بسم الله الرحمن الرحيم

Ain Shams University
Faculty of Engineering
Electrical power and Machine Dept.

A Medium Voltage Drive for Active Heave Compensation

Ph.D. Thesis
By

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Submitted in Partial Fulfillment of The Requirements
for the Ph.D. Degree in Electrical Engineering

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Statement

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for Ph.D. degree in Electrical Engineering.

The included work in this thesis has been carried out by the author at the Electrical Power and Machine Department, Ain Shams University. No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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To

My Parents, my wife, my daughters, my brothers, and my sisters.

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ABSTRACT

The thesis studies a sensorless induction motor drive with a reduced voltage stresses on the motor windings suitable for oil well drilling process. The drive consists of a Neutral Point Clamp (NPC) inverter, an Indirect Field Oriented Controller (IFOC) and a speed estimator. The NPC inverter is regulated by either a sinusoidal pulse width modulation or hystresis current control technique to track the current reference generated from the IFOC. The speed estimator is implemented to produce the rotor speed, from the terminal voltage and current measurements, which is necessary for the IFOC and the speed regulation loop.

The thesis presents a second order model for speed estimation of the induction motors. This model includes the motor speed as a state parameter. Moreover, this model is simplified to a first order model in a trial to reduce the mathematical burden of the estimation process. The Kalman Filter (KF) and the recursive least square (RLS) algorithm are proposed for estimating the motor speed. The main objective of the proposed estimation models is to reduce the computational effort, the memory and processor requirements of the sensorless drives. Furthermore, a novel method is introduced to estimate the motor speed and it is named the maximum denominator estimator.

The rotor resistance is a time varying parameter due to the motor temperature variation. The variations of the rotor resistance affect the accuracy of the IFOC operation, if it is based on the value of a cold rotor resistance. A braided system using two RLS estimators is proposed to estimate the motor speed as well as the rotor resistance.

The proposed drive system is an application oriented. It is proposed to compensate the heave motion effects on the drilling operation of the oil well drilling semi-submersible rig. The heave motion causes the drilling tools to go away from the surface to be drilled then to approach it periodically. A controllable opposite motion is achieved by the proposed drive system to compensate the heave motion.

Simulation results based on MATLAB/SIMULINK software package are conducted to examine the dynamic behavior of the proposed methods under different tests. A practical operating range of heave motion is considered.

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