Permanent Magnet Synchronous Motor Drives Control Technology

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Abstract: Permanent magnet synchronous machines are known as a good candidate for hybrid electric vehicles due to their unique merits. However they have two major drawbacks i.e. high cost and small speed range. In this paper we have reviewed the various technologies that are used in the control techniques are described. Other than FOC and DTC another type of control i.e. intelligent control techniques are also described in the paper.

Keywords: Permanent magnet Synchronous motor drive(PMSM), Field Oriented Control Techniques(FOC), Direct Torque control(DTC),

I. INTRODUCTION

PM synchronous motors are more and more popular for new drives, replacing brushed DC, universal, and other motors in a wide application area. The reason is a better reliability (no brushes), better efficiency, lower acoustic noise, and also other benefits of electronic control. The PM synchronous motor also has advantages when compared to an AC induction motor. Because a PM synchronous motor achieves higher efficiency by generating the rotor magnetic flux with rotor magnets, it is used in white goods (such as refrigerators, washing machines, dishwashers), pumps, fans, and in other appliances that require a high reliability and efficiency. A Power-Quality Problem is an occurrence manifested in a nonstandard voltage, current, or frequency deviation that results in a failure or a miss operation of end-use equipment. Power quality is a reliability issue driven by end users.

Some different types of techniques used for speed control of PMSM as shown in the figure:[10]

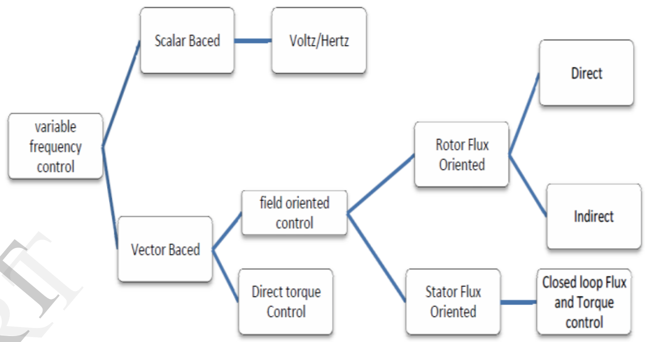

Figure 1: Some Common Control Techniques Uses for PMSM

A.SPEED CONTROL OF PMSM DRIVE

Predictive speed control of a two-mass system driven by a permanent magnet synchronous motor

Esteban j. Fuentes, césar a. Silva (member ieee) and juan i. Yuz (member ieee) presents a predictive strategy for the Speed control of a two-mass system driven by a permanent magnet Synchronous motor (pmsm). The proposed approach allows to Manipulate all the system variables simultaneously, including mechanical And electrical variables in a single control law. The state Feedback is achieved with a reduced order extended kalman filter, Which observes the non-measured variables as well as reduces the Impact of measurement noise. The performance of the control Strategy is shown through simulation and experimental results in A 4 [kw] laboratory prototype.

B. Types of electric motors

Electric motor power HEV cars are the main species. Each has advantages and disadvantages, as shown below.

- *Asynchronous (induction) motors:* Asynchronous electric motors has a long history of successful applications in industry and is very durable and reliable. The project FREEDOMCAR [2], asynchronous motor is presented as less effective and less powerful engines than RM. Therefore, low cost, high reliability and low technological risk will likely remain a primary advantage of this technology for the future.

- *Brushless PM motors*: Brushless PM motors are designed so that, in the stator induces electrical magnetic field acting on the permanent magnets in the rotor [1]. There are several configurations of the conventional motors. In recent years, there were more new concepts to improve the PM machines. PM engines generally have higher efficiency. PM engines are more powerful per unit weight than other types of electric motors, as are light and occupy less space.
- IPM motors *Parametric Analysis of the PM Motor for Hybrid Electric Vehicles*: Unlike surface-mounted magnets of PM engines, internally mounted magnets in IPM motor offers certain advantages - such as higher speed of rotation, which is the most obvious advantage. The main difference , that the placements on the surface of the rotor magnet, the flow cannot be touching the magnets connected in order to rot r - stator phase advance, [1].

