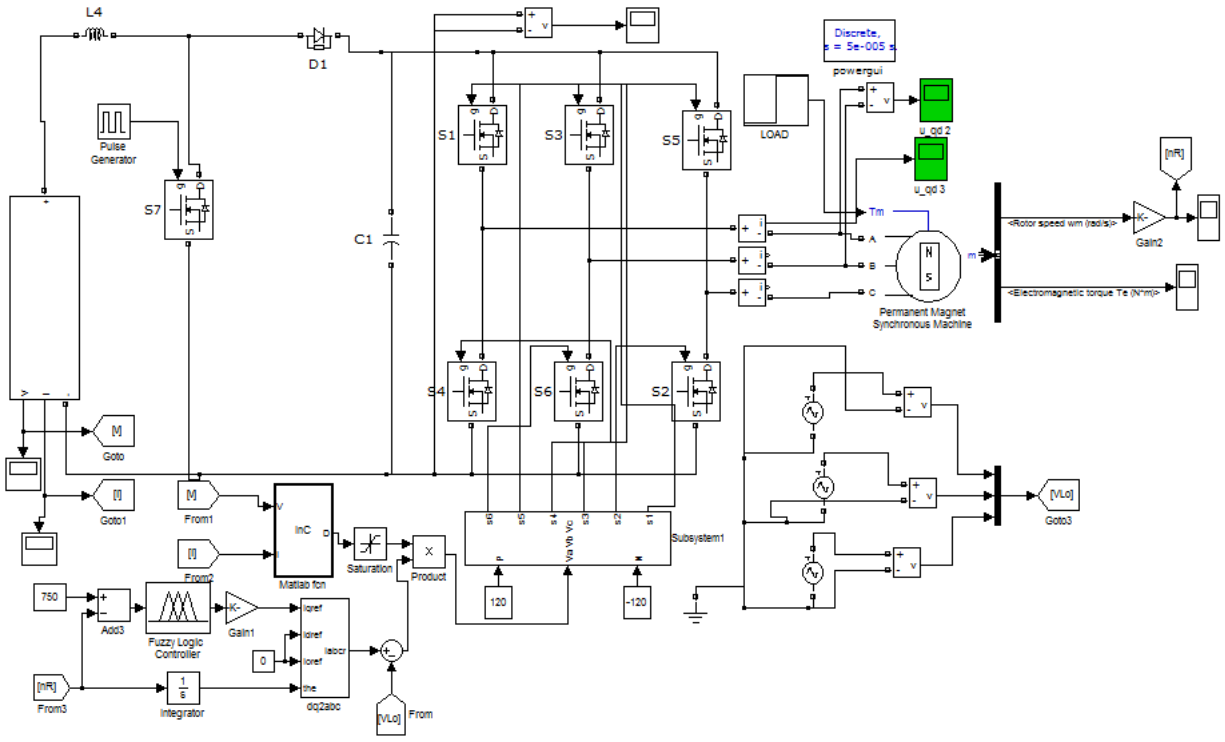
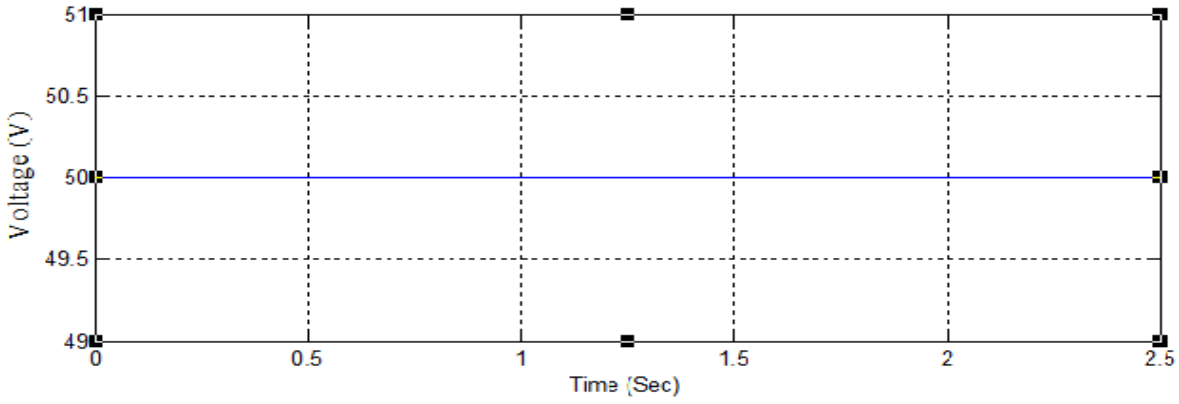


