CHAPTER 7

CONCLUSION AND SCOPE FOR FUTURE WORK

The isolated hybrid power system is a better option to supply power to load where availability of the grid supply is negligible. These systems require special control strategies, because of intermittent nature of wind and frequent change in load demands. The number of output control strategies can be avoided if the diesel power generation unit is equipped with a load frequency control. The Load Frequency Controller and Blade pitch controller regulates the frequency and generated power of the wind-micro hydro-diesel hybrid power system using intelligent control techniques. The important contributions and conclusions are given below.

The mathematical modelling for Load Frequency Control and Blade pitch control of an isolated wind-micro hydro-diesel hybrid power system has been developed with supplementary PI controller. The different parameters of the Load Frequency and Blade pitch controllers, $K_{pp}$, $K_{pi}$, $K_{dp}$ and $K_{di}$ have been optimised using integral square error criterion. The dynamic performance of the hybrid system for LFC and BPC are observed by simulating the model with conventional PI controller. The performance of the system with PI controller is used for comparison with the proposed intelligent controllers designed in the thesis for various load disturbances and wind input power disturbances.
Fuzzy Logic Controller is designed and investigated with basic structure for LFC and BPC of the Hybrid system. The FLC showed better performance than conventional PI Controller.

Self tuning fuzzy logic PI controller is designed to tune the parameters \( K_p \) and \( K_i \) by suitable rule base. The dynamic performances are observed from simulation for wide range of load disturbances with self tuning FLPI Controller and compared with FLC. Self tuning FLPIC provides significant improvement in system performance by automatically tuning the parameter of PI controller.

Adaptive gain scheduling Fuzzy Logic PID Controller is designed to tune the parameters \( K_p, K_i \) and \( K_d \) by proper gain scheduling approach. The hybrid system is simulated with Adaptive gain scheduling FLPIDC for LFC and BPC against wide range of step load disturbances and wind input disturbances. It is observed from comparison that this controller is efficient in producing a reliable system performance by adapting it to the unpredictable load changes.

A different novel approach of fuzzy logic structure is used to design the Multi stage FLPID Controller. The parameters \( K_p, K_i \) and \( K_d \) are tuned in two different stages for improving the control performance of the isolated hybrid system. The Multi stage FLPIDC provides a satisfactory performance when compared to conventional PIC, FLC, FLPIC and FLPIC with less settling time and oscillations against various load disturbances. During wind input disturbance, Multi stage FLPIDC maintains the wind power generation and frequency of the system. The robust performance observed from simulation against wide range of load disturbances with Multi stage fuzzy logic technology proves its superiority.
A new approach of Neuro-Fuzzy Control has been investigated for regulation of frequency and generated power of the hybrid power system. The Neuro-Fuzzy Controller is developed based on ANFIS architecture to optimise its parameters. The performance improvement of the proposed controller is compared with conventional PIC and FLC in terms of settling time and oscillations. It has been observed that the proposed ANFIS based NFC is effective and provides improvement in system performance by combining the benefits of fuzzy logic and neural networks.

It is concluded that the proposed intelligent controllers such as Self tuning FL PIC, Adaptive gain scheduling FL PIDC, Multi stage FL PIDC and ANFIS based NFC can be extensively used for regulation of frequency and generated power of the isolated wind-micro hydro-diesel hybrid power system. Significant improvement in frequency response and power generation response is achieved in terms of less settling time and oscillations. Hence the application of intelligent techniques improves the system performance by easy adjustment of controller parameters based on system dynamics.

7.1 COMPARISON OF INTELLIGENT CONTROLLERS IN THIS WORK WITH PREVIOUSLY PUBLISHED TECHNIQUE

Bhatti et al (1997b) analysed the performance of the isolated wind-diesel- micro hydro hybrid power system for LFC using conventional PI controller only. They have analysed the transient responses of frequency deviation and wind power generation for 1% step load disturbance and input wind power disturbance. Responses recorded by Bhatti et al (1997b) for deviation in frequency and change in wind power generation are damped out for the above said disturbances, but not with zero steady state error value, as given in their publication.
The frequency oscillations $\Delta F_S$ settles only after some time (about 4 sec) and that too with error. It is observed that for a step increase in input wind power and load, the BPC and LFC designed with conventional controller by them, damps out the deviations in $\Delta P_{GW}$ with a settling time of about 12 sec with some steady state error value.

In my proposed work, the responses for frequency deviations are shown in Figure 4.29 for Adaptive gain scheduling FLPIDC and in Figure 5.11 for Multi-stage FLPIDC, against the same 1% step increase in input wind power. For various step increase in load, the frequency deviation responses for different intelligent controllers designed in my work are shown in Figures 3.8, 4.25, 4.31, 5.7 and 6.10.

The proposed intelligent controllers in this work brings the deviation $\Delta P_{GW}$ to zero with a settling time of about 1.4 sec to 2 sec as shown in Figures 4.9, 4.32, 5.8, 6.11 for various load disturbances and the responses of $\Delta P_{GW}$ are shown in Figures 4.30 and 5.12 for 1% step increase in wind input power.

Tables 4.3, 4.7, 5.4 and 6.1 presents the settling time in seconds for deviation in frequency, change in wind, diesel and hydro power against various load disturbances. The amplitude of oscillations for deviation in frequency, change in wind, diesel and hydro power of the hybrid system against various load disturbances are given in Tables 4.8, 5.5, 6.2 and 6.3.

It is observed from this, that the settling time, steady state error value and the amplitude of oscillation for change in frequency response, change in wind, diesel and hydro power against various load disturbances for the proposed intelligent controllers are less compared to the responses given by Bhatti et al. (1997b). This demonstrates the accuracy and the validity of this work.
7.2 SCOPE FOR FUTURE WORK

During the course of investigation of the present work, it has been found that there is a scope for future work in the following area.

- In the present work, Load Frequency Control and Blade Pitch Control of an isolated wind-micro hydro-diesel hybrid system for regulating the frequency and generated power have been investigated. Study may be made in future with combination of other renewable energy sources like wind-PV-diesel, wind-biogas-diesel etc.

- In the present work, the generation rate constraints of diesel power generation units have not been considered. It would be worthwhile to consider these practical constraints.

- Now, the hybrid system providing power to a local area is considered for investigation. It may be linked to grid via small HVDC line.

- Further study can be made using optimisation