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Performance Improvement in BLDC Motor Using Self Tuning PID Controller

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ABSTRACT: BLDC motors are dominating modern trend in industry to shift to use of highly efficient and compact permanent magnet motors for various applications. Moreover, electric vehicle industry has seen BLDC motors as most reliable and versatile motors for constantly changing industrial needs. However, dynamics of a BLDC motor are largely governed by its drive performance. Conventionally, PI and PID controllers have been used for decades for speed control of a BLDC motor which have a disadvantage that they need to be tuned or retuned for any change in operating point to derive optimal performance. Recent developments in control systems have made it possible to auto-tune PID controller to get optimal performance for various operating speeds. This project proposes a self- tuning PID controller for control of BLDC motor for wide speed range.

KEYWORDS : VSI, Six pulse Inverter, SVM

I. INTRODUCTION

The use of single-phase permanent magnet (PM) brushless DC (BLDC) motors has been rapidly increased due to their high torque and power density, low manufacturing cost, high efficiency, and high-speed operation capability. It is widely accepted for automotive, medical and consumer electronics applications including fans, compressors, and blowers. A low power (< 2 kW) single-phase BLDC (SPBLDC) motor is applicable for electric forced induction system (EFIS) such as electric turbocharger for small passenger vehicles. An additional electric motor in conjunction with the conventional FIS helps to improve transient response, engine output power, and fuel efficiency. The typical operating condition of the electric turbocharger for a small passenger vehicle is summarized in where output power is 1.5 kW, and the speed of the motor ranges from 60,000 to 100,000 rpm. The SPBLDC is more cost-effective than the three phase motor due to the reduced number of switching devices and sensors. However, it suffers from the high vibration and noise due to the lack of alternative phases, which tend to increase a pulsating torque. In SPBLDC motors, it is inevitable to have a relatively high reluctance torque due to the presence of an asymmetric air gap for a unidirectional rotation. Besides, a square-voltage excitation does not generate a rectangular current waveform, especially in high-speed SPBLDC motor due to the significant phase current distortion from the stator winding inductance and the back emf. A current shaping technique is required to increase the operating speed of the SPBLDC motor without reaching the current limit of the drive. One of the most commonly used phase current shaping techniques is phase advance control. Depending on the speed of the motor and input voltage, phase advance angle is determined using either a phase advance circuit or a delay function to compensate the phase current distortion. Commutation pulse control is the other technique to compensate the distorted current as well as to improve the overall efficiency by eliminating inefficient tail current. Both phase advance and commutation pulse controls require a sequencing algorithm based on a Hall effect sensor signal which has low accuracy due to low resolution, misalignment, electrical noise and physical vibration. The erroneous position feedback signal can aggravate the output torque ripple due to the unbalanced operation. These control techniques also have an undesirable impact on the excitation torque. Phase advance control produces negative torque and commutation pulse control has a zero-torque period, which increases the excitation torque ripple. In order to solve these issues, this paper proposes a new current shaping method, reference voltage controlled (RVC) PWM, which can significantly reduce the excitation torque ripple while increasing the speed of the motor. This control technique is based on varying slope of a linearly decreasing reference voltage, which does not require any sequencing algorithm.

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II. SYSTEM ANALYSIS EXISTING SYSTEM

In SPBLDC motors, it is inevitable to have a relatively high reluctance torque due to the presence of an asymmetric air gap for a unidirectional rotation. A current shaping technique is required to increase the operating speed of the SPBLDC motor without reaching the current limit of the drive. Phase current shaping techniques ,depending on the speed of the motor and input voltage, phase advance angle is determined using either a phase advance circuit or a delay function to compensate the phase current distortion. Commutation pulse control is the other technique to compensate the distorted current as well as to improve the overall efficiency by eliminating inefficient tail current. Both phase advance and commutation pulse controls require a sequencing algorithm based on a Hall effect sensor signal, which has low accuracy due to low resolution, misalignment, electrical noise and physical vibration.

III. PROPOSED SYSTEM

To propose a new method, auto-tune PID controller PWM, which can significantly reduce the excitation torque ripple while increasing the speed of the motor. This control technique is based on varying slope of a linearly decreasing reference voltage, which does not require any sequencing algorithm. It reduces the motor vibration while improving the maximum speed and the efficiency of the motor drive.

