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Sensorless Speed Control For Brushless DC Motors System Using Sliding Mode Controller And Observers

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ABSTRACT

An improved Sensor less operation scheme for the Brushless DC motors (BLDC) control system is proposed. A high-speed sliding-mode observer (SMO) for back electromotive force (back-EMF) estimation is employed to obtain the position and speed. A speed control algorithm for the BLDC control systems combining a sliding mode controller with disturbance observer (DOB) is developed to restrain the speed fluctuation caused by abrupt change of load torque. The DOB is used to estimate the load torque and generate a feed-back compensating signal for a controller. Detailed simulation results show that the proposed high-speed SMO could improve the estimation accuracy, and the designed compensating scheme could enhance the robustness against the abrupt load torque change effectively.

Direct Torque Control (DTC) is a method to control the torque in variable frequency drives. This paper describes Sensor less DTC of brushless dc (BLDC) motor drive operating in constant torque region under two phase conduction mode to get instantaneous torque control. Sliding Mode Observer (SMO) which is robust to parameter uncertainties is proposed to estimate the phase-to-phase trapezoidal back-EMF for the Sensor less operation. This estimated back-EMF is used to deduce the rotor position and the angular velocity of the rotor. And instantaneous electromagnetic torque can be calculated by the product of back-EMF and current. In this paper the effectiveness of sliding mode observer with signup and saturation functions for DTC scheme is invDirect Torque Control (DTC) is a method to control the torque in variable frequency drives.This paper describes Sensor less DTC of brushless dc (BLDC) motor drive operating inconstant torque region under two phase conduction mode to get instantaneous torque control.Sliding Mode Observer (SMO) which is robust to parameter uncertainties is proposed toestimate the phase-to-phase trapezoidal back-EMF for the Sensor less operation. Thisestimated back-EMF is used to deduce the rotor position and the angular velocity of the rotor.And instantaneous electromagnetic torque can be calculated by the product of back-EMF andcurrent. In this paper the effectiveness of sliding mode observer with signup and saturationfunctions for DTC scheme is inv.

INTRODUCTION

Brushless DC motor (BLDC) has been widely used in various fields. And, a great deal of attention has been given to the sensor less control of BLDC motor. On the one hand, a large number of methods have been proposed to obtain or estimate the rotor position and speed, including the extended kalman filter (EKF), artificial neural networks (ANN), model reference adaptive system (MRAS) and sliding mode observer (SMO). SMO is well known for its simple structure and good robustness. For chatting reduction of sliding mode at a high speed, low pass filter and reaching law method are used in the sliding mode observer. For large speed variations, a modified SMO incorporating the speed component in the estimation of back electromotive force (back-EMF) On the other hand, in a practical BLDC control system, there are a large number of the disturbances and uncertainties, e.g., parameter variation, friction force, and load disturbance. Large quantities of control techniques have been adopted to improve the performance in systems with varies of disturbances and uncertainties, such as sliding mode control (SMC) technique , robust control technique, adaptive control technique , intelligent.On the BLDC control system, there are a large number of the disturbances and uncertainties, e.g., parameter variation, friction force, and load disturbance. Large quantities of control techniques have been adopted to improve the performance in systems with varies of disturbances and uncertainties, such as sliding mode control (SMC) technique, robust control technique, adaptive control technique, intelligent control technique, and so on. SMC technique is popular for its good robustness, convenient realization, and the applicability to control with strong nonlinearity and load variation.

• In this proposed control scheme, SMC is robust to internal parameter variations and disturbance once system trajectory reaches and stays on the sliding surface. In addition, DOB is used, and the estimated system disturbance is considered as the feed forward compensation to compensate the controller.

• One SMC algorithm combined with the disturbances observer as a compensation part is proposed to suppress disturbances.

The proposed composite control method that the combines adaptive SMO and the SMC with disturbances observers developed to further improve

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the performance of speed control and the load disturbance rejection ability.