II. FIELD ORIENTED CONTROL TECHNIQUES

Field Oriented Control was invented in the beginning of 1970's and it demonstrates that an induction motor or synchronous motor could be controlled like a separately excited dc motor by the orientation of the stator mmf or current vector in relation to the rotor flux to achieve a desired objective. Field Oriented Control usually refers to controllers which maintain a 90 angle between rotor and stator field components. Systems which d the 900 orientation are referred to as field angle control or angle control. The performance of FOC is comparable to DC Machine. It produces less ripples but the system is more complex and less robust compares to DTC. The Field Orientated Control (FOC) consists of controlling the stator currents represented by a vector. This control is based on projections which transform a three phase time and speed dependent system into a two co-ordinate (d and q co time invariant system. These projections lead to a structure similar to that of a DC machine control. Field orientated controlled techniques Uses for PMSM maintation 900 electrical depart from angle co-ordinates) ant machines need two constants as input references: the torque component (aligned with the q co-ordinate) and the flux component (aligned wi Field Orientated Control is simply based on projections the control structure handles instantaneous electrical quantities. This makes the control accurate in every working operation (steady state and transient) and independent of the mathematical model. [10]

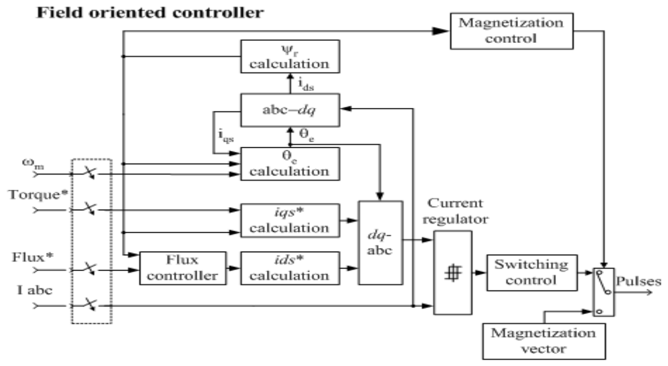

Figure-2. FOC Scheme

A. Sensorless field oriented control of a pm motor including zero speed

H. Rasmussen and p. Vadstrup and h. Børsting presents a simple control method for controlling Permanent magnet synchronous motors (pmsm) in a wide speed Range without a shaft sensor. The method estimates the stator flux by integration of the measured emf signal. To compensate for the offset in the emf the offset is estimated. The control method is made robust at zero And low speed by changing the direct vector current component to a value Different from zero. In order to verify the applicability of the method the Controller has been implemented and tested on a 800 w motor.

B.Field oriented control of pmsm using svpwm Technique

E.prasad, b.suresh, k.raghuveer presents the principle of space vector pulse Width modulation (svpwm) was introduced And implementing for pmsm. Applying Svpwm technique to the pmsm and Obtaining the speed, torque, current Responses when load was increased. The Mathematical model of pmsm is analyzed by Neglecting the saturation of the electric motor Ferrite core, turbulent flow and hysteresis loss In electric motor. Assuming that the current In the electric motor is symmetrical three Phase sinusoidal current and the system Model of foc vector control has-been Established. The control system has been Simulated by matlab/simulink. Simulation results show that the model is Effective, and the method provides a frame of reference for software and hardware designs.

C.Input admittance expressions for field-oriented Controlled salient pmsm drives

Oskar wallmark (member ieee), stefan lundberg, and massimo bongiorno (member ieee) presents analytical expressions for the converter Input admittance in field-oriented controlled permanentmagnet Synchronous motor (pmsm) drives. The effect of rotor Saliency is taken into consideration and the derived admittance Expressions are valid for maximum-torque-per-ampere as well as High-speed (field weakening) operation. Experimental results illustrate The validity of the derived admittance expressions. The presented Work can be used to predict dc-link voltage instabilities in Pmsm drives in, e.g., railway traction, aerospace and automotive Applications.

III. DIRECT TORQUE CONTROL TECHNIQUES

A.Speed control of pmsm by using Dsvm -dtc technique

J. Sinivas rao, s. Chandra sekhar, t. Raghu (International journal of engineering trends and technology- volume3issue3- 2012) presents the direct torque control (dtc) requires low Computational power when implemented digitally for ac Drives. The dtc possess good dynamic performance but Shows quite poor performance in steady-state since the Crude voltage selection criteria give rise to high ripple Levels in stator current, flux linkage and torque. To reduce the problems with dtc the discrete space vector modulation Method is proposed for dtc by applying more vectors in one Interval. In this paper, after a brief review of the primary Concept of dtc technique, a new scheme of dsvm dtc for Pmsm is proposed with a new set of switching tables. Simulation On the proposed scheme is carried out and compared with basic Dtc scheme.