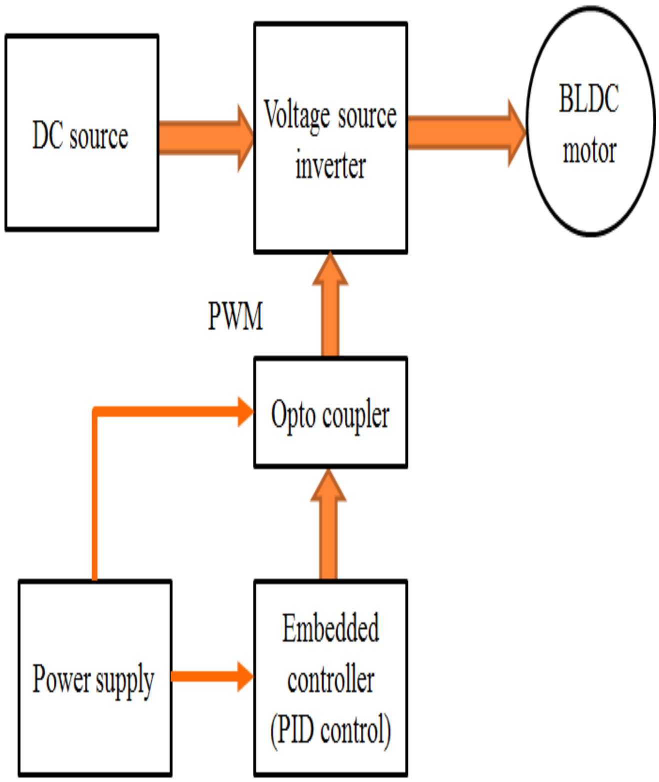

Fig. 1 Block Diagram

IV. BLOCK DESCRIPTION

In this project, a torque ripple reduction of BLDC motors are based on embedded system. The BLDC acts as a generator, and it transfers the kinetic to electrical energy. Its produce a reverse voltage. DC source is also given to supply the motor trough motor driver as three phase voltage source inverter. Inverter is used to invert DC to AC voltage. To give the gate pulse signal in inverter by using gate driver. Gate driver we use opto coupler 4N35. To control the opto coupler by using micro controller. In this project we used Atmega328 controller. This controller used PID control technique for gives PWM signal to inverter through opto coupler. Power supply is used to give supply to controller and opto coupler unit.

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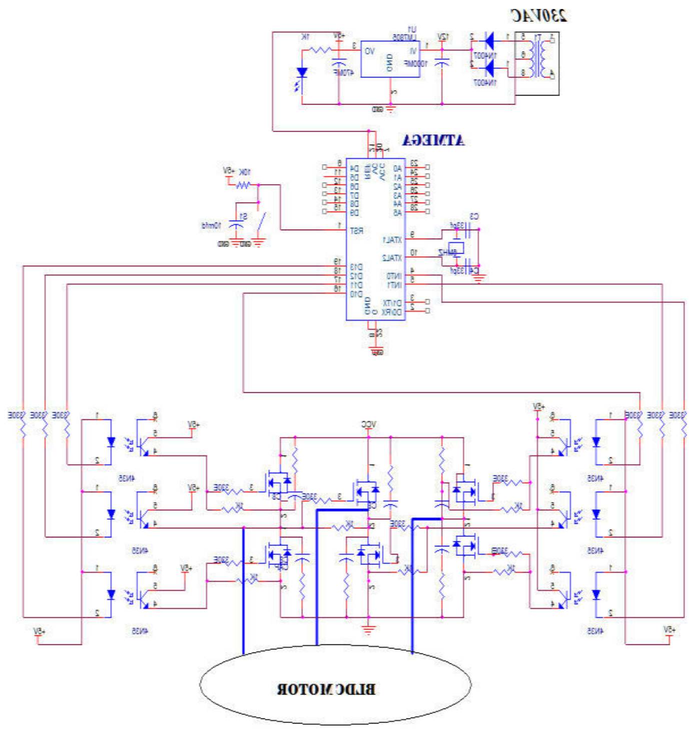

V. CIRCUIT DESCRIPTION

Power supply gives supply to all components. It is used to convert AC voltage into DC voltage. Transformer used to convert 230V into 12V AC.12V AC is given to diode. Diode range is 1N4007, which is used to convert AC voltage into DC voltage. AC capacitor used to charge AC components and discharge on ground. LM 7805 regulator is used to maintain voltage as constant. Then signal will be given to next capacitor, which is used to filter unwanted AC component. Load will be LED and resister. LED voltage is 1.75V.If voltage is above level beyond the limit, and then it will be dropped on resister. In this project we use Atmega328 controller. Then the microcontroller watches inputs and display the information. We want clock pulse to run our program. So we can give clock input using the crystal oscillator. It is connected to controller port 9 & 10. Then one reference resistor also connected for reset purpose. Control switches are connected to controller port A0 to A2. Controller to control the motor with the help of driver circuit. Controller port D10 to D13 is connected to IC7404. It is inverter, its output is connected to opto coupler. Opto coupler we used 4N35. It is used to give the trigger gate pulses to inverter. Inverter we use three phase inverter. It consists of six switches. Each switches get trigger pulses from opto coupler separately. Opto coupler output is connected to gate terminal of mosfet. This inverter is used to invert the voltage DC to AC. It is given to BLDC motor.

