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Fuzzy Logic Controller for Four Quadrant Operation of Three Phase BLDC Motor

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Abstract— Brushless DC (BLDC) motors are one of the electrical drives that are rapidly gaining popularity in industries. In this paper, proposed system gives a three phase Brushless DC (BLDC) in all four quadrant operation by using fuzzy logic controller. The average settling time delay in conventional PI controller drastically overcome by the fuzzy logic controller in order to achieve the constant speed of the motor in any one of the direction respectively. The back EMF is generated during the reverse motoring. In quadrant operation the breaking is applied leads to waste the kinetic energy as heat energy. Utilization of wasted kinetic energy is stored in a battery possible by proposed scheme. The four quadrant operations are Forward Motoring, Forward Braking, Reverse motoring and Reverse Braking. In forward driving the input feed to the BLDC motor up to the set time fastened. Subsequently the Forward Braking is applied then the motor speed reduced to zero. This helps to create a back emf and that is being converted to DC and stored in a battery. Then the Reverse Motoring is applied for rotating the motor at the reverse direction. At last the Reverse Braking is applied it also create the back emf and the converted energy stored in a battery. Rotor position is obtained by the Hall Sensor signal. The system consist of Input source, Fuzzy logic controller, Three phase inverter, Relay, Brushless DC motor (BLDC), Battery, Hall sensor..

Index Terms- Brushless DC motor (BLDC), Fuzzy Logic Controller, Four quadrant operation, Regenerative Braking, Utilize the wasted kinetic energy.

1. INTRODUCTION

A Brushless DC Motor (also referred to as a BLDC Motor), may be a synchronous motor high-powered by a right away current. Because the name implies, the Brushless DC Motor doesn't operate victimization brushes rather it operates with a controller via electronic commutation. A motion system supported the electricity (DC) motor provides a decent and economical resolution to satisfy the necessities of variable speed drive. Though DC motor posses smart management characteristics and strength, their performance and application in wider areas in inhibited attributable to sparking and commutation issues. Induction motor don't possess the on top of mentioned issues, they need their own limitations like low power issue and non-linear speed torsion characteristics. The four quadrant operation and regenerative braking achieves of a 3 section magnet BLDC motor with the intrinsical Hall result detector. The four quadrant operations of brushless DC motor chiefly helps within the locomotive of train systems for of times reversal of command. The projected digital system performs the subsequent tasks.

- Four quadrant operations
- Regenerative braking
- Utilize the wasted kinetic energy

2. BRUSHLESS DC MOTOR

Brushless DC (BLDC) motors are desired for tiny H.P. management motors attributable to their high potency, salient operation, compact kind, dependableness, and low maintenance. However, the management complexness for variable speed management and also the high price of the electrical drive twiddling my thumbs the widespread use of Brushless DC motor. Over the last decade, continued technology development in power semiconductors, microprocessors/logic ICs, adjustable speed drivers (ASDs) management schemes and permanent-magnet brushless motor production have combined to alter reliable, efficient resolution for a broad vary of adjustable speed applications. Appliance have historically relied on historical classic motor technologies like single section AC induction, as well as split section, capacitor-start, capacitor–run sorts, and universal motor. These classic motors usually square measure operated at constant-speed directly from main AC power while not concerning the potency. BLDC motors don't expertise the "slip" that is unremarkably seen in induction motors. BLDC motors one in single-phase, 2-phase and 3-phase configurations. Admire its kind, the mechanical device has a similar variety of windings. Out of those, 3-phase motors square measure the foremost in style and wide used. This application note focuses on 3-phase motors. Every commutation sequence has one among the windings energized to positive power (current enters into the winding), the second winding is negative (current exits the winding) and also the third is in a very non-energized condition. Torsion is created due to the interaction between the magnetic flux generated by the mechanical device coils and also the permanent magnets. Ideally, the height torsion happens once these 2 fields square measure at 90° to every alternative and falls off because the fields move along. The rotor is mainly made of permanent magnet and can vary from two to eight pole pairs with North (N) and South (S) poles. Based on the density in the rotor magnetic field, the proper magnetic material is chosen to make the rotor. Ferrite magnets used to make permanent magnets. As the technology advances, rare earth alloy magnets are gaining popularity as shown in the Figure 1.

Figure1.Circular core with rectangular magnets embedded in the core.

The primary solid solution magnets are less costly however they need the disadvantage of low compactness for a given volume. In distinction, the alloy material has high magnetic density per volume and permits the rotor to compress any for an equivalent torsion. Also, these alloy magnets improve the size-to-weight magnitude relation and provides higher torsion for an equivalent size motor exploitation primary solid solution magnets. Metal (Nd), atomic number 62 atomic number 27 (SmCo) and therefore the alloy of metal, primary solid solution and element (NdFeB) ar some samples of group alloy magnets. Continuous analysis goes on to enhance the compactness to compress the rotor any. For a three-phase BLDC motor, solely six distinct rotor positions per electrical cycle ar required to feed an oblong current in section with the back-EMF as elaborate here.

