Review of Modelling and Simulation of Torque Hysteresis Controller of Brushless D.C Motor Drive

Aboli Vijay Mohitkar, Prof. Pratik Ghutle, Dr.Harikumar Naidu

Integrated Power System (IPS), T.G.P.C. E .T, Nagpur, India

Assist. Professor, Dept. of Electrical Engg, T.G.P.C. E .T, Nagpur, India

Head, Dept. of Electrical Engg, T.G.P.C. E .T, Nagpur, India

ABSTRACT: Modelling and simulation of a torque hysteresis controller for brushless DC motors. Brushless DC (BLDC) motors can offer great advantageous compared to other machines used in industrial applications due to its compactness, high torque density, simpler controller and lower maintenance. At first the mathematical modelling of BLDC motor that is suitable to analyse the dynamic performance will be given. A method of torque hysteresis controller will be adapted to drive the motor such that the current (or torque) ripple can be restricted within the predefined band-gap. Moreover, a new current blocking strategy is proposed to prevent the current drained from DC supply when the torque demand is set to zero, that can prolong the capacity voltage of batteries. Some simulation results were carried out using MATLAB/ Simulink to verify the proper modelling as well as functionality of the controller.

KEYWORDS: component; brushless DC motor; hall effect; simulation, torque hysteresis controller.

I. INTRODUCTION

Several years ago, brushes DC motors were regularly used in many applications since it has a simple construction, easy to control and can give superior dynamic performance. However, this type of the motor that equipped with commutator and brush requires frequently maintenance, cannot be performed at dirty or explosive environment and at very high speed operations. Due to these reasons, many types of motors were developed to minimize or solve the problems such as induction motor, switched reluctance motor and permanent magnet synchronous motor. Among these types of motors, the use of permanent magnet synchronous machine (PMSM) has recently received much attention, particularly for electric vehicle applications. This mainly due to the fact that the PMSM offers higher efficiency and torque density (i.e. Nm/kg). In general, the PMSM can be classified into two types depending on back-emf wave shape production, i.e. sinusoidal and trapezoidal wave shapes. The one that is operated in sinusoidal is normally referred to as permanent magnet AC motor or brushless AC motor. The latter one that produces trapezoidal back-emf wave shape is normally called as brushless DC motor (BLDC). It can be shown that the production of torque in BLDC is quite similar to that of brushes DC motor with simple control algorithm and comparable performance .In many electrical drive applications, it is desirable to achieve fast torque dynamic response as produced in brushes DC motor, whereby the torque can be directly controlled by regulating the armature current. Several papers were reported to achieve this requirement, for examples ; fully utilized the available DC link voltage through over modulation strategy and generated the maximum possible voltage vector that is tangential to the flux component to have a quick change of torque dynamic. Ultimately, all these methods used a vector control which is complicated to be implemented. This paper will discuss the principle of torque hysteresis controller for BLDC motor to provide naturally current protection, reliable and fast torque dynamic control. In fact the hysteresis controller is known to

provide high control bandwidth and robust control. It will also present a new current blocking strategy once a torque pedal of electric vehicle is released (i.e. $T_{ref} = 0$) so that , it can preserve the capacity of voltage of batteries.

II. REVIEW OF LITERATURE

1. Dong-MyungLee: This paper proposes a new position sensorless drive for brushless DC (BLDC) motors. Typical sensorless control methods such as the scheme with the back-EMF detection method high performance only at a high speed range because the magnitude of the back-EMF is dependent upon the rotor speed. This paper presents a new solution that estimates the rotor position by using an unknown input observer over a full speed range. In the proposed method, trapezoidal back-EMF is modelled as an unknown input and the proposed unknown input observer estimating a line-to-line back-EMF in real time makes it possible to detect the rotor position. In particular, this observer has high performance at a low speed range in that the information of a rotor position is calculated independently of the rotor speed without an additional circuit or complicated operation process. Simulations and experiments have been carried out for the verification of the proposed control scheme.