BLDC Motor Control

BLDC motor requires relatively complex electronics for control. As illustrated in Fig.2, in a BLDC motor, permanent magnets are mounted on the rotor, with the armature windings being fixed on the stator with a laminated steel core. Rotation is initiated and maintained by sequentially energy opposite pairs of pole windings that are said as form phases.

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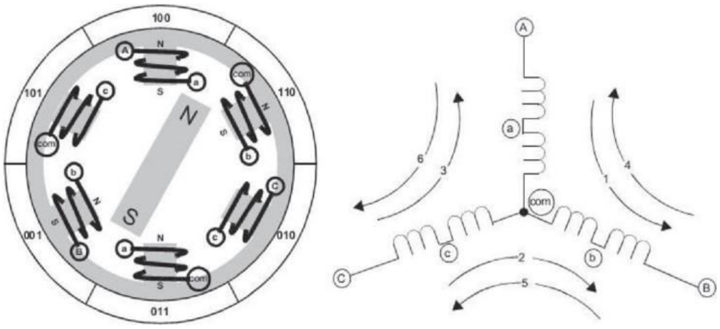

Fig. 2 Y-connected BLDC motor construction

BLDC motor control is the main control of the electronic commutator (inverter), and the commutation is achieved by controlling the order of conduction on the inverter bridge arm. A typical H-bridge is shown in Fig. 3. A BLDC motor uses a dc power supply which is required to provide energy. If we want to control a BLDC motor, we must know the position of the rotor which determines the commutation. Hall Effect sensors are the most common sensor for predicting the rotor position. The BLDC voltage vector is divided into six sectors, which is just a one-to-one correspondence with the Hall signal six states, as illustrated in Fig. 3.

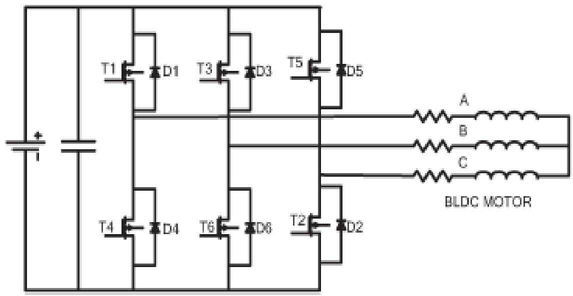

Fig. 2. H-bridge inverter circuit

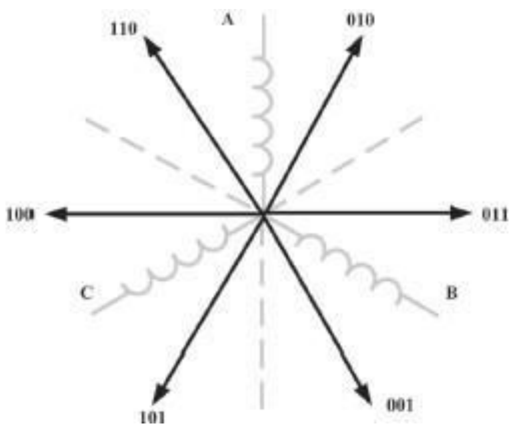

Fig. 3. Six sectors of the BLDC motor voltage vector

The basic drive circuit for a BLDC motor is shown in Fig. 2. Each motor lead is connected to high-side and low-side switches

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VII. CONCLUSION

A new torque ripple minimization control technique for a high-speed single- phase BLDC motor has been proposed and experimentally verified. The analytical estimation of phase current has shown that PID PWM control technique can effectively reduce the high peak current with the linearly decreasing reference voltage. The phase current has been measured at several different operating points to verify the effectiveness of PID PWM in peak current reduction. The voltage of the motor has been measured with a voltage measuring unit, and it has clearly shown the benefit of the torque ripple reduction in the proposed control technique. To reduces the motor vibration while improving the maximum speed and the efficiency of the motor drive.

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