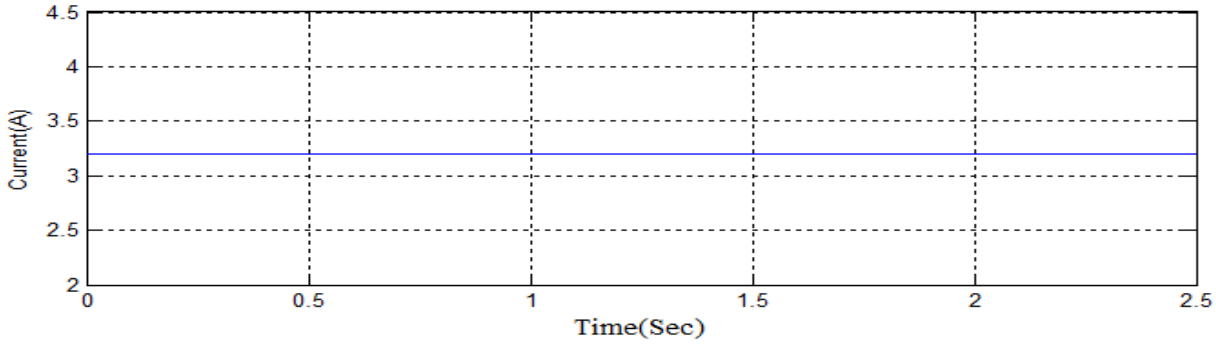
Fig 4: simulation implementation of proposed photovoltaic fed BC and sensorless control of brushless DC Motor

Table I Simulation parameters

Name	Range
Impedance source inductors (L_1)	0.001mH
Impedance source capacitors(C_1)	1000μF
Switching frequency (f)	4500Hz
Photovoltaic voltage (PV_V)	50V
DC-Link Voltage (V_{DC})	58V
Motor parameters	
Stator resistance (Ω)	6.5
Stator inductance (mH)	6.5
Rotor moment of inertia(mH) J$(kg.m^2)$	0.8
Number of poles (N_P)	4
Load Torque constant (k)	1.2124
Rotor speed (ω_r)	1180



(a)



(b)

Fig 5: (a) PV voltage, (b) PV current

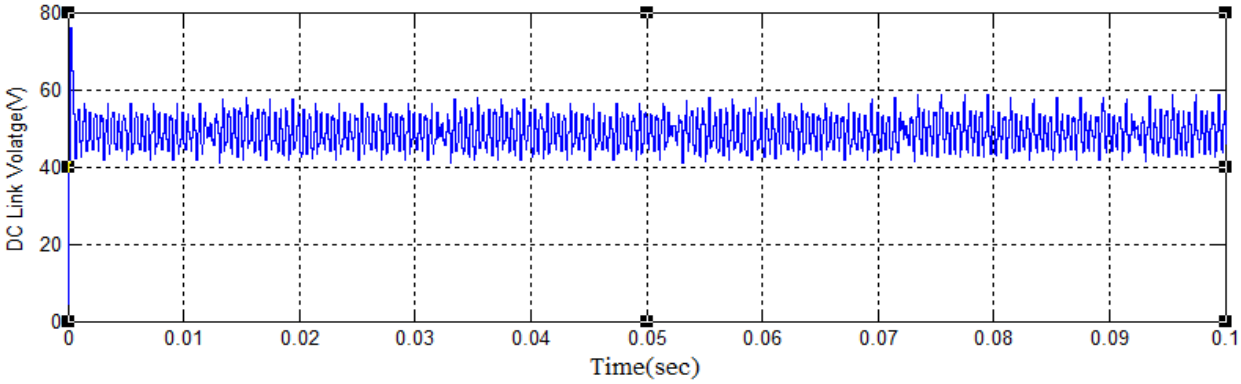


Fig 6: DC Link voltage

The present Brushless DC Motor performances was achieved by present sensor-less topology in stator voltage, stator current as well as speed which is shown in Fig.7 and 8 respectively. The speed and torque characteristics of brushless dc motor are shown in Fig.9 and 10 respectively.

