Abstract

The work presented in this thesis is related to the development and performance evaluation of self-controlled synchronous motors as Commutatorless Series Motors (CLSMs) which, when the field winding is located in the dc link, exhibit an inherent series characteristics making them ideal alternatives to the dc series machine in its wide application area. Two versions of these drives have been studied, of which the transistorised version has been presented for the first time. Next, a simpler topology, as compared to the ones proposed earlier, has been investigated for the thyristorised version.

Motoring and braking modes of operation of the transistorised CLSM have been experimentally and analytically investigated, after exploring several possible topologies for the simplest, cheapest and yet most reliable one, to identify primarily the basic behaviour of the selected drive topology and also to suggest conditions under which it should be operated for most acceptable performance. In the process, the effect of the supply voltage variation, mechanical loading, position sensor location, etc. on the fundamental machine behaviour has been studied to obtain, besides the other features, the speed-torque characteristics under both motoring and dynamic braking conditions for several position sensor locations.

Having experimentally established the inherent series nature of the drive, further investigations have been made on a simulated system, which has been validated by comparing its results with those of the former. It has thus been possible to establish the superior features of the proposed drive, specially in respect to phase current

harmonics, torque ripples and terminal power factor. However, the internal power factor has been found to be low with the test machine - a retrofitted one.

A steady state analysis which gives a simple, but comprehensive, view of the drive has next been used to suggest parameters of a machine which would perform better in respect to operating power factors, without significantly sacrificing for torque ripple and phase current harmonic content, the last part being determined, again, by the dynamic simulation. The drive so realised, has been found to be superior on many counts to the presently available solutions for the load specifications relevant to such drives applicable for low and medium power applications.

The thyristorised version has been studied specifically to explore the self-starting ability of such a drive under induced voltage commutation. This achievement, has a very important contribution in presenting it as an ideal drive for very high power applications as no power components are required, besides the machine, six inverter thyristors, and a simple control circuit, to operate it over the entire speed range.

The role of damper windings in improving commutation ability, besides its other effects, has been investigated on a simulated system, which had also been used to predict the specifications of the machine suitable for unaided start-up. The scheme has been tested on an available synchronous machine and its performance recorded. The phasor diagrams corresponding to this CSI-fed series drive has been utilised to confirm the machine specification as obtained from the dynamic simulation of the system.

Key words : Synchronous machine, Series Motor, Comutatorless motor, Commutatorless Series Motor, Traction/transit drive, Self-controlled drive, Transistorised inverter, Operating modes, Dynamic simulation, Torque ripples, Harmonics, Induced voltage commutation, SCR inverter, Position sensor, Overlap angle, Unaided start-up, Phasor diagrams, Transformer/rotational voltages, $\lambda - i$ plots.