Fuzzy Logic Control Strategy for Four Quadrant Operation of Three Phase Sensorless Bldc Motor

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***Abstract*-Brushless DC (BLDC) motor drives are becoming more popular in industrial and traction applications. The control of BLDC motor in four quadrants is very vital.This paper deals with the fuzzy logic control of three phase BLDC motor.Without any loss of power the motor can be controlled in all the four quadrants.During regenerative braking period energy is conserved.The calculation capability of digital signal processor and controlling capability of fuzzy logic controller is used to achieve a precise control.**

***Index terms*-BLDC motor.dsPIC, fuzzy logic control, four quadrants, regenerative braking.**

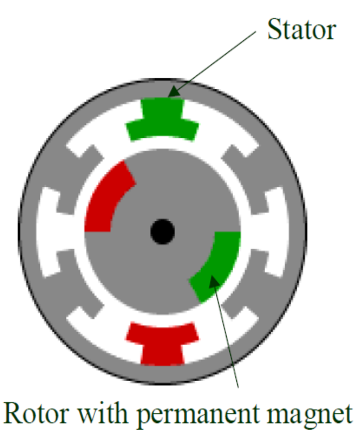

fig.1.Cross sectional view of BLDC motor

I.INTRODUCTION

A typical brushless motor has permanent magnets which rotate and a fixed armature, eliminating problems associated with connecting current to the moving armature. An electronic controller replaces the brush/commutation assembly of the brushed DC motor, which continually switches the phase to the windings to keep the motor turning. The controller performs similar timed power distribution by using a solid-state circuit rather than the brush/commutation system. The motor has less inertia, therefore easier to start and stop. Bldc motor are potentially cleaner and 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 and rotor flux is kept close to 90 to get the maximum developed torque.BLDC motors are used inAutomotive,Aerospace,Consumer,Medical,Industrial automation equipments and instrumentation. This paper is organized as follows: section II describes the four quadrant operation of three phase BLDC motor, its features; the controller is explained in Section

III. The simulink model is reviewed in section IV. In Section V, the simulation of four quadrant operation of the BLDC motor with the results are presented.

II.FOUR QUADRANT OPERATION OF BLDC MOTOR

A.SENSORLESS BLDC motor

These brushless dc motors are generally controlled using a three-phase inverter,
requiring a rotor position sensor for starting and for providing the proper commutation
sequence to control the inverter. These position sensors can be Hall sensors, resolvers, or absolute position sensors. Those sensors will increase the cost and the size of the motor, and a special mechanical arrangement needs to be made for mounting the sensors. These sensors, particularly Hall sensors, are temperature sensitive, limiting the operation of the motor to below about 75 oC . On the other hand, they could reduce the system reliability because of the components and wiring. In some applications, it even may not be possible to mount any position sensor on the motor. Therefore, sensor less control of BLDC motor has been receiving great interest in recent years. In brushless dc motor, only two out of three phases are excited at one time, leaving the third winding floating point. The true back EMF can be detected directly from terminal voltage by properly choosing the PWM and sensing strategy. The PWM signals are only applied to high side switches and the back EMF is detected during PWM off time. The resulting feedback signal is not attenuated or filtered, providing a timely signal with a very good signal/noise ratio. As a result this sensor less BLDC driver can provide a much wider speed range, from start-up to full speed.

B.FOUR QUADRANT OPERATION

There are four possible modes of operation which is depicted in fig.2

When the BLDC motor is operated in the first and third quadrant which is forward motoring and reverse motoring modes, the supplied voltage is greater than the back emf. When the motor operated in second and fourth quadrant which are forward braking and reverse braking modes, the value of back emf generated by the motor should be greater than the supplied voltage. The direction of current flow is reversed.