2.Ching-Tsai, P. and C. Ting-Yu: This paper, an improved inverter hysteresis current controller is proposed. It coordinates the switching of the three phase switches in d-q phase plane. In addition to the current error, information of the current error derivative is further employed so that one can take more advantage of adding the zero voltage vector for reducing the switching frequency.

3. Sanita C S1, J T Kuncheria : 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- The motor is operated in four steady state operating modes of torque-speed plane. To control a BLDC machine it is generally required to measure the speed and position of rotor by using the sensor because the inverter phases, acting at any time, must be commutated depending on the rotor position. Simulation of the proposed model was done using MATLAB/ SIMULINK.

4. Mr.P.Nagasekhar Reddy : The Brushless DC motors (BLDC) find widespread applications in domestic and industries due to their low and high power density and ease of speed control. To accomplish desired level of performance the motor requires suitable speed controllers. In case of permanent magnet Brushless DC motors, usually control of speed is reached by using proportional integral (PI) controller. PI controllers are widely used in the industry due to their simple control structure and ease of implementation, these controllers pose difficulties where there are some control complexity such as nonlinearity, load disturbances and parametric variations. Moreover PI controllers require precise linear mathematical models. In this paper, the analysis and mathematical modelling of BLDC motor is implemented. Also, speed control of three phase BLDC motor drive using power electronic device is projected by using matlab/Simulink. The simulation result shows the improved performance of developed Brushless DC motor drive.

5. Ahmad Faiz Noor Azam: The presence of the commutator and brushes in a dc machine enforce severe limitations on its voltage and current ratings, means that the output power capability of a dc machine is restricted. The mechanical commutator in a dc machine limits its high speed capabilities. Both the brushes and commutator of a dc machine require regular maintenance. In addition, dc machines are prone to sparking and cannot be normally used in explosive atmosphere. The dust produced by brush wear, makes the dc machine undesirable for use in certain industries like the semiconductor or food industries. Thus, to overcome this problem BLDC machine is proposed due to its advantages over the conventional dc machine. The torque hysteresis controller is presented as the technique chosen to control the phase current and torque of the BLDC machine. This method used to replace the voltage control in BLDC machine. Voltage control is conventional methods used but have a very high current overshoot, by using torque hysteresis controller it will provide current protection which is the value of current and torque will stay within certain limits around with reference value.

6. Salih Baris Ozturk : In this paper, the position-sensorless direct torque and indirect flux control of brushless dc (BLDC) motor with non sinusoidal back electromotive force (EMF) has been extensively investigated. In the literature, several methods have been proposedfor BLDC motor drives to obtain optimum current and torque control with minimum torque pulsations. Most methods are complicated and do not consider the stator flux linkage control, therefore, possible high-speed operations are not feasible. In this study, a novel and simple approach to achieve a low-frequency torque ripple-free direct torque control (DTC) with maximum efficiency based on dq reference frame is presented. The proposed sensorless method closely resembles the conventional DTC scheme used for sinusoidal ac motors such that it controls the torque directly and stator flux amplitude indirectly using d-axis current. This method does not require pulsewidth modulation and proportional plus integral regulators and also permits there gulation of varying signals.Furthermore ,to   eliminate the low-frequency torque oscillations ,two actual and easily available line-to-line back EMFconstants (kba andkca) according to electrical rotor position are obtained offline and converted to the dq frame equivalents using the new line-to-line park transformation.Then, they are set up in the look-up table for torque estimation.The validity and practical applications of the proposed sensorless three-phase conduction DTC of BLDC motor drive.

7. Kamalapathi.K1, Vinod Kumar.P2, Balaji.C3: Now a days BLDC motor is getting more attraction due to its high efficiency, good performance and ease of control for many applications. This paper proposes a model for Brushless DC (BLDC) motor drive for constant torque applications. At first, a theoretical analysis of a BLDC motor drive is presented and the validity of the proposed analysis is verified via simulation. The torque is controlled via current via current directly. The motor model is then simulated using MATLAB/SIMULINK, with   trapezoidal waveforms of back-EMF.

