Close Loop Low Cost BLDC Control Using PWM

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ABSTRACT:

A DC Brushless Motor uses a permanent magnet external rotor, three phases of driving coils, one or more Hall Effect devices to sense the position of the rotor, and the associated drive electronics. The coils are activated, one phase after the other, by the drive electronics as cued by the signals from the Hall effect sensors, they act as three-phase synchronous motors containing their own variable frequency drive electronics. A simplified current controlled modulation technique for BLDC motors is presented. It is based on generation of Quasi-square wave current, using only one current controller for three phases. The advantages of this strategy are: 1. Very simple control scheme. 2. Phase currents are kept balanced. 3. The current is controlled through only one DC component.This paper describes a simpler way to control the speed of PMBLDC motor using pwm control method. The performance of the PMBLDC system is simulated. The speed is regulated by PI controller. Simulink is utilized with MATLAB to get a reliable and flexible simulation. In order to highlight the effectiveness of the speed control method used. The method proposed suppresses torque oscillations. This drive has high accuracy, robust operation from near zero to high speed.

Keywords: MATLAB, PMBLDC, PWM, BLDC Motor,

INTRODUCTION

The closed loop analysis of BLDC motor. BLDC motors are very popular in a wide variety of applications compared with a DC motor; the BLDC motor uses an electric commutator rather than a mechanical commutator so it is more reliable than the rotor’s magnetiü fluz, so BLDŶ motors aühieve higher effiüienüy. It has beüome possible because of their superior performance in terms of high efficiency, fast response, weight, precise and accurate control, high reliability, maintenance free operation, brushes construction and reduced size, torque delivered to motor size is higher making it useful in applications where space and weight are critical, thermal overload and under load protection is provided. The inverter used is a three-phase bridge inverter making use of IGBT switches and suitable gate pulses are provided. Brush less DC motor requires external commutation circuit to rotate the rotor. Rotor position is very important. HALL SENSOR senses the position of the coil accurately. The commutation logic used here is to both turn ON and OFF the IGBT switches using gate pulses regulated in a suitable manner so that only two switches are turned ON at a time, others being. The current reference is determined by a PI regulator, which maintains the rotor average speed constant. The PI controller is used here suitably as the error dealt is steady state error. PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on speed of the response and overall stability of the system.

Thus, PI controller will not increase the speed of response. It can be expected since PI controller does nothave means to predict what will happen with the error in near future. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decreasea reaction time of the controller. PI controllers are very often used in industries, especially when speed of the response is not an issue

Objective:

This paper proposes a digital control for BLDC motor drives, which is low cost and simple to implement. This digital PWM controller treats the BLDC motor as a digital system. The BLDC system is only allowed to operate at a low duty(DL) or a high duty (DH). Speed regulation is achieved by alternating between low duty and high duty ratios. This new concept helps to reduce the cost and complexity of motor control hardware and in turn can boost the acceptance level of BLDC motors for commercial mass production applications and successfully fulfill the promises of energy savings associated with adjustable speed drives

Controlling a BLDC Motor

Control unit is implemented by microelectronic has several high-tech choices. This may be implemented using a micro-controller, a dedicated micro- controller, a hard-wired microelectronic unit, a PLC or similar other unit.Analog controller are still using, but they cannot process feedback messages and control accordingly. With this type of control circuits it is possible to implements high performance control algorithms, such as vector control, field oriented control, high speed control all of which are related to electromagnetic state of the motor. Furthermore outer loop control for variousdynamics requirements such as sliding motor üontrols, adaptive üontrol, prediütive üontrol…etü are also implemented conventionally. Speed control of BLDC motor is essential for making the motor work at desired rate. Speed of a brushless dc motor can be controlled by controlling the inputdc voltage. The higher the voltage, more is the speed. When motor works in normal mode or runs below rated speed, input voltage of armature is changed through PWM model. When motor is operated above rated speed, the flux is weakened by means of advancing the exiting current. The speed control can be closed loop or open loop speed control.

- **Open Loop Speed Control** – It involves simply controlling the dc voltage applied to motor terminals by chopping the dc voltage. However this results in some formof current limiting.