Literature Review

Design and implementation of the extended Kalman filter for the speed and rotor position estimation of brushless DC motor A method for speed and rotor position estimation of a brushless DC motor (BLDCM) is presented in this paper. An extended Kalman filter (EKF) is employed to estimate the motor state variables by only using measurements of the stator fine voltages and currents. When applying the EKF, it was necessary to solve some specific problems related to the voltage and current waveforms of the BLDCM.

During the estimation procedure, the voltage- and current-measuring signals are not filtered, which is otherwise usually done when applying similar methods. The voltage average value during the sampling interval is obtained by combining measurements and calculations, owing to the application of the predictive current controller which is based on the mathematical model of motor. Two variants of the estimation algorithm are considered: (1) speed and rotor position are estimated with constant motor parameters and (2) the stator resistance is estimated simultaneously with motor state variables. In order to verify the estimation results, the laboratory setup has been constructed using a motor with ratings of 1.5 kW, 2000 r/min, fed by an insulated gate bipolar transistor inverter.

An Adaptive Speed Sensor less Induction Motor Drive with Artificial Neural Network for Stability Enhancement

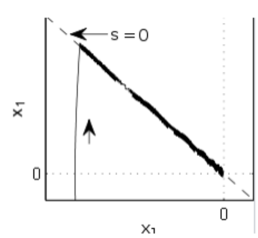
An artificial neural network (ANN) based adaptive estimator is presented in this paper for the estimation of rotor speed in a Sensor less vector-controlled induction motor (IM) drive. The model reference adaptive system (MRAS) is formed with instantaneous and steady state reactive power. Selection of reactive power as the functional candidate in MRAS automatically makes the system immune to the variation of stator resistance. Such adaptive system performs satisfactorily at very low speed. However, it is observed that an unstable region exists in the speed-torque domain during regeneration. In this work, ANN is applied to overcome such stability related problem. The proposed method is validated through computer simulation using MATLAB/SIMULINK. Sample results from a laboratory prototype (using dSPACE-1104) have confirmed the usefulness of the proposed estimator.

Sensor less control of linear permanent magnet synchronous motors using a combined sliding mode adaptive observer

A novel combined sliding mode adaptive observer for flux and speed estimation of direct thrust controlled surface mounted Linear Permanent Magnet Synchronous Motor (LPMSM) without using position sensors is proposed. The observer comprises a linear state observer combined with a novel nonlinear sliding mode component. The sliding mode component is improved by using two boundary layers which reduce the chattering without compromising the robustness. The novel observer is experimentally validated. The flux, speed and position estimation errors are small resulting in reliable observer performance.

METHODOLOGY

Sliding mode control (SMC) is a nonlinear control method that alters the dynamics of a nonlinear system by application of a discontinuous control signal (or more rigorously, a setvalued control signal) that forces the system to "slide" along a cross-section of the system's normal behavior. The state-feedback control law is not a continuous function of time. Instead, it can switch from one continuous structure to another based on the current position in the state space. Hence, sliding mode control is a variable structure control method. The multiple control structures are designed so that trajectories always move toward an adjacent region with a different control structure, and so the ultimate trajectory will not exist entirely within one control structure. Instead, it will slide along the boundaries of the control structures. The motion of the system as it slides along these boundaries is called a sliding mode[1] and the geometrical locus consisting of the boundaries is called the sliding (hyper)surface. In the context of modern control theory, any variable structure system, like a system under SMC, may be viewed as a special case of a hybrid dynamical system as the system both flows through a continuous state space but also moves through different discrete control modes.



SIMULATION RESULTS AND DISCUSSION

Below figure shows the proposed sensor less scheme combing SMC with two observers, SMO and DOB. In this scheme, the SMO estimates the back-EMF (, E Eabbc) and provides the estimate position θˆ and speed ωˆ .Essentially, the estimated load torque is considered as the feed forward part to compensate disturbances of aforementioned SMC method stated in

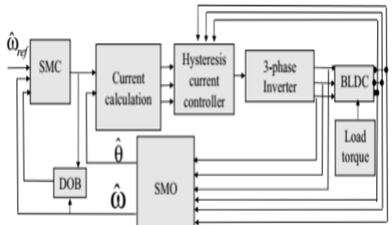


Fig.1: Proposed method

Simulation Results of Estimation

In order to demonstrate the effectiveness of the proposed approach c in BLDC motor Sensor less system, a simulation using MATLAB/Simulink environment is presented.

