HIGH DYNAMIC PERFORMANCE OF BRUSHLESS PERMANENT MAGNET SYNCHRONOUS MOTOR UNDER EFFECT OF FIELD ORIENTED CONTROL

By

Hamdi Mohamed Soliman Hegazy

A Thesis Submitted to the Faculty of

Engineering at Cairo University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

In

Electrical Power and Machines Engineering

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Prof. Dr. S. M. EL. Hakim **Dr. Abd. EL. Kader Habash**

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Signature

Hamdi mohamed soliman

ABSTRACT

With inventing the motor, engineers work on development it. In the past, they are important by development the materials which used in it to improve the performance. Recently, they are improve the performance characteristics by using the semiconductor devices and software programs. In this thesis, the permanent magnet synchronous (PMSM) is chosen due to have some advantages as; high torque to current ratio, high torque to inertia, high efficiency, quick acceleration and declaration and high long life. Also the PMSM has some disadvantages as; demagnetizing at high temperature and very large opposing magneto motive force. Field oriented control (FOC) is used to making the PMSM emulates separately excited DC motor to improve the dynamic performance. With using the FOC, the PMSM still suffered from ripples and noise in the motor torque, motor current and harmonics. Two current control methods are used to trying improvement the performance of PMSM. The two methods of control are hysteresis current control and ramp comparison current control. Proportional integrator current controller is used with these methods of control to improve the performance characteristics of permanent magnet synchronous motor. These PI's are used in different situation of control i.e. in the field orientation block or in the current controller blocks. The first model used two PI current controllers in field orientation control region one is for the torque and the other is for the flux. The first PI controller is feeding from the torque error between the reference and estimated torques to get new q-axis current component representing modifier current arises from uncertain things. This current will add to reference q-axis current to get robust new q-axis current to satisfy the drive requirement and solve the

torque problem. In the other PI controller, the d-axis flux is compared to rotor permanent magnet flux. The output of the PI controller is introduced to the reference d-axis current. The new d-axis current will improve the total harmonic distortion.

The second model used three PI current controller i.e. one PI introduced in each phase after comparing between the actual and reference currents. The occurring improvement can be seen through the torque ripple and total harmonic distortion. These proposed models are compared to classical model to show the effectiveness of the proposed models.

Also simple model used to reduce the effect of sudden applied or removal the load to increase the high dynamic performance.

These methods of control are simulated where found that, the performance of the motor under study is improved.

In the laboratory, proto type drive system is constructed to control the PMSM. This proto type consists of power inverter, control circuit of inverter, encoder circuit, power circuit, start stop control circuit, manual and automatic circuit to apply or remove the load, protection circuit against over current, resistive load circuit, signal conditioning circuits for current feedback, motor speed and PWM. DSP from texas instruments (TI) is used to control the PMSM overall. The experimental results are compared to simulate results where found that, the experimental and analytical are in good agreement.

In this thesis the performance of a PMSM drive under a stator winding fault and sensor current fault is studied. This thesis is suggested two models for solving these faults. The control in these models depends upon controlling each phase separately. The first model doesn’t contain any special tools to improve the torque ripple and THD. The second model contains 2PI current controllers to reduce the performance at fault and remedial operation. The simulation shows that, the performance of the two model are accepted but model two is the best due has more performance in reducing the ripples in the current and torque.

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