- **Closed Loop Speed control** – It involves controlling the input supply voltage through the speed feedback from the motor. Thus the supply voltage is controlled depending on the error signal. The closed loop speed control consists of three basiccomponents.

  - A PWM circuit to generate the required pwm pulses. It can be either amicrocontroller or a timer IC.
  - A sensing device to sense the actual motor speed. It can be a Hall Effect sensor,an infrared sensor or an optical encoder.
  - A motor drive to control the motor operation.

This technique of changing the supply voltage based on the error signal can be eitherthrough pid controlling technique or using fuzzy logic.

Closed loop analysis of BLDC motor

BLDC motors are very popular in a wide variety of applications compared with a DC motor; the BLDC motor uses an electric commutator rather than a mechanical üommutator so it is more reliable than the rotor's magnetiü fluz, so BLDŸ motors achieve higher efficiency. It has become possible because of their superior performance in terms of high efficiency, fast response, weight, precise and accurate control, high reliability maintenance free operation, brushes construction and reduced size, torque delivered to motor size is higher making it useful in applications where space and weight are critical, thermal overload and under load protection is provided. The inverterused is a three-phase bridge inverter making use of IGBT switches and suitable gate pulses are provided. Brush less DC motor requires external commutation circuit to rotate the rotor. Rotor position is very important. HALL SENSOR senses the position of the coil accurately. The commutation logic used here is to both turn ON and OFF theIGBT switches using gate pulses regulated in a suitable manner so that only two switches are turned ON at a time, others being. The current reference is determined by a PI regulator, which maintains the rotor average speed constant. The PI controller is used here suitably as the error dealt is steady state error. PI controller will eliminate forced oscillations and steady state error resulting in operation of on-off controller and P controller respectively. However, introducing integral mode has a negative effect on speed of the response and overall stability of the system. Thus, PI controller will not increase the speed of response. It can be expected since PI controller does nothave means to predict what will happen with the error in near future. This problem can be solved by introducing derivative mode which has ability to predict what will happen with the error in near future and thus to decrease a reaction time of the controller. PI controllers are very often used in industries, especially when speed of the response is not an issue.

Introduction:

SYSTEM DESCRIPTION

model description

A standard system concept is chosen for the motor control function Thesystem Incorporates the following hardware:

- BLDC motor 6t a 2212aduino
- display 16*2
- Arduino
- Power supply

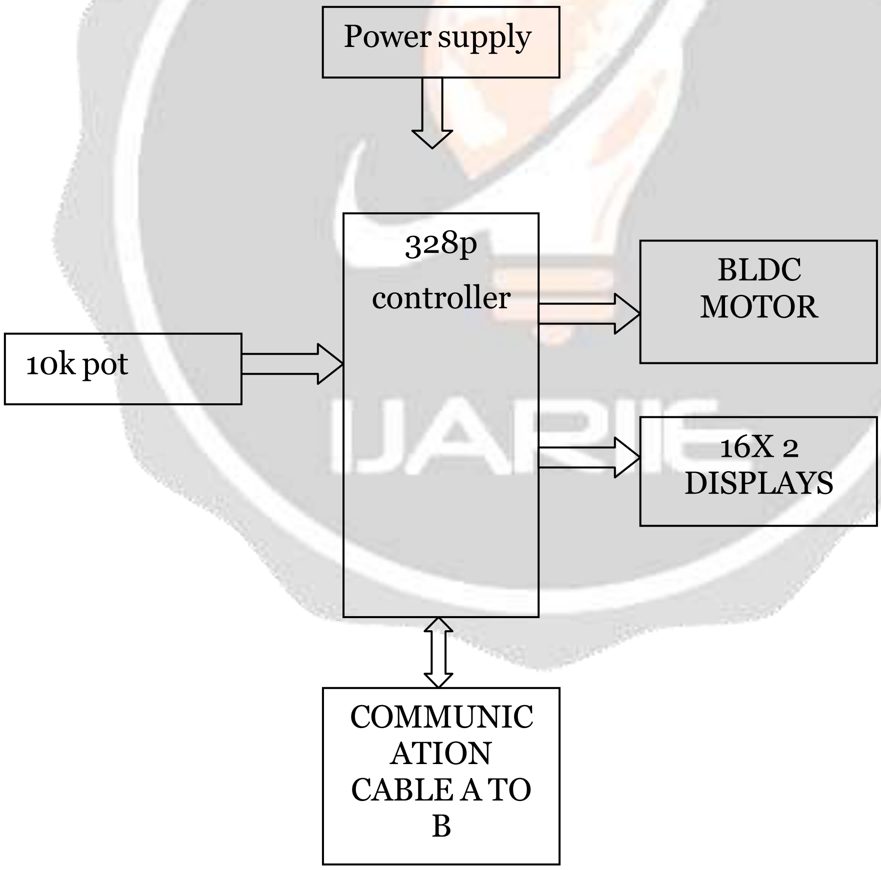

Fig. 1 Block Diagram

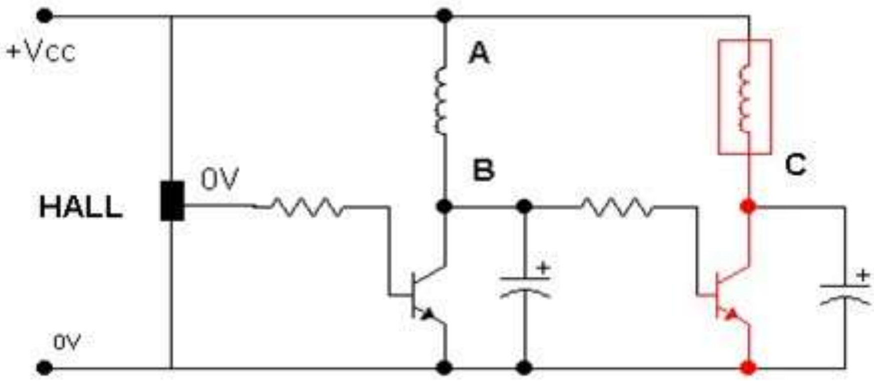

Fig. 2 : Circuit Diagram

Principle of Working

The principles for the working of a BLDC motors are the same as for a brushed DC motor, i.e., the internal shaft position feedback. In case of a brushed DC motor, feedback is implemented using a mechanical commutator and brushes. Within BLDC motor, it is achieved using multiple feedback sensors. In BLDC motors we mostly use Hall-effect sensor, whenever rotor magnetic poles pass near the hall sensor, they generate a HIGH or LOW level signal, which can be used to determine the position of the shaft. If the direction of the magnetic field is reversed, the voltagedeveloped will reverse too.

SOFTWARE USED:

- MATLAB.