B. A direct torque controller for permanent magnet Synchronous motor drives

L. Zhong, m. F. Rahman, w. Y. Hu and k. W. Lim presents and describes an investigation of dtc for Permanent magnet synchronous motor (pmsm) drives. The Analysis of pmsms shows that the increase of electromagnetic Torque is proportional to the increase of the angle between the Stator and rotor flux linkages and therefore fast torque response can Be obtained by increasing the rotating speed of the stator flux Linkage as fast as possible. The implementation of dtc in pmsm Drives is discussed and the switching table specific for an interior Pmsms is derived. The proposed control is implemented on a Prototype pmsm, which has a standard induction motor stator, and The experimental results show that the torque response is extremely Fast. It is also demonstrated that the position sensor is not essential For the inner torque control loop of pmsm drives with dtc.

C. Nonlinear control of a permanent magnet Synchronous motor with disturbance Torque estimation

Jorge solsona, (member ieee), maría i. Valla, (senior member ieee), and carlos muravchik (senior member ieee) presented paper introduces a sensorless nonlinear control Scheme for controlling the speed of a permanent magnet Synchronous motor (pmsm) driving an unknown load torque. The states of the motor and disturbance torque are estimated via An extended nonlinear observer avoiding the use of mechanical Sensors. The control strategy is an exact feedback linearization Law, with trajectory tracking evaluated on estimated values Of the pmsm states and the disturbance torque. The system Performance is evaluated by simulations.

D. Direct instantaneous torque control in Direct drive permanent magnet synchronous Motors—a new approach

Yasser abdel-rady ibrahim mohamed(ieee transactions on energy conversion, vol. 22, no. 4, december 2007) presents a novel direct instantaneous torque control Scheme for a direct drive (dd) permanent magnet synchronous Motor (pmsm) is presented. A hybrid control structure combining The internal model principle and the variable structure control (vsc) approach is proposed. First, a variable structure torque controller Is adopted to regulate the torque angle increment according To the torque feedback error. Second, the appropriate control voltage Vector is determined using the reference stator flux vector and The estimated dynamic back electromotive force (emf) vector, as An internal model, in a deadbeat control manner. Subsequently, Better disturbance rejection can be obtained with the proposed Cascaded control structure. To robustly obtain the instantaneous Torque and flux information, a robust adaptive motor model is Proposed. The lyapunov stability theory is used to analyze the Stability of the augmented robust adaptive motor model and to Give a guideline for tuning model parameters. Experimental results Are presented to demonstrate the validity and effectiveness of The proposed instantaneous torque control scheme.

E. Direct instantaneous torque control in Direct drive permanent magnet synchronous Motors—a new approach

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IV. INTELLIGENT CONTROL

Advanced control based on artificial intelligence technique is called intelligent control [3]. Every system with artificial intelligence is called self-organizing system. Intelligent control, act well than conventional adaptive controls. Artificial intelligent techniques divide two groups: hard computation and soft computation. The high power, high speed and low cost modern processes like DSP, FPGA and ASIC IC's along with power technique switches like IGBT made the intelligent control to be used widely in electrical drives In recent two decades, soft computation is used widely in electrical drives.[5][6]

They are,

1. Artificial Neural Network (ANN)
2. Fuzzy Logic Set (FLS)
3. Fuzzy-Neural Network (FNN)
4. Genetic Algorithm Based system (GAB)
5. Genetic Algorithm Assisted system (GAA)

Neural networks and fuzzy logic technique are quite different, and yet with unique capabilities useful in information processing by specifying mathematical relationships among numerous variables in a complex system, performing mappings with degree of imprecision, control of nonlinear system to a degree not possible with conventional linear systems.

Fuzzy logic is a technique to embody human-like thinking into a control system.

Recently the fuzzy logic approach has been objected of an increasing interest and has found application in many domains of control problem [4]. The main advantage of fuzzy logic control method as compared to conventional control techniques resides in fact that no mathematical modeling is required for controller design and also it does not suffer from the stability problem.

V.CONCLUSION

Thus we can conclude that the new intelligence control system can help in betterment of the PMSM drives. The uniqueness provided by the artificial intelligence based system or the fussy logic based system or the neural network system add to the increase in performance of drives, by adding the features that help in improvement of PMSM drives.

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