SYNOPSIS

This investigation is concerned with the theoretical and experimental studies on the nature and characteristics of Linear Induction Motors (LIMs), under steady state and transient conditions of operation and aims at presenting a complete terminal model of the machine. Briefly the objectives of the research can be specified as follows:

1. To develop a mathematical model of the machine so as to predict the steady state performance of both current-fed and voltage-fed LIMs under general conditions of supply unbalance.

2. To examine the problem of dynamic modelling of the LIM and solve for the switching transients, following reconnection of supply at the terminals for different operating conditions of the machine.

In general, the machine may be operated either in a current-fed or voltage-fed mode, depending on the choice of the control scheme employed. Theoretically, the current-fed operation has attracted considerable interest, since the attention can be focussed on the essential energy conversion process in the machine, leaving aside questions of primary resistance and leakage reactances.
The voltage-fed operation, on the other hand is of more practical importance and calls for a complete modelling of the machine. Analytical predetermination of the leakage fields in machines, it is recognised, is often quite difficult. At the same time, LIMs are generally characterised by large leakage reactances and the conventional formulae for the coil end turn reactances may not hold in view of the essential topological differences. Consequently an important and original feature of the investigation is the analytical modelling of the overhang leakage fields and derivation of expressions for the leakage reactances in terms of design data. Here the reactive flow is computed from the Poynting vector using a 3-dimensional analysis, keeping the topology of the machine well in view. This enables, along with the inclusion of stator resistance and slot leakage reactances, a complete terminal characterisation of the LIM in the current-fed and voltage-fed modes of operation.

Previous studies have documented the basic phenomena associated with energy conversion in the LIM and certain distinctive features characterising the machine in comparison with the behaviour of rotary induction motors. These publications indicate that a field theoretic formulation under certain broad simplifying assumptions is capable of describing the internal behaviour of the LIM,
besides predicting the terminal characteristics satisfactorily. The emphasis in the present investigation is on obtaining a unified model capable of treating a family of problems characterised by general or specific source unbalances. Accordingly, a Fourier transform solution for the field quantities in terms of an arbitrary slot current distribution, with the machine run either in the current-fed or voltage-fed mode is presented. In view of the possibility of severe source unbalance, the second order effects of diffusion of magnetic flux in the rotor are taken into account in the derivation. This general formulation enables the single phasing and plugging operations of the machine to be treated directly, as special cases of the unbalanced theory. An objective study of the performance characteristics of the problems considered leads to some major conclusions regarding the superiority of the current-fed-motor and voltage-fed-brake modes of operations.

The considerations for the efficient computation of performance characteristics of the LIM using the above analysis are discussed along with the results of a simulation of the machine in an IBM 360/44 System. The validity of the mathematical models and the analysis is verified by a series of experiments on a 2.5 kw rotating disc facility that employs a double sided, sheet rotor type LIM.
The second part of the thesis is devoted to the development of a transient model of the voltage-fed LIM. A close examination of the steady-state field model of the machine suggests a line of approach for the extension of the same to cover the switching transients through the frequency response technique. The problem of sudden reconnection of the machine onto the supply with residual speed on the rotor is examined using this approach. Here the LIM is represented as a time-invariant system and the applied voltages as forcing functions are described by their respective frequency spectra. This approach essentially involves solution of the basic airgap boundary value problem with the angular frequency $\omega$ as a parameter. The sampled frequency domain response functions characterising the machine behaviour are obtained for different values of rotor speed and the switching angle. Discrete convolution of the slot current and flux density distributions directly yields the discrete frequency domain thrust function. The time domain solutions of the current and thrust variations are given by the inverse discrete Fourier transforms of the respective frequency domain functions. The study covers reconnection of supply in the motoring and plugging modes and reveals generation of large subharmonic components of currents and thrust oscillations. These are presented and discussed along with corresponding experimental evidence.