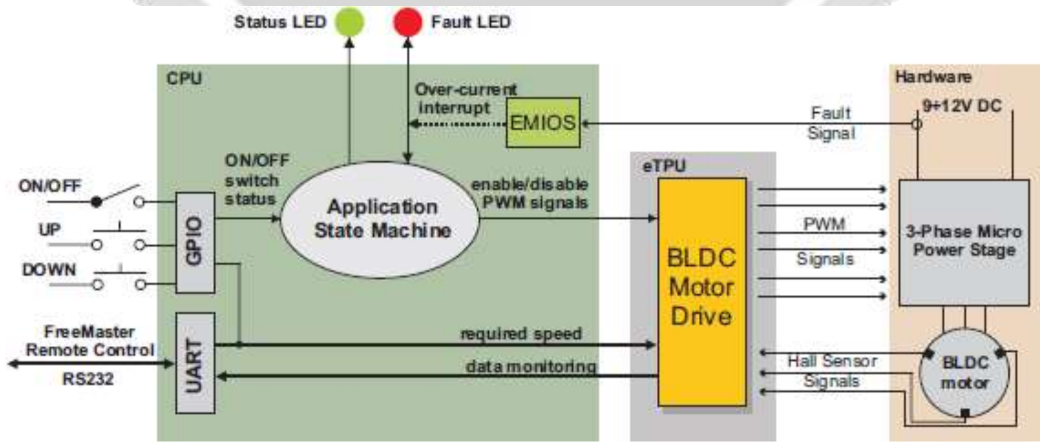

Fig. 3 : System Concept

Brushless DC Motor The brushed DC motor generates torque directly from DC powersupplied to the motor by using internal commutation, stationary magnets (permanentor electromagnets), and rotating electrical magnets. This conventional DC motor has much attractive properties, so it has been used both in industry and daily life for many years. The advantages include its low cost, high reliability, high efficiency, linear propertied and simple control of motor speed. However, the disadvantages 18 are alsoobvious. Its mechanical commutator decides its low life-span for high intensity uses and high maintenance. Now, due to the rapid development of electronic device, brushless DC motor are widely used to replace the conventional DC motor. Brushless DC motor (BLDC motor) is a type of synchronous motors that are powered by a DC electric source via an integrated inverter which produces an AC electric signal to drive the motor. In this context, AC, alternating current, does not imply a sinusoidal waveform, but rather a bi-directional current with no restriction on waveform. Additional sensors and electronics control the inverter output amplitude and waveform (and therefore percent of DC bus usage/efficiency) and frequency (i.e. rotor speed). The rotor part of a brushless motor is often a permanent magnet synchronous motor, but can also be a switched reluctance motor, or induction motor. There are many different configurations of BLDC motors and the most common type is the three

phase motor due to its efficiency and low torque ripple./12/ BLDC motors have somesignificant advantages over the conventional brushed dc motors:
Better speed vs torque characteristics :

- Long operating life
- High efficiency
- Noiseless operation
- Higher speed range
- Higher torque-weight ratio
- High dynamic response

System Design:

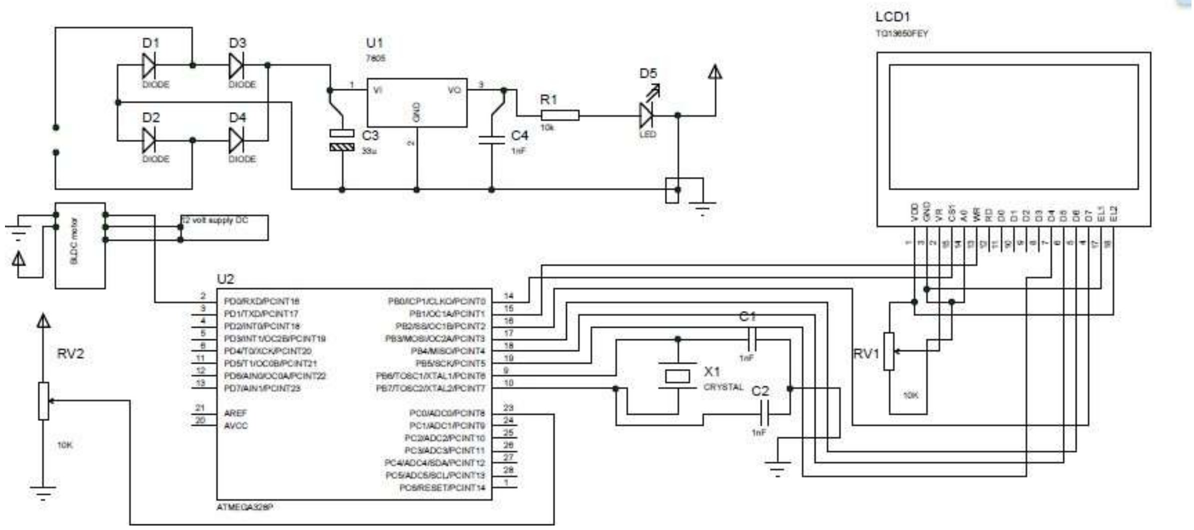

Fig.4: System Overview

Working:

As mentioned above, the brushless dc motor is a 3-phase motor. In the circuit diagram above the 3 phases are named: Phase A, Phase B and Phase C.The first three 33k (connected to motor phases) and the three 10kresistors are used as voltage dividers, the other three 33k resistors generate the virtual natural point.In this project we need 3 comparators to compare the BEMF of each phase with respect to the virtual natural point because we need to detect the zero crossing of each phase, here I used the LM339 quad comparator chip. The virtual point is connected to the inverting input (–

) of the three comparators as shown in the circuit diagram above. BEMF A is connected to the non-inverting pin (+) of comparator number 1, BEMF B is connected to the positive terminal of comparator2 and BEMF C is connected to the positive terminal of comparator 3. Comparator 4 is not used and its input terminals should be grounded. As known the comparator output is logic 1 if the non-inverting voltage is greater than the inverting voltage and vice versa. The LM339 outputs are open collector which means a pull up resistor isneeded for each output, for that I used three 10k ohm resistors. The outputs of the 3 comparators are connected to Arduino pins 2, 3 and4 respectively for BEMF A, BEMF B and BEMF Arduino UNO pins 2, 3 and 4 are ATmega328P microcontroller external interrupt pins PCINT18, PCINT19 and PCINT20 respectively.

