PERFORMANCE ANALYSIS OF DIRECT TORQUE CONTROL BASED INDUCTION MOTOR DRIVE WITH APPLICATION OF CARRIER SPACE VECTOR PULSE WIDTH MODULATION TECHNIQUE

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by

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CERTIFICATE

This is to certify that the thesis entitled, **"Performance Analysis of Direct Torque Control based Induction Motor Drive with Application of Carrier Space Vector Pulse Width Modulation Technique"** being submitted by **Mr. Saurabh Nandkishor Pandya** for the award of the degree of **Doctor of Philosophy** is a record of bona-fide research work carried out by him in the Department of Electrical Engineering, Indian Institute of Technology, Delhi.

Mr. Saurabh Nandkishor Pandya worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The matter embodied in this thesis has not been submitted for the award of any degree or diploma elsewhere to the best of my knowledge.

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ABSTRACT

An optimally designed induction motor (IM) drive based on best balance of cost, size and performance have made major impact in industrial application as compared to DC and PM drive technology. Simplicity and robustness make 3-phase IM attractive for use in most of the industrial drives. Induction motor which is backbone of industrial drive applications, often require, accurate and step-less control of torque and speed. This can be achieved by supplying the induction motor with 3-phase voltages of variable frequency and variable amplitude. In recent years, due to enormous advances in semiconductor technology makes it possible for developing such advance modern IM drives. Among the various techniques available for control of torque and speed of induction motors Direct Torque Control technique, popularly known as conventional DTC becomes attractive choice as drive for many industrial applications. This is due to its features like simple, direct torque and flux control, high dynamic performance comparable to field oriented control technique of induction motor, absence of: co-ordinate transforms, voltage modulator block as well as other controllers needed in field oriented control. However, limitations like high torque ripple and variable switching frequency restricts its applications, particularly when precise and smooth torque control is of prime need.

Present work is related to the development of a suitable drive technology which address above problems of conventional DTC to meet the industrial requirements like precise and smooth control of torque and speed with good dynamic performance for the motor ratings laid within the range 3-20 kW. These objectives have been achieved by incorporating suitable changes in basic structure of conventional DTC based IM drive, without altering its basic operating principle and features like fast torque response. Space vector pulse width

modulation (SVPWM) DTC based IM drives are currently being used in many industrial drive applications. SVPWM technique does not provide the best solution in terms of harmonic distortions in voltage and current waveforms which ultimately affect the magnitude of electromagnetic torque ripple in the induction motor. In carrier space vector pulse width modulation technique (CSVPWM), which is a special variant of standard SVPWM technique; greater flexibility and lesser harmonic distortion than standard SVPWM technique can be obtained by adding appropriate amount of common mode voltages. Hence, a CSVPWM DTC based IM drive can be designed to obtain reduced electromagnetic torque ripple in the IM. CSVPWM DTC based IM drive has three controllers one each for speed, torque and flux loop. For reducing the electromagnetic torque ripple, the torque and flux controllers are designed optimally. A multirate sampling technique is applied for better estimation of stator flux linkages, electromagnetic torque ripple and rotor speed by operating parameter estimation block at faster sampling rate than speed, torque and flux loop sampling rate. The effect of adding different amount of common mode voltages to 3-phase sinusoidal reference signals on the features like linear modulation range and THD has been examined. For the optimum magnitude of common mode voltages, the performance analysis of CSVPWM DTC based IM drive has been carried out. Integrating all the above mentioned attempts in the present work, the DTC IM drive has been designed using "a multirate carrier space vector pulse width modulation technique with best controller settings". The performance of a drive during acceleration/deceleration period has been evaluated and a new technique is proposed to obtain matched acceleration-deceleration rate of the drive under different speed and load conditions. For medium and high power applications, a multirate 3-level CSVPWM DTC based IM drive has been implemented.

TABLE OF CONTENTS