HIGH PERFORMANCE PERMANENT MAGNET SYNCHRONOUS MOTOR CONTROL USING PIC MICROCONTROLLER

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Abstract— *This paper deals with the design and implementation of a PMSM drive control system, considering a PIC-based controller. The PMSM drive is simulated and tested through the software MATLAB. As in any high-performance AC electric drive system, field oriented control is applied. The complete control system is distributed in three control loops, namely torque, speed and position. A standard PIC control system, and a hybrid control system based on fuzzy logic, are implemented and tested. The natural variation of motor parameters, such as winding resistance and magnetic flux, are also simulated. Comparisons between the two control schemes are carried out for speed and position control using different error measurements, such as, integral square error, integral absolute error and root mean squared error. Comparison results show a superior performance of the PIC-based controller when coping with parameter variations, and by reducing torque ripple, but the results are reversed when periodical torque disturbances are present.*

1. INTRODUCTION

The permanent magnet synchronous motors (PMSMs) have been extensively applied in many fields such as numerically-controlled machine tools, aerospace, ship electric propulsion for its advantages like compact structure, simple control, and high power density. Compared with traditional three-phase motors, multiphase PMSMs have incomparable strengths, for instance, high output power with low voltage, high system reliability, small torque ripple etc. Therefore, it is of great theoretical significance and practical value to study the speed control system of a six-phase dual Y shift 30°PMSM.The classical proportional integral (PI) control technique is universally employed in the Current six-phase PMSM system due to its high Reliability and simple implementation. However, linear PI controller cannot eliminate its dependence on the plant model and parameters; especially, the internal parameter perturbations and external disturbances (called lumped uncertainty), which occur in the applications of six-phase PMSM system. In order to improve the robustness of adaptive hybrid strategy and overcome the disturbance-matching limitation of sliding mode control, the adaptive hybrid adaptive sliding mode control (ABSMC) algorithm has been developed and utilized in the motors control system. The adaptive control algorithm a combination of the merits of fuzzy neural network for learning from process and wavelet decomposition for identification of dynamic system, has been proved to be better than the other neural networks in that the structure can provide more potential to enrich the mapping relationship between inputs and outputs. Since most of the practical applications are dynamic, the recurrent structure has been added into WFNN to enhance its ability of dynamic mapping and temporal information storage. Here for the testing purpose did process using PIC microcontroller.

2. RELATED WORK

This paper presents a new speed control system of permanent magnet synchronous motor (PMSM) using FPGA (Field Programmable Gate Array) with an SiC inverter. SiC MOSFET is one of the most promising alternatives to Silicon (Si) for power semiconductor devices due to its superior material characteristics. SiC devices provide significant performance improvement compared to traditional Si devices, such as lower conduction loss and higher switching speed [1]. SiC is a compound semiconductor comprised of Silicon (Si) and Carbon (C). The inverter using SiC MOSFET is presented to achieve high-frequency operation up to 100 kHz with a switching PWM technique. PMSM has been widely used in many industrial applications such as robots, rolling mills and machine tools [2]. PMSM has advantages like high efficiency, high power factor, high power density and maintenance free operation, and this motor is nowadays preferred in a variety of applications [3].A high-performance motor control system requires a high response system and recovery to steady state condition immediately when a motor is loaded and influenced by any disturbances. To achieve it, the high frequency PWM is needed so the speed control system using FPGA with SiC inverter is proposed. There are many advantages of using high frequency PWM (in range of 50 to 100 kHz) in motor drive applications. High motor efficiency, fast control response, lower motor torque ripple, close to ideal sinusoidal motor current waveform, smaller filter size, lower cost filter, etc. are a few of the advantages [4].There are many published studies that have given attention to achieve a high response control system in the speed control of a permanent magnet synchronous motor. Zhou [5] proposed an FPGA-realisation of a speed servo controller of PMSM. Ying [6] proposed a speed control integrated circuit (IC) for permanent magnet synchronous motor (PMSM) drive under this SoPC environment. Then, an adaptive fuzzy controller is adopted to cope with the dynamic uncertainty and external load effect in the speed loop of PMSM drive. Hanamoto [7] proposed the hardware speed control system of PMSM using FPGA. However, the above researchers studied the speed control system on Si based inverter and achieved the frequency of PWM in the 20-40 kHz range. Kamel [8] and Advan [9] proposed speed control of PMSM using Fuzzy Logic Controller. These researches used simulation with MATLAB SIMULINK to perform Fuzzy Logic Controller in the speed control of permanent magnet synchronous motor.

3. PROPOSED DESIGN

The control method of PMSM is a vector control employed for variable speed control systems. The speed commands are sent to control blocks which include three PI controllers for speed control and two current control loops, dq and inverse dq coordinate transformation. Then, a PWM pulse generator is produced for switching of inverter. Rotor position and motor angular speed are detected and calculated from a pulse series generated from an incremental pulse encoder which is mounted on the rotor axis of the PMSM. Phase currents are measured by sensors and converted into a digital value by 12 bit AD converters. In order to maximize the switching frequency, a high performance.