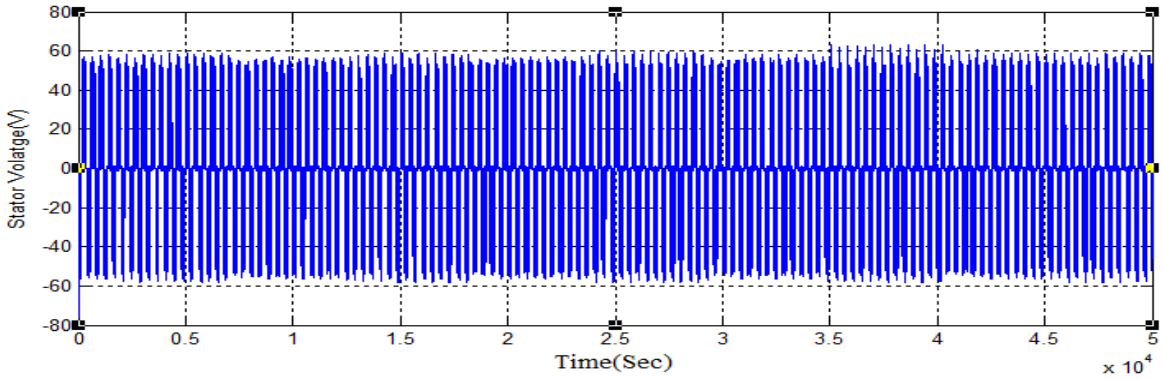


Fig 7: Stator voltage of BLDC motor

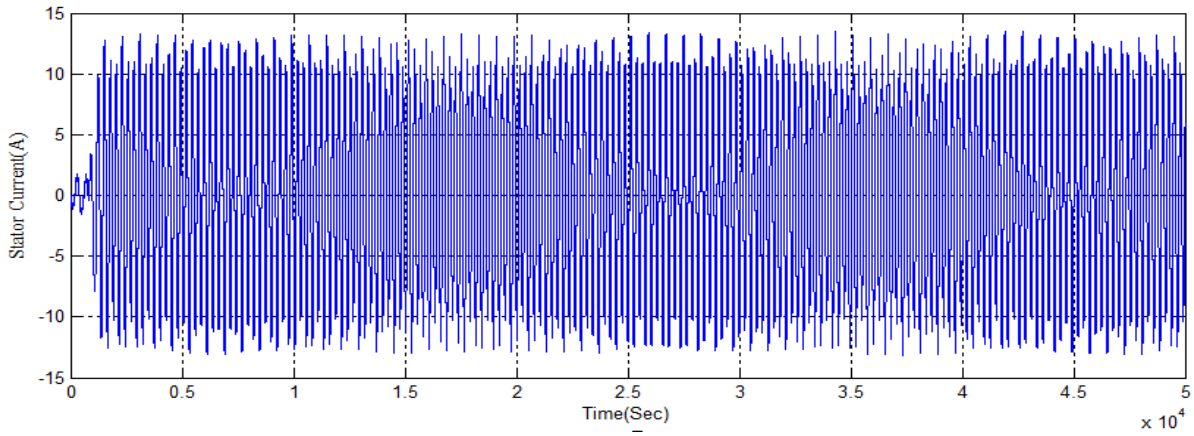


Fig 8: Stator current of BLDC motor

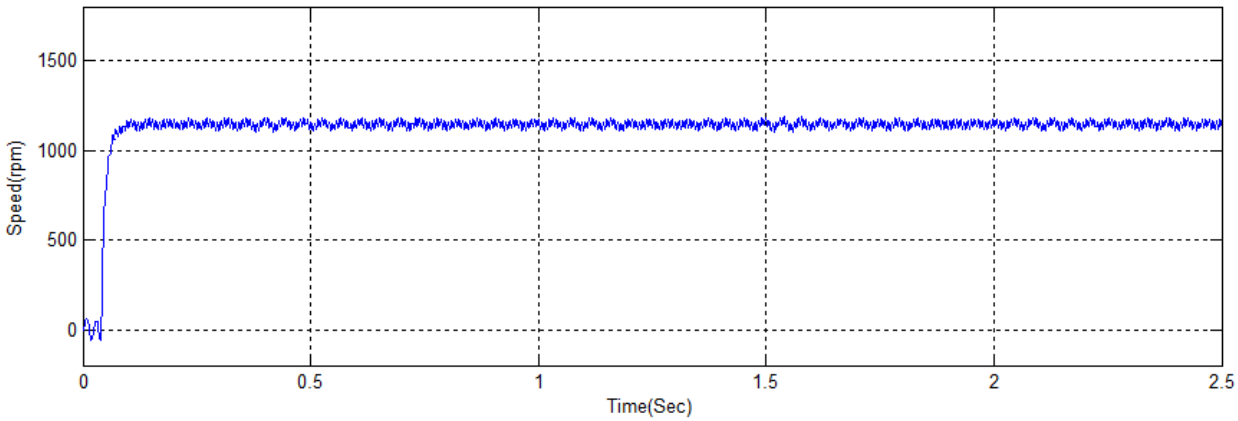


Fig 9: Speed characteristics of BLDC motor

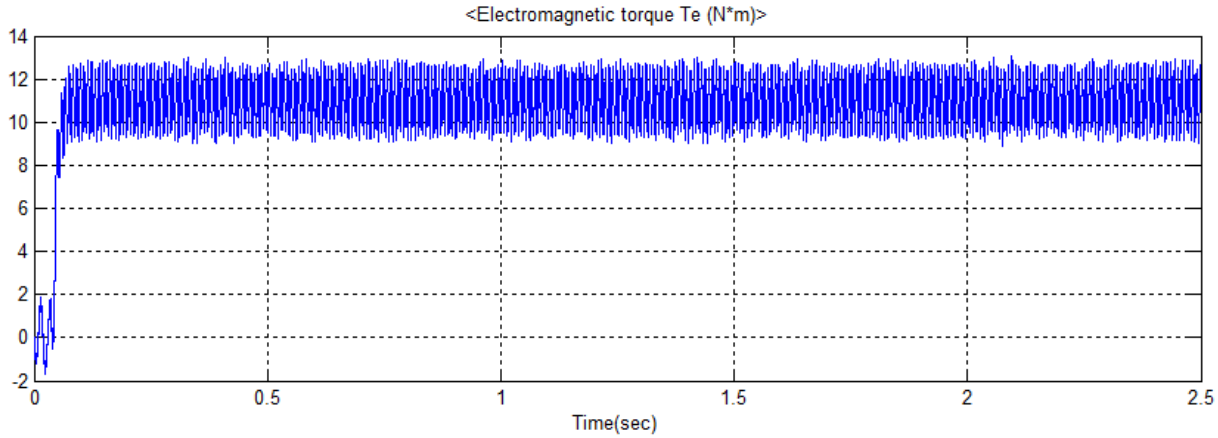


Fig 10: Torque Characteristics of BLDC motor

5. Conclusion

The proposed paper is explained about the speed control of brushless dc motor using the fuzzy logic controller. The proposed circuit has continuous flow of current to the sensorless brushless dc motor. The design and use of solar panel for extracting the maximum power and the power is fed into the BLDC motor. Proposed Boost Converter is used to obtain a high step up lossless power conversion by continuous tracking capability of pulse generator and also provides a continuous power to inverter DC-Link. Proposed sensor-less vector control is having simplified approach and torque, speed control is achieved using fuzzy logic controller. Performance of drive is maintained in desired limits by phase current of angle control, field control of speed and flux control circuitry. The performance of solar power generation using boost converter fed sensor-less controller for Brushless DC Motor is implemented using MATLAB/Simulink and performance are verified by simulation results.