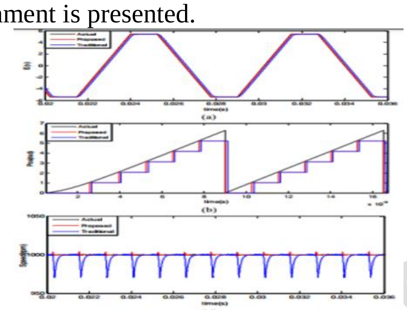


Fig.2: Comparisons of results derived from the proposed and traditional observer at a speedOf 1000 rpm :(a) actual and estimated back-EMF.(b) actual and estimated position.(c) actualAnd estimated speed

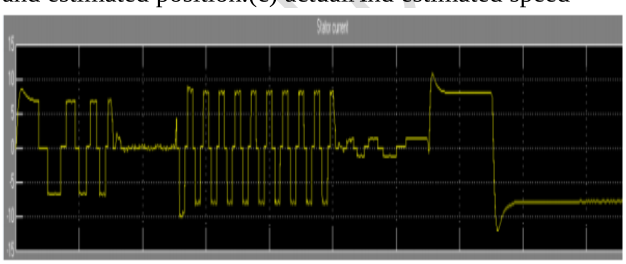


Fig.3: The Stator Current in motor.

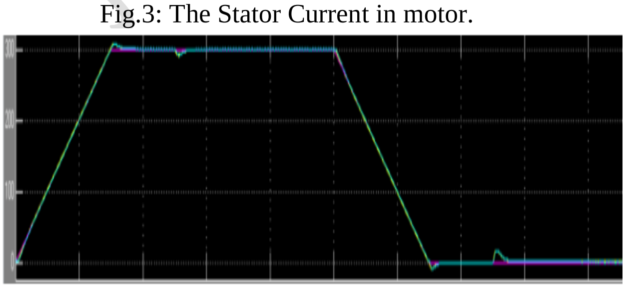


Fig.4: The speed of the BLDC motor

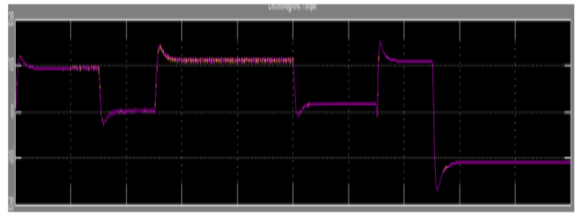


Fig.5: Electromagnetic Torque of BLDC motor

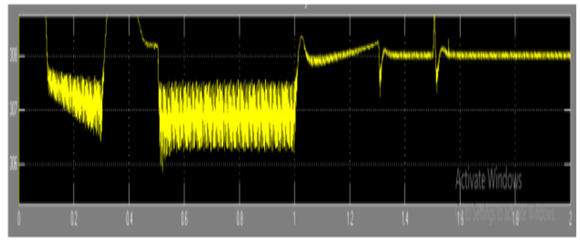


Fig.6: The DC bus voltage

CONCLUSION

This paper is focused on the problems existing in the back-EMF estimation of traditional SMO and the speed fluctuation caused by load torque. A sigmoid function with a flexible switching gain replaces the signum function, which improves the estimated accuracy. One SMC algorithm combined with the disturbances observer as a compensation part is proposed to suppress disturbances .The proposed composite control method that the combines adaptive SMO and the SMC with disturbances observers developed to further improve the performance of speed control and the load disturbance rejection ability. The simulation results have validated the proposed scheme.

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