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Fuzzy based digital Control Strategy for Four Quadrant, 3 Phase BLDC Motor with speed stability

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***Abstract*—Brushless DC (BLDC) motor drives are becoming more popular in industrial, traction applications. This makes the control of BLDC motor in all the four quadrants very vital. This project deals with the digital control of three phase BLDC motor. The motor is controlled in all the four quadrants without any loss of power; in fact energy is conserved during the regenerative period. This digital controller with PI and fuzzy, is very advantageous over other controllers, as it combines the calculation capability of Digital Signal Processing and controlling capability of using a precise optimized PI and fuzzy to achieve fast precise control.To validate the developed technique simulations are carried out through MATLAB/SIMULINK.**

***Index terms*—BLDC motor, ds PIC, Regenerative ,braking ,digital control, four quadrants.**

I. INTRODUCTION

Brushless DC motor has a rotor with permenant magnets and stator with windings.. It is essentially a DC motor turned inside out. The brushes and commutator have been eliminated and the windings are connected to the control electronics.The control electronics replace the function of the commutator and energize the proper winding. It has less inertia,therefore easier to start and stop. BLDC motors are potentially cleaner, faster, more efficient, less noisy and more reliable. The Brushless DC motor is driven by rectangular or trapezoidal voltage strokes coupled with the given rotor position. The voltage strokes must be properly aligned between the phases, so that the angle between the stator flux and the rotor flux is kept close to 90 to get the maximum developed torque. BLDC motors often incorporate either internal or external position sensors to sense the actual rotor position or its position can also be detected without sensors. BLDC motors are used in Automotive, Aerospace, Consumer, Medical, Industrial equipments. Changliang Xia et al..[1] proposed A Control Strategy for Four-Switch Three-Phase Brushless DC Motor Using Single Current Sensor. Chung-Wen Hung et al..[2] introduced A Variable-Sampling Controller for Brushless DC Motor Drives With Low-Resolution Position Sensors. Arulmozhiyal.R et al..[3] Developed Design and implementation of fuzzy PID controller for BLDC motor using FPGA. Kalavathi et al.[4]developed ,Performance evaluation of classical and fuzzy logic controller technique for BLDC motor. Arulmozhiyal et al..[5] proposed An intelligent speed controller for BLDC motor. Cheng et al..[6]introduced Fuzzy PI controller for BLDC motors considering variable sampling effect. Tan chee et al[7]..proposed Implementation of fuzzy logic controllers for permenant magnet BLDC motor drives.

II. CONVENTIONAL SYSTEM

To design the fuzzy rule base based on the error obtained in the speeds (that means speed deviations from set value of speed) To operate the BLDC in both modes like as a motor and as well as a generator. The conventional system consists of a BLDC motor derive is implemented with PI controller for speed stability and both motoring operation and power generation operation is achieved in the existing work.Speed control stability and has been analysed with 0.5 and 1 kg load.

The main drawback in conventional method is that it could not able to achieve the stability, performance has not been analysed and in some cases the settling time is not achieved. To overcome these disadvantages the fuzzy logic has been introduced. The simulation is carried out through Matlab/ Simulink.The four quadrant operation of BLDC motor is shown in the figure.1

