CHAPTER 7

CONCLUSIONS

7.1 CONCLUSIONS

The study of Fuzzy and ANN control techniques and its application to control the speed of separately excited DC motors has been taken up in this thesis. The DC motor drive system uses Buck type DC-DC converters and microcontroller based embedded system for intelligent control algorithm implementation.

Initially, the conventional controller design starting from mathematical modeling of the DC motor and the related power electronic converters were discussed. Instead of the general time averaged model, the small signal model was developed and based on the small signal model; the conventional PI controller was designed. The small signal model is advantageous as it takes care of the dynamics of the system under study. The designed conventional controller was implemented in a Personal Computer (PC) system with a Data Acquisition Card.

A modified form of PI like fuzzy controller with embedded systems implementation in mind was then developed for speed control of single quadrant buck converter fed DC motor along with a current controller. The designed system was verified using computer simulations. The controller was then implemented in an 8051 microcontroller based embedded system. The performance results of the fuzzy controller and the conventional PI controller were compared and it was found that the fuzzy controller has better performance and does not need any mathematical modeling.
Based on the fuzzy controller for a single quadrant DC drive, fuzzy controller for four-quadrant chopper drive was designed and implemented in the microcontroller based embedded system. The fuzzy controller was designed such that it acts as a universal controller and can be easily implemented in a real-time basis. The designed system has the advantage that it is low cost and it can be used for any motor with any rating with a minor modification in the hardware. As the fuzzy controller design does not require system parameters, it is expected to work satisfactorily even if the parameters of the system are changed. The designed fuzzy logic control system works well even when the parameters of the motor were changed.

The designed fuzzy controller’s performance was then analysed for the different parameters of the controller. The parameters chosen for analysis were the slope of the membership functions and the membership functions themselves. The analysis reveals that the triangular membership function is best suited for the DC-DC converter fed DC drive. The triangular membership function also has the advantage that it can be easily implemented in embedded systems. The analysis for the slope of the triangular membership functions is done by assuming three different slopes for the error and change in error in the universe of discourse. The results conclude that increasing the slope of change in error has no effect, while increasing the slope of the error improves the system performance by reducing the steady state error.

The properties of nonlinear modeling, adaptability and tolerance of ANN can be well used to control chopper fed DC drive. The data set for training the neural network was obtained from both the conventional controller and the fuzzy controller designed. So, two neural controllers viz., the fuzzy implemented neuron controller and PI implemented
neuron controller were designed and their performance were studied. The aim was to design a simple ANN controller with as low neurons as possible while improving the performance of the controller. The architecture of the neural network controller designed uses only three biased neurons. The input layer has two neurons and the output layer has only one neuron. The simulation studies show that the neuron controller provides better dynamic response. The neuron controller is easy to implement and requires less computation burden in an embedded system. The ANN control algorithm developed for real time embedded system implementation has very less code size and occupies less memory space. The designed ANN controller was tested for universality by implementing the same controller for two different motors. The results proved the controller could act as a universal controller.

The performance analysis and comparative study of all the designed PI, fuzzy and neuron controllers were done for the chopper fed embedded DC drive. The comparison on the response of the motor speed controllers was carried out based on the rise time and the steady state error. It has been found that PI implemented neuron controller is giving optimum results compared to the other controllers designed.

**7.2 DIRECTIONS FOR FURTHER WORK**

The intelligent control of separately excited DC motor with buck type DC-DC converter has been taken up in this work along with real-time implementation. Many modifications can be carried out in the work presented.

The intelligent control can be extended for other types of motors. The same DC-DC power converter with PWM control can be used for other configurations of DC
motors. For AC motors, the inverter, which converts DC-AC power, will be the power converter to be used. The control should aim to vary the frequency of the inverter output.

Many variations of the fuzzy controller are listed in literature. One of the possible modifications is to make the fuzzy controller adaptive. The scaling factor, the fuzzy set slopes or the fuzzy rules can be changed in real-time based on a performance factor. Similarly, self-organising fuzzy controller is also available in the literature. There is possibility of generating or fine-tuning of rules using Adaptive Neuro-Fuzzy Inference System (ANFIS). The ANFIS system uses neural networks with the controller model data to obtain and design the fuzzy controller. But, the work presented in this thesis has shown a better performance without the need for these variations.

The neural network controller presented has been trained using the designed PI and fuzzy controllers. In spite of these training data, the neural controller can be designed using Model Reference Adaptive Control technique. But this requires an actual model for the motor drive system used.

The controller implementation has been done on an 8051-based microcontroller in the work. The designed control algorithms can be implemented in other embedded system platforms such as DSP processors or VLSI based chips.