RESULTS :

Fig.5 : Desired Speed : 1

Fig.6: Measured Speed

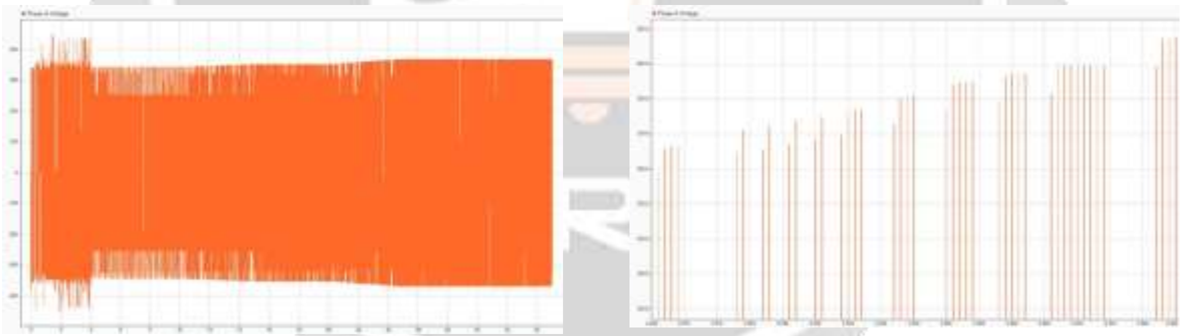

Fig7 : Phase A Voltage

Application:

- Electrical vehicle
- fans
- appliances power tools
- Treadmill exercise units.
- Hard drives
- Motors
- Drones

- Home appliances
- Industrial appliances controlling

Advantage:

1. **Compact size**
2. **High efficiency**
3. **High speed**
4. **No maintenance**
5. **Fast response**
6. **Lower radio frequency interference**
7. **Linear speed-torque characteristics**
8. **High starting torque**
9. **Adjustable speed**
10. **Better heat removal**
11. **Much better controllability versus induction motors**
12. **Noiseless operation**

Applications:

- Consumer electronics
- Transport
- Heating and ventilation
- Industrial engineering
- Model engineering

CONCLUSION:

- The simulation of the closed loop speed control of BLDC motor is done byusing MATLAB. The speed control is achieved through PI controller and has a simple operation, which is cost effective, as it requires only one current sensor for themeasurement of DC link current.
- Closed loop speed control of BLDC motor i.e. the speed remains constant at adesired speed in closed loop control method.

The nonlinear simulation model of the BLDC motors drive system with PI control based on MATLAB/Simulink platform is presented. The control structure has an inner current closed-loop and an outer-speed loop to govern the current. The speed controller regulates the rotor movement by varying the frequency of the pulse based on signal feedback from Hall sensors. The performance of the developed PI algorithm based speed controller of the drive has revealed that the algorithm devises the behavior of the BLDC motor drive system work satisfactorily. Current is regulated within band by the hysteresis current regulator. And also by varying the moment of inertia observe that increase in moment of inertia it increases simulation time to reach the steady state value. Consequently, the developed controller has robust speed characteristics against parameters and inertia variations. Therefore, it can be adaptedspeed control for high performance BLDC motor.

FUTURE SCOPE :

For the future development, Hardware development can be implemented. As well as different triggering techniques like SPWM and NSPWM can be implemented for the three phase bridge inverter. Sinusoidal Pulse width modulation (SPWM) generated by comparing amplitude of triangular wave (carrier) and sinusoidal reference wave (modulating) signal. By using SPWM technique it can control the inverter output voltage as well as reduce harmonics. NSPWM is the advanced techniqueafter spwm technique.

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