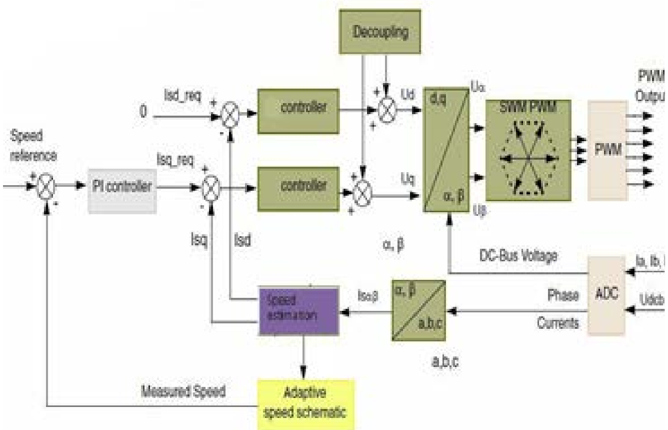
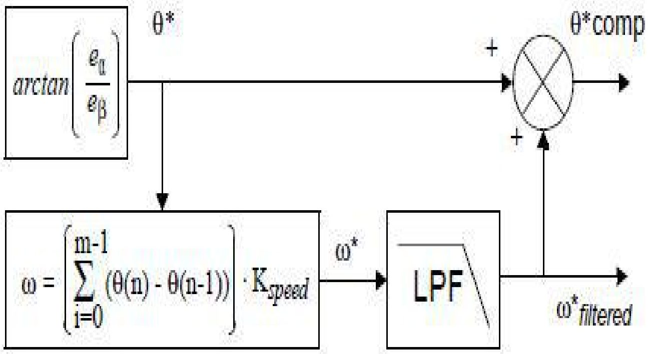


Fig: 3. PMSM Vector Control Algorithm Overview

The block diagram of the implemented control algorithm is illustrated in Fig 3. Similar to, other vector control oriented techniques, it enables to control the field and torque of the motor separately. The main aim of the control is to regulate the motor speed. The algorithm is executed by two control loops. The fast inner control loop executes with a period. The slow outer control loop is executed with a period of one millisecond. To achieve the goal of the PMSM control, the algorithm uses feedback signals. The essential feedback signals are: three-phase stator current and voltage. But, the control structure presented requires the rotor position. In the case of the algorithms of a sensor less technique using a sliding mode observer with an adaptive speed scheme is used. The fast control loop executes 2 independent current control loops. They are the direct & quadrature-axis current (iSd, iSq) PI controllers. The isd is used to control the rotor magnetizing flux. The quadrature-axis current corresponds to the motor torque. The current PI controller's outputs are added to corresponding d, q axis components of the decoupling stator voltage, obtaining the desired SV for the stator voltage applied to the motor. The fast control loop executes all the necessary tasks to enable to achieve an independent control of the stator current components; in reference .This includes: Forward Clark transformation; Forward and backward park transformations; Sliding mode observer and rotor position reconstruction; DC-bus voltage ripple elimination; Space vector modulation (SVM). The PI speed controller output sets a reference for the torque producing quadrature axis component of stator current (iSq).



Due to the filtering function applied during the data calculation, some phase compensation is needed before the calculated angle is used to energize the motor windings. The amount of theta compensation depends on the rate of change of speed of the motor.

Speed is calculated by accumulating theta values over m samples.

Where = Angular velocity of the motor,

n =Current Theta value, n-1 = previous value, Kspeed = Amplification factor for desired speed range and m = Number of accumulated Theta deltas. To obtain a smoother signal from the speed calculation, a first order filter is used to obtain filtered speed (filtered) from (unfiltered). Speed has been calculated after uncompensated theta. This is accomplished by adding a compensating offset theta (offset), which is determined from the motor speed, to the uncompensated theta (*), as follows:

*comp = * + offset.

The vector control of currents and voltages results in control of the spatial orientation of the electromagnetic fields in the machine and has led to the mms field orientation. FOC usually refers to controllers which maintain a 90° electrical angle between rotor and stator field components. Systems which depart from the 90° orientation are known as field angle control or angle control. In a DC motor the field flux, the stator flux, and the armature flux (rotor) are held orthogonal mechanically by the commutation. When the fields are orthogonal, armature flux does not affect the field flux and the motor torque responds immediately to a change in armature flux or equivalently, armature current. In an AC motor the field flux rotates, but in a FOC the controller rotates the armature (stator) flux so that armature and field flux are kept orthogonal, and hence, the AC motor behaves as a DC.

a) PERMANENT MAGNET MOTORS

A permanent magnet synchronous motor (PMSM) uses permanent magnets embedded in the steel rotor to create a constant magnetic field. The stator carries windings connected to an AC supply to produce a rotating magnetic field. At synchronous speed the rotor poles lock to the rotating magnetic field. Permanent magnet synchronous motors are similar to brushless DC motors.

4. APPLICATION

Synchronous motors are especially useful in applications requiring precise speed and/or position control.

- Speed is independent of the load over the operating range of the motor.
- Low-power applications include positioning machines, where high precision is required, and robot actuators.

5. CONCLUSION

Permanent magnet synchronous motor vector-control systems contain current loops. This paper illustrates the performances of sensor less control of PMSM. Simulation results are in full agreement for all cases. This is calculated by using mathematical calculations. From these results we can conclude that this control is much suitable for controlling a permanent magnet synchronous motor with senseless. The performance of current control drives in terms of torque, flux and current ripple, with respect to FOC, is partly compensated since its allows higher sample frequencies. The only problem is that the inverter sets an upper limit for its switching frequency. Since the introduction of current control a lot of research has been done to improve performance of current control drives while retaining the good properties, such a low complexity and good dynamic response.

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