Reference:

[1]. J. Sriram and K. Sureshkumar, "Speed control of BLDC motor using fuzzy logic controller based on sensorless technique," 2014 International Conference on Green Computing Communication and Electrical Engineering (ICGCCEE), Coimbatore, 2014, pp. 1-6.

[2]. R. Manikandan, R. Arulmoziyal and K. R. Priyadharsini, "Fuzzy PI based speed sensorless speed control of position sensorless BLDC drive," IET Chennai Fourth International Conference on Sustainable Energy and Intelligent Systems (SEISCON 2013), Chennai, 2013, pp. 57-64.

[3]. W. S. Yan, H. Lin, H. Li and Yan Wei, "Sensorless direct torque controlled drive of brushless DC motor based on fuzzy logic," 2009 4th IEEE Conference on Industrial Electronics and Applications, Xi'an, 2009, pp. 3411-3416.

[4]. S. A. K. Mozafari Niapoor, S. Danyali and M. B. B. Sharifian, "PV power system based MPPT Z-source inverter to supply a sensorless BLDC motor," 2010 1st Power Electronic & Drive Systems & Technologies Conference (PEDSTC), Tehran, Iran, 2010, pp. 111-116.

[5]. S. M. M. Mirtalaei, J. S. Moghani, K. Malekian and B. Abdi, "A novel sensorless control strategy for BLDC motor drives using a fuzzy logic-based neural network observer," 2008 International Symposium on Power Electronics, Electrical Drives, Automation and Motion, Ischia, 2008, pp. 1491-1496.

[6]. V. Nigam, S. Hussain and S. N. Agarwal, "A hybrid fuzzy sliding mode controller for a BLDC motor drive," 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), Delhi, 2016, pp. 1-4.

[7]. R. Akhila and S. Nikhil, "A comparative study of sensor and sensor less control of four-switch Inverter fed Permanent Magnet Brushless DC motor," 2012 International Conference on Power, Signals, Controls and Computation, Thrissur, Kerala, 2012, pp. 1-6.

[8]. A. A. Rajan, R. D. Raj and S. Vasantharathna, "Fuzzy based reconfigurable controller for BLDC motor," 2010 Second International conference on Computing, Communication and Networking Technologies, Karur, 2010, pp. 1-7.

[9]. Niapoor, S.K.M., Danyali, S. and Sharifian, M.B.B., 2010, February. PV power system based MPPT Z-source inverter to supply a sensor less BLDC motor. In Power Electronic & Drive Systems & Technologies Conference (PEDSTC), 2010 1st (pp. 111-116). IEEE.

[10]. Pattanaphol, A., Khomfoi, S. and Paisuwanna, P., 2010, May. Z-source grid-connected inverter for solving the photovoltaic cell shading problem. In Electrical Engineering/Electronics Computer Telecommunications and Information Technology (ECTI-CON), 2010 International Conference on (pp. 823-827). IEEE.

[11]. Kumar, R., Singh, B.: 'Buck – boost converter fed BLDC motor drive for solar PV array based water pumping '. IEEE Int. Conf. on Power Electronics, Drives and Energy Systems (PEDE S), December 2014, vol. 16 – 19, pp. 1 –6

[12]. Sundaram A and G.P. Ramesh, "MPPT Based Autonomous PV Module with Sensor Less Control of BLDC Motor for Maximum Solar Power Generations" I J C T A, 9(6), 2016, pp. 2911-2922

[13]. Sundaram, A. and Ramesh, G.P., 2016. An Advance Solar Power Generation and Control of Brushless DC Motor Using Phase Current Sensing of Sensor Less Vector Control. International Journal of Computer Science and Application.

[14]. Ouada, M., Meridjet, M.S., Talbi, N.: 'Optimization photovoltaic pumping system based BLDC using fuzzy logic MPPT control'. Int. Renewable and Sustainable Energy Conf. (IRSEC), 2013, vol. 7– 9, pp. 27 – 31

[15]. Z. Zhao, M. Xu, Q. Chen, J. S. Jason Lai, and Y. H. Cho, "Derivation, analysis, and implementation of a boost–buck converter-based high-efficiency pv inverter," IEEE Trans. Power Electron., vol. 27, no. 3, pp. 1304–1313,Mar. 2012