8.Yong Liu: The application of direct torque control (DTC) to brushless ac drives has been investigated extensively. This paper describes its application to brushless dc drives, and highlights the essential differences in its implementation, as regards torque estimation and the representation of the inverter voltage space vectors. Simulated and experimental results are presented, and it is shown that, compared with conventional current control, DTC results in reduced torque ripple and a faster dynamic response.

III.METHEDOLOGY

There are different way to control speed of BLDC motor such as by with current controller and without   current controller
and torque controller ,but by using torque controller its is very easy to control speed of BLDC motor by PI controller, where by using hall effect sensors ,the sensor which can sense the phase shift of electromagnetic pole of BLDC motor.This method is very convenient and easy to work .
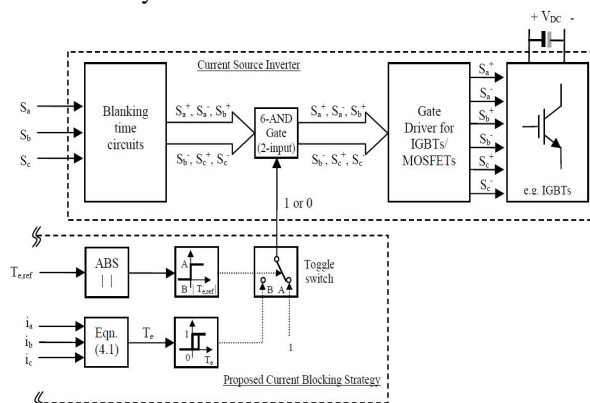

Figure 1. Block Diagram Of Proposed System

This section will present a new current blocking strategy to avoid waste of energy from the battery (due to the current drawn) when the torque pedal is released (i.e. $Te,ref = 0$) for electric vehicle applications. In the conventional THC method, the current is still drawn from the battery even the reference current is set to zero; as the phase current needs to be regulated within the hysteresis band at around zero Amperes(A). To block the current drawn from the battery, the proposed current blocking strategy will turn OFF all IGBTs/MOSFETs in the inverter, when the torque pedal is released ($Te,ref = 0$) and once the actual motor torque is completely reduced to zero. This can be simply established with minor modification on the original structure of THC using hysteresis comparator.

IV.CONCLUSION

This paper has presented the modelling and simulation of torque hysteresis controller for BLDC motor. Moreover, a new current blocking strategy to prevent the energy wastage from the batteries such that it can prolong the capacity of voltage battery is proposed. From the simulation results obtained, it showed that the hysteresis controller can offer inherent current protection/limitation and robustness in controlling the motor torque.

REFERENCES

[1]   Yong Liu, "Direct Torque Control of Brushless DC Drives With Reduced Torque Ripple" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 41, NO. 2, MARCH/APRIL 2005.

[2]   Kamalapathi.K1, Vinod Kumar.P2, Balaji.C3, " TORQUE CONTROL OF BLDC MOTOR DRIVE USING MATLAB/SIMULINK " International Journal of Emerging Trends in Engineering Research (IJETER), Vol. 3 No.6, Pages : 448 - 452 (2015)   Special Issue of NCTET 2K15 - Held on June 13, 2015 in SV CollegeofEngineering,Tirupati http://warse.org/IJETER/static/pdf/Issue/NCTET2015sp80.pdf

[3]   Ahmad Faiz Noor Azam , "TORQUE HYSTERESIS CONTROLLER FOR BRUSHLESS DC MOTOR DRIVES" Power and Energy Conversion Symposium (PECS 2012) Melaka, Malaysia 17 Dec 2012

[4]   Mr.P.Nagasekhar Reddy , " Modeling and Analysis of PI Controller Based Speed Control of Brushless DC Motor Drive" . INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY,Reddy, 2(9): September, 2013.

[5]   Salih Baris Ozturk, "Direct Torque and Indirect Flux Control of Brushless DC Motor", IEEE/ASME TRANSACTIONS ON MECHATRONICS, VOL.16,NO.2,APRIL2011.