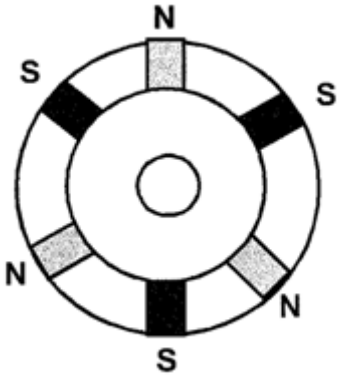

Figure2.Circular core with rectangular inserted into the rotor core

Selecting the appropriate Brushless DC Motor requires knowing the requirements of the application, such as torque, speed, size, power, length, etc. While determining which Brushless DC Motor best fits the requirements, the controller must be considered as well, as this goes hand in hand with theoperation of the Brushless DC Motor. Lastly, environment is important to consider. Applications requiring a harsh, damp environment may require motors with specific IP ratings. For more detailed information on this subject, The applications of the BLDC motor includes low and high power

- Refrigerator
- Hair drier / blower
- Air conditioner
- Medical Field
- Robotics
- Servo motor
- Feed drives for CNC machine tools
- Vehicles

3. PROPOSED SYSTEM

FOUR QUADRANT OPERATION OF BLDC MOTOR

There are four possible modes or quadrants of operation using a Brushless DC Motor which is depicted When BLDC motor is operating in the first and third quadrant, the supplied voltage is greater than the back emf which is forward motoring and reverse motoring modes respectively, but the direction of current flow differs. When the motor operates in the second and fourth quadrant the value of the back emf generated by the motor should be greater than the supplied voltage which are the forward braking and reverse braking modes of operation respectively, here again the direction of current flow is reversed.

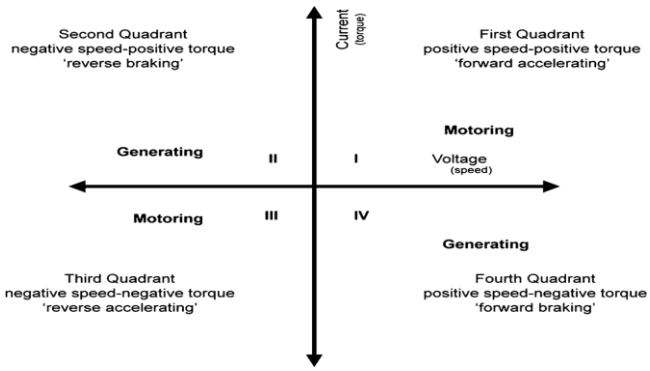

Figure3.Four Quadrant Operation of BLDC motor

The BLDC motor is initially created to rotate in dextrorotary direction, however once the speed reversal command is obtained, the management goes into the dextrorotary regeneration mode, that brings the rotor to the standstill position. Rather than awaiting absolutely the standstill position, continuous energization of the most section is tried. This quickly slows down the rotor to a standstill position. Therefore, there's the requirement for crucial the moment once the rotor of the machine is ideally positioned for reversal. The reference speed is feed to the Fuzzy logic controller from hall device signal. Input from the facility supply is send to the 3phase electrical converter circuit. Output of the electrical converter directly connected to the relay component which may create a breakpoint over there to the BLDC motor.

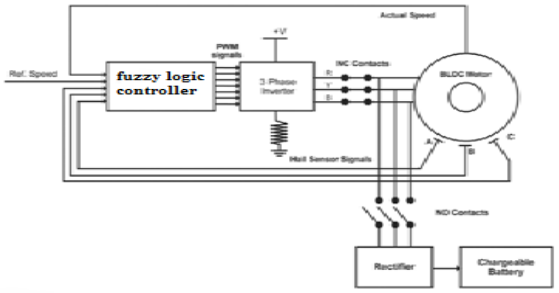

Figure.4.Proposed model of four quadrant BLDC motor

BLDC motor operates in four totally different modes that square measure forward driving, Forward braking, Reverse driving, Reverse braking. Every mode operates per the signal provided by the input and its parameters. Throughout forward driving mode the input is fed from the input supply. However just in case of reverse driving the input not given to the motor till it achieves to zero level. Back voltage is created throughout reverse driving.