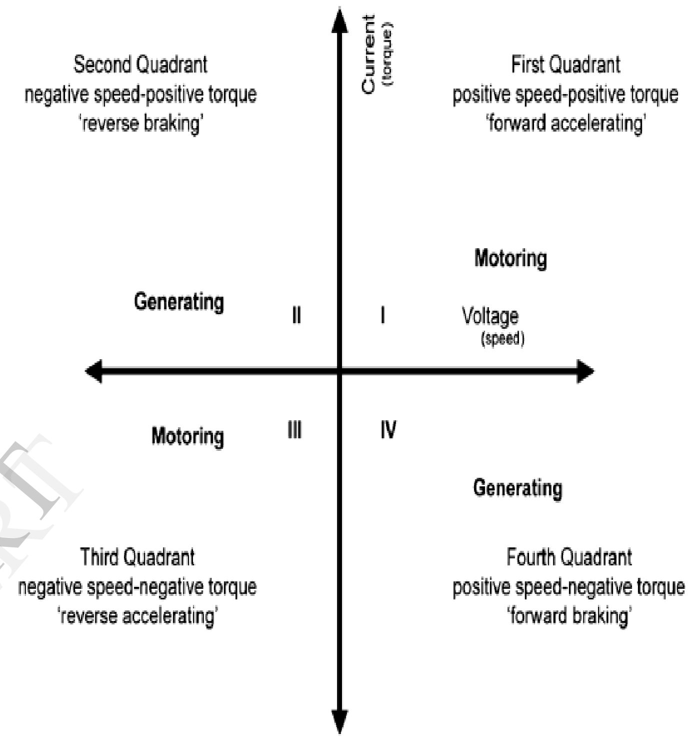

Fig.2. Four quadrant operation

III. PROPOSED CONTROLLER

A.DSP CONTROLLER

The controller has a modified Harvard architecture, with a 16×16 bit register working array. It has two 40 bit wide accumulators. All the DSP instructions are performed in a single cycle. The three external interrupt sources, with eight user selectable priority levels for each interrupt sources. The reference speed and the required duty cycle can be fed to the controller. The closed loop control is achieved using fuzzy logic controller.

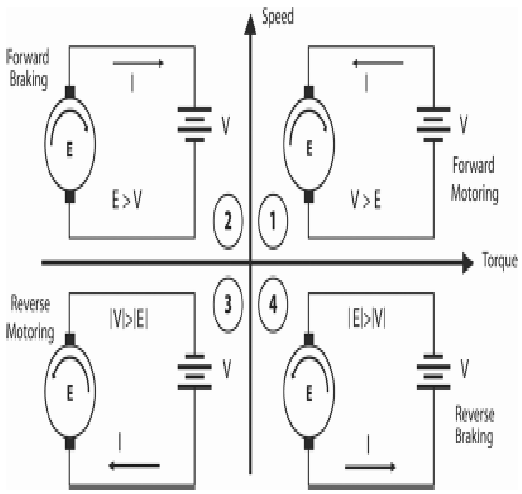

Fig.3.Operating modes

B.FUZZY LOGIC CONTROLLER

The disadvantage of PI controller is its inability to react to abrupt changes in the error signal, ε, because it is only capable of determining the instantaneous value of the error signal without considering the change of the rise and fall of the error, which in mathematical terms is the derivative of the error denoted as Δε. To solve this problem, Fuzzy logic control is used.

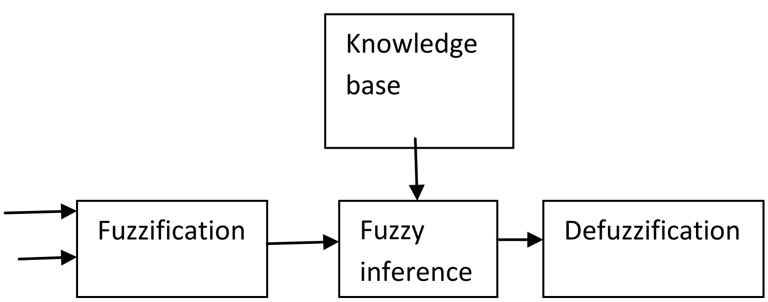

Fig.4.Fuzzy model

The determination of the output control signal, is done in an inference engine with a rule base having if-then rules in the form of
"IF ε is…..AND Δε is…..THEN output is……"
With the rule base the value of output is changed according to the value of error signal, the rate of change of error. The structure and determination of rule base is done using trial and error method.

C. PWM MODULE

The PWM module simplifies the task of generating multiple synchronized Pulse width modulation(PWM)outputs. It has six PWM I/O pins with three duty cycle generators. The three PWM duty cycle registers are double buffered to allow glitch less updates of PWM outputs. For each duty cycle, there is a duty cycle register that will be accessible by the user while the second duty cycle registers holds the actual compared value used in the present PWM period. The output compare module generates an interrupt to trigger the relay circuit during regenerative mode.

