PERFORMANCE OF INDUCTION MOTOR FED FROM A LINE COMMUTATED INVERTER-SYNCHRONOUS MACHINE SYSTEM

by

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DEDICATED TO

MY BELOVED MOTHER

WHO ALWAYS ENCOURAGED ME

TO LEARN MORE

CERTIFICATE

Certified that the thesis entitled "Performance of Induction Motor Fed from a Line Commutated Inverter-Synchronous Machine System" which is being submitted by Mr. M.V.S.S. Ranganadhachari, in partial fulfilment for the award of the Degree of Doctor of Philosophy in the Department of Electrical Engineering of Indian Institute of Technology, Delhi, is a record of student's own work carried out by him under our joint supervision and guidance. The matter embodied in this thesis has not been submitted for the award of any other degree or diploma.

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ABSTRACT

For the variable speed operation of the induction motor, the use of forced commutated inverter or cycloconverter circuits as a variable frequency source is well documented. These variable frequency sources are known to provide output waveforms with significant harmonic contents. This leads to increased losses and torque pulsations as a result of which, the motor gets derated. The inverter circuits are of forced commutated type and the risk of commutation failure is more. Even though the cycloconverter uses natural commutation, its application is limited to low frequencies.

The major objective of the investigation reported here is to eliminate the aforesaid drawbacks by using a line commutated inverter (LCI)-synchronous machine (SM) combination as a variable frequency source. This type of inverter naturally commutates because of the availability of three phase voltages from the synchronous machine. The voltage and current waveforms obtained from this scheme are near sinusoidal as the LCI operates from the mains. Thus, the clean, near sinusoidal voltage and current waveforms fed to the induction motor are encouraging features of this scheme as the torque produced in this case should be more smooth compared to that of the forced commutated inverter schemes. The main advantage of this scheme is that it is possible to build two different control schemes around this. The LCI-SM combination can be used as a variable speed drive. In addition, the line commutated

inverter-synchronous machine combination can also be used as a variable frequency source from which a single induction motor or a group of them can be supplied to achieve the variable speed operation.

The performances of both the LCI-SM and the LCI-SM-induction motor systems under steady state and dynamic conditions are studied. Analytical models of the system using equivalent circuit approach are developed for predicting the steady state and dynamic performances. The line commutated inverter-synchronous machine-induction motor drive system is developed in the laboratory and extensive tests are carried out on this under different operating conditions.

The steady state performances of the LCI-SM system are predicted by using the simple steady state equivalent circuits both for the conduction and the commutation modes of the line commutated inverter-synchronous machine operation. It is shown that the speed-torque characteristics of the LCI-SM system closely resemble the characteristics of a separately excited d.c. motor. For the analytical model of the LCI-SM-induction motor system, the equivalent circuits developed for the LCI-SM combination are modified by incorporating the equivalent circuit of the induction motor. From this, a set of performance equations are established. The steady state performance characteristics are obtained by solving these performance equations using an iterative procedure and computer oriented analysis. Similarly, the steady state performances of two induction motors fed from the LCI-SM system are predicted by extending the procedure used for the single induction motor case. Further, the steady state performance of the LCI-SM-induction motor system with the capacitor network is also studied. It is observed that the insertion of the capacitor improves the steady state performances of the LCI-SM-induction motor system. For studying the dynamic performance, a simplified d.c. equivalent circuit approach has been used both for the LCI-SM and the LCI-SM-induction motor systems.

Extensive tests have been carried out in the laboratory on both the LCI-SM and the LCI-SM-induction motor systems and test results show a good agreement with predicted ones. The study shows that the LCI-SM system is capable of operating as (i) a variable speed drive and (ii) a variable frequency source from which an induction motor or a group of induction motors can be fed.

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