ABSTRACT

In recent years, there is an increased emphasis on the energy saving and performance improvement of electrical apparatus and systems. The electric drives being the major consumers of electrical energy, their energy efficient operation is of prime importance. Significant amount of electric energy can be saved by the use of efficient and right type of electrical drives. AC drives employing 3-phase induction machines and single-phase ac series motors find wide application in industries as well as in domestic appliances. Hence, it was considered appropriate and worthwhile to carry out certain investigations on the performance improvement of these drives.

In some applications, induction motors work at rated load during only part of the load cycle. So, during the periods of reduced loads, substantial energy saving can be achieved by operating the motor at low voltages which can be obtained, now a days, by using ac voltage controllers. This also improves the power factor. Recently, the introduction of ac voltage controllers has been suggested for the power factor improvement of grid connected induction generators. Though the induction motor application was well established, not much work has been reported so far on the analysis of induction generators with voltage control. Again, the performance evaluation of these converters employed for the economical and efficient speed control of ac series motors also remains uninvestigated.

In this context, a study of ac voltage controllers feeding machines like induction machines and ac series motors is undertaken. When fed by such power converters, it is more appropriate to represent these machines by their RLE equivalent circuits. Hence, in this research work, certain investigations are carried out on ac voltage controllers with a

general resistive, inductive and emf load and these investigations are extended to induction machines and ac series motors.

To begin with, extensive investigations are carried out on the steady state operation of phase controlled ac voltage controllers connected to RLE loads. Simulation of ac voltage controller with RLE load using PSPICE software package and experimental investigations are carried out to confirm the theoretical results.

AC chopper is found to have better performance compared to conventional phase control technique. The performance of an ac chopper with RLE load is analysed and compared with that of phase control to bring out the advantages of chopper control. Here again, simulation is carried out to confirm the theoretical results.

An attempt is made, in this thesis, to extend the above investigations to two practical applications, such as induction generators and ac series motors. A comprehensive analysis on the performance of grid connected induction generators with voltage control is carried out. The induction generator is represented by its RLE equivalent circuit. The feasibility of employing the ac voltage controller, used for the soft start of the induction machine as a motor in Wind Energy Conversion Systems (WECS), for the power factor improvement of the system is also studied.

AC voltage controllers employing phase controlled Triac or back to back connected SCRs are widely used for the speed control of ac series motors in a number of applications. However, they are found to create some problems such as introduction of harmonics, poor supply power factor, interference to communication equipments and heating of the motor. Hence, in this thesis, these problems are analysed in detail by representing the series motor by its RLE equivalent. Chopping technique employing

PWM control strategy has been found to overcome some of the problems associated with phase control. AC chopper fed series motor is extensively analysed and the improvements in performance that can be achieved by the introduction of chopper control are observed.

Artificial intelligence tools such as fuzzy logic and neural networks are expected to usher a new era in power electronics and motion control in the coming decades. These technologies have advanced significantly in recent years. Hence, it is decided to make an attempt to apply these AI tools for the optimal control of voltage controller fed drives.

Fuzzy logic control is basically non linear and adaptive in nature and hence gives good performance under parameter variations and load disturbances. Hence, in this thesis, an attempt is made to introduce fuzzy logic for the closed loop speed control of induction motor. Further, fuzzy logic is applied to the Wind Energy Conversion Systems. The performance of WECS depends upon the wind speed. Since wind is an uncertainty, it is very difficult to have a well defined mathematical model for estimating the performance and hence the operator has to make use of his past experience. Hence, fuzzy logic is introduced for controlling the firing angle of the voltage controller according to the wind speed.

Artificial Neural Networks are becoming very popular recently because of their superiority with respect to speed, accuracy etc. over the other methods of control. Once trained for a particular application, neural network based controller will be fast and found to give optimum performance. Hence, in the present work, an attempt is made to use neural network for the optimal control of the ac voltage controller.

The thesis report is concluded with suggestions that may be taken up for further research.