IV.SIMULINK MODEL

The simulink model of the BLDC motor. The closed loop controller for a three phase sensor less BLDC motor is modified using MATLAB/Simulink is shown in fig.7
The fuzzy controller receives the signal as its input, converts it to appropriate voltage signls.The gate signals are generated by comparing actual speed with reference speed. Thus a closed loop speed control is achieved with the help of fuzzy controller. The simulation results are shown in fig. indicates that, when a negative torque is applied at a time 0.6s,there is a peak overshoot in the actual speed, which means it aids the motor to run. At other times the speed is stabilized with reference speed. The reference speed is 400rpm.

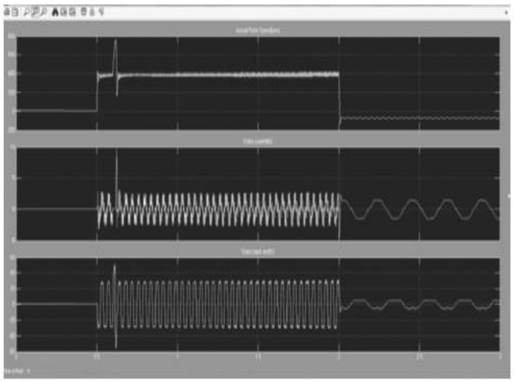

Fig.5.Output of simulink model-rotor speed(rpm), stator current(A),stator back emf(V)

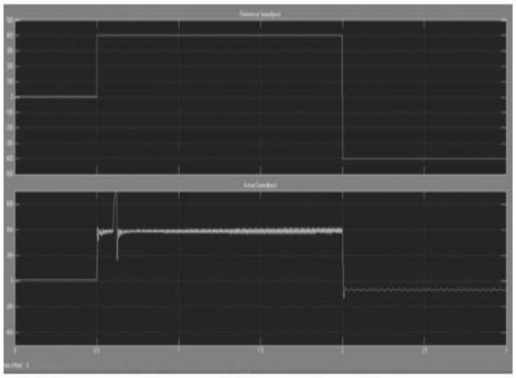

fig.6. Reference speed and actual speed in rpm

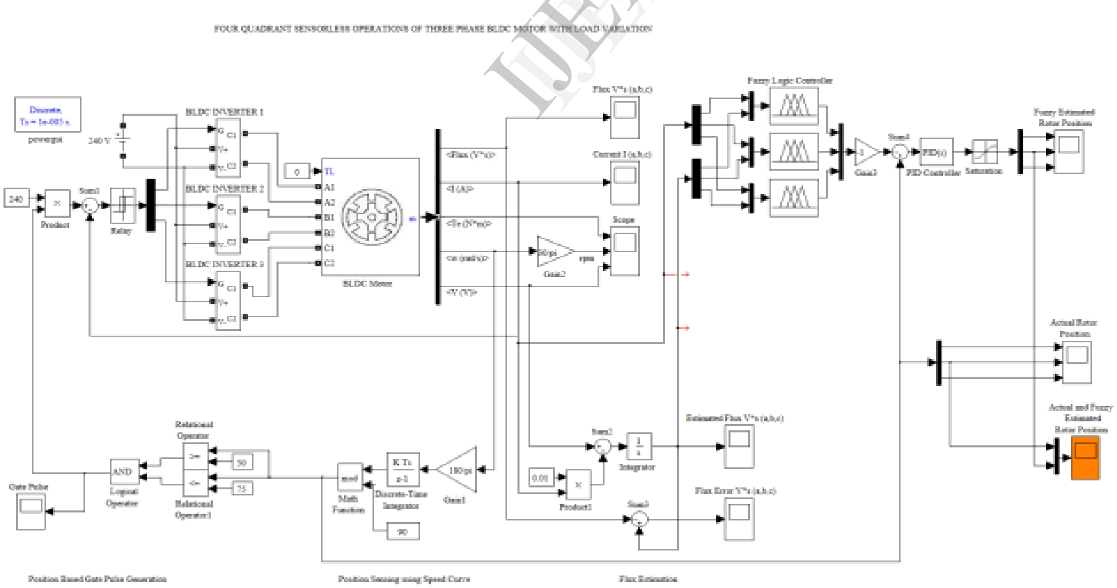

Fig.7.simulink model

V.CONCLUSION

In this paper a control scheme is proposed for sensor less BLDC motor to change the direction from CW to CCW and the speed control is achieved. In this paper fuzzy logic control is proposed to control the speed. we are discussing to maintain the speed and current constant. It is possible to control the speed and maintain the current constant. We are discussing over the four quadrant operation using simulink.

The advantages of this proposed method are: simple hardware circuit, excellent speed control, smooth transition between the quadrants and efficient conservation of energy.

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