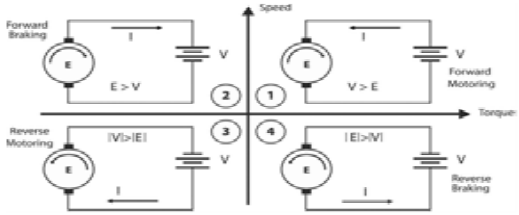

Figure.5.modes of operation in BLDC motor

FUZZY LOGIC CONTROLLER

Figure 6 shows that the fuzzy controlled BLDC motor for many fuzzy interference systems, the mathematical logic Controller block mechanically generates a hierarchal diagram illustration of the FIS. This automatic model generation ability is named the Fuzzy Wizard. The diagram illustration solely uses integral Simulink blocks and so permits for economical code generation. Fuzzy code designed to manage one thing, typically mechanical and it will be in hardware or software package and may be utilized in something from little circuits to giant circuits.

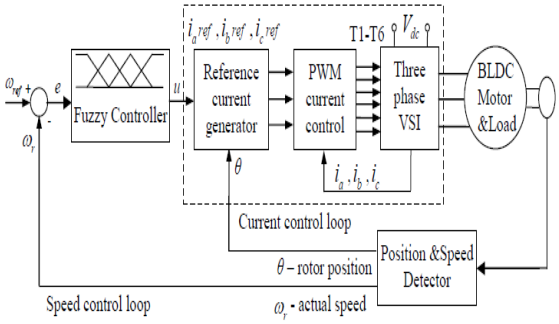

Figure.6 Fuzzy logic controller

4. SIMULATION RESULTS AND ANALYSIS

Existing PI controller technique has additional fluctuations in average sinking time of a BLDC motor. Thus it is often qualified by victimization projected fuzzy logic controller technique. If the sinking time is reduced then the motor starts to run at constant speed with sleek operation. Projected fuzzy logic controller based mostly output has reduced sinking time is shown in figure 7.

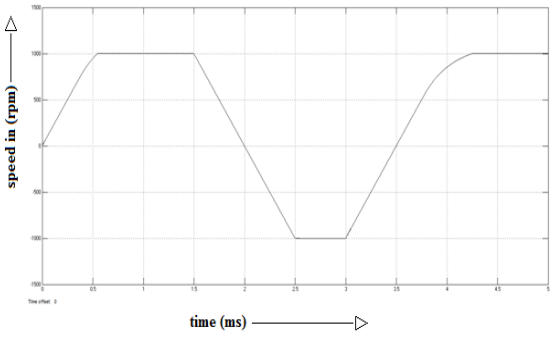

Figure.7. PI controller output waveform

So the motor are often operate at any mode with enough speed. Four quadrant operative modes moderately give the relay activating state and battery charging per the set time. The average sinking in time has additional fluctuations and it tends to relinquish average worth of 0.6ms. That the application of BLDC motor by PI controller is not compact for excellent industrial operations. The projected fuzzy logic controller based mostly output has shown in figure 8. Four quadrant operations were dead and also the average sinking time is obtained as 0.53ms. This is often virtually not up to the prevailing system.

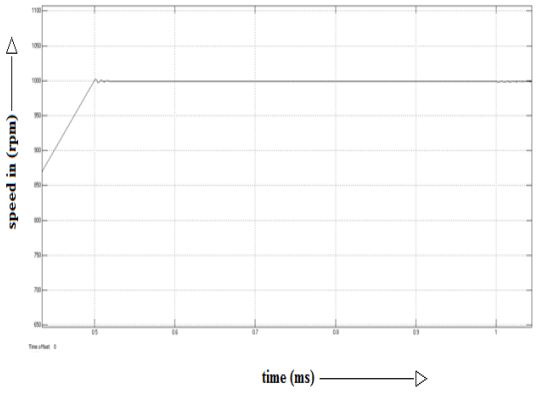

Figure.8 Fuzzy controller output

5. CONCLUSION

BLDC motor could be a synchronous motor hopped-up by an instantaneous Current. BLDC motor has become a good application in industries. Brushes were not used here, it result in avoid the mechanical friction with rotor. The beginning force is relatively high. The management of the motor is presumably done through a device within the input. PWM signals needed to

feed the input. During this project fuzzy logic controller is employed for economical outcome. Four quadrant operation of a 3 phase BLDC motor has been done through the mathematical logic controller. Forward driving, Forward Braking, Reverse Braking, Reverse driving and also the motor is controlled victimization the fuzzy logic controller. The back emf is generated throughout the reverse braking and forward braking. The energy is wasted as heat throughout breaking. This has been used by victimization the projected theme. Back voltage is regenerate and it keep in an exceedingly battery. Sinking time of the BLDC motor is drastically reduced by the new projected controller as 0.53ms to run the motor at a continuing speed.

Advantages

- High starting torque
- Reduced settling time
- Back emf is utilized

Applications

- Electric vehicle
- Refrigerator
- High speed applications

FUTURE WORK

The projected theme deals with the sinking time improvement in four quadrant operation of the 3 phase BLDC motor victimization mathematical logic controller. In future the project are often extended to hardware implementation victimization FPGA.

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