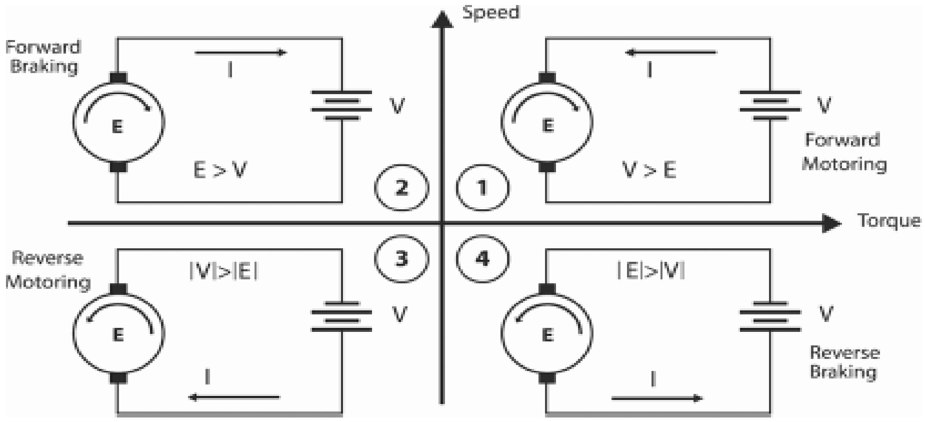

Fig 1 Block diagram of conventional systems

III. PROPOSED SYSTEM

The proposed system consists of A BLDC drive system is designed and simulated using matlab tool box. While, operating the BLDC in both motoring and generation mode, the speed is maintained with fuzzy based closed loop control. The BLDC motor is initially made to rotate in clockwise direction, but when the speed reversal command is obtained, the control goes into the clockwise regeneration mode, which brings the rotor to the standstill position. Instead of waiting for the absolute standstill position, continuous energization of the main phase is attempted. This rapidly slows down the rotor to a standstill position. Therefore, there is the necessity for determining the instant when the rotor of the machine is ideally positioned for reversal. Hall effect sensors are used to ascertain the rotor position and from the Hall sensor outputs, it is determined whether the machine has reversed its direction. This is the ideal moment for energizing the stator phase so that the machine can start motoring in the counter clockwise direction. One of the advantages of this technique is that the method proposed in this paper is simple and reliable. It conserves energy in a rechargeable battery during the regenerative braking mode. Relay circuits are employed to run the motor during the accelerating mode and charge the battery during the regenerative mode.

Complete drive system

Four quadrant Zero current transition converter (4Q—ZCT) was implemented for DC motor and single controllable switch for four quadrant operation was implemented for SRM drive. The common regenerative braking methods include adding an extra converter, or adding an extra ultra-capacitor, or switching sequence change of power switches. But the method of adding a converter not only increases cost but also reduces conversion efficiency. The method of adding an ultra-capacitor doesn't require extra DC-DC converter, but it needs a sensor to detect the ultra-capacitor voltage. This makes the circuit very complex and hard to implement. Moreover ultra-capacitor is very expensive. Whenever there is a reversal of direction of rotation it implies there is a change in the quadrant .When the motor is operating in the motoring mode, in the clockwise direction, the relay contacts are normally open. The relay circuit is shown in But when braking is applied or when a speed reversal command is received, the relay contacts are closed. The kinetic energy which will be wasted as heat energy is now converted into electric energy which is rectified and stored in a chargeable battery. The braking energy can be given back to the power source. But it increases the complexity of the circuit, the DC power generated has to be inverted to be given back to the mains. The frequent reversal of direction of rotation will result inthe continuous charging of the battery. The energy thus storedcan be used to run the same motor when there is an interruption of power supply. The actual speed of the motor is fed back to the ds PIC controller, which is compared with the reference speed. The difference in speed generates an error signal which aids the motor to run at a constant speed.

IV. RESULTS

We performed computer-aided simulations to prove availability of the proposed systems. The simulations are implemented using Mat lab. The simulation output of the conventional system is shown in the fig. 2.

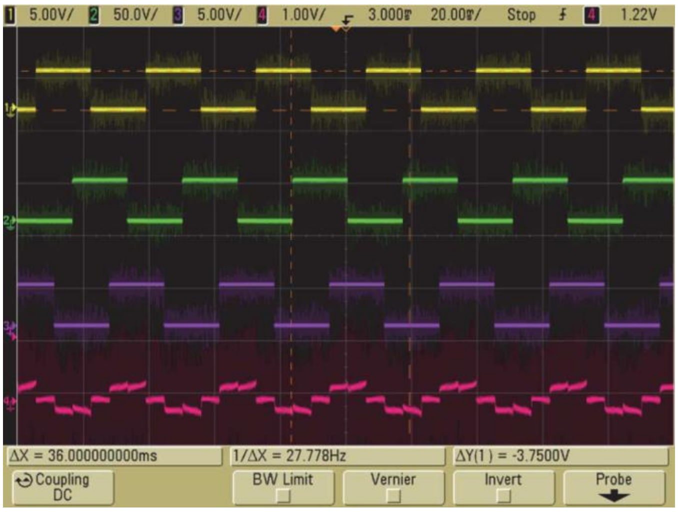

Fig 2 Hall sensor signals and phase current

Fig 3 Speed control with 0.5 load

In this proposed method the simulation output has been obtained using the Matlab/ Simulink. The simulation output of the proposed method is shown in the fig. 3 and fig:4.

Fig 4 Energization with a load of 0.5 kg

V. Conclusion

In this paper, a control scheme for BLDC motor is presented. To change the direction from CW to CCW and the speed control is achieved both for servo response and regulator response. The motor reverses its direction almost instantaneously, it will pass through zero, but the transition is too quick. The time taken to achieve this braking is comparatively less. The generated voltage during the regenerative mode can be returned back to the supply mains which will result in considerable saving of power. This concept may well be utilized in the rotation of spindles ,embroidery machines and electric vehicles where there is frequent reversal of direction of rotation of the motor.The significant advantages of the proposed work are: simple hardware circuit, reliability of the control algorithm, excellent speed control, smooth transition between the quadrants and efficient conservation of energy is achieved with and without load conditions.

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