# AN ABSTRACT OF A DISSERTATION

# SPEED SENSORLESS CONTROL AND OPTIMIZATION OF DOUBLE-END CONVERTER FED FIVE-PHASE INDUCTION MOTOR DRIVE

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Doctor of Philosophy in Engineering

The expressions for the modulation signals used in the carrier-based sinusoidal and generalized discontinuous pulse-width modulation schemes for two-level, five-phase voltage source converters have been derived. These expressions can be used for both balanced and unbalanced reference phase voltages generated by any two-level multi-phase inverter. Simulation and experimental results using a five-phase resistive-inductive load and a five-phase induction machine are presented in which a close examination shows that both results are similar for the balanced and unbalanced load voltage cases.

A relationship between the modulation magnitudes and the sharing coefficients of the real and reactive power in a double-end three-phase inverter system is derived. This determines the contribution of each converter to the overall operation of the system.

The modeling and simulation of a three-level diode-clamped five-phase voltage source converter is presented. Using the conventional carrier-based switching method, the average switching functions are derived. These result into three modulation signals which are used to derive the model equations, in the synchronous quadrature-direct (qd) reference frame, that can be used for control. Simulation results show significant reduction of the ripple magnitude in both the capacitor and neutral point voltages.

A new carrier-based pulse-width modulation (NCBPWM) technique is developed. It introduces a natural balancing of the capacitor voltage and significantly reduces the harmonic content in both capacitor and output inverter voltages. The technique also ensures zero-neutral-point (NP) potential in the three-level voltage source inverter.

A double-end three-level diode clamped voltage source induction motor drive is analyzed. Using the NCBPWM, the drive is operated in open loop and closed loop control. Simulation and experimental results reveal that with a double-end configuration, the five-phase induction motor can be operated at its rated speed with low voltage requirements from each five-phase inverter. Vector orientated control has been implemented for speed sensorless operation. Using rotor voltage equations and full order flux observers the expressions for the estimation of the rotor speed have been derived, and simulation results are presented.

A theoretical analysis supported by measurements on the common mode voltages (CMV) is performed. Different multilevel modulation techniques are compared and contrasted. A double-end converter configuration reveals that it can reduce the peak-to-peak value of the CMV without requiring any external circuitry.

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A Dissertation

Presented to

the Faculty of the Graduate School

Tennessee Technological University

by

Sosthenes Francis Karugaba

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In Partial Fulfillment

of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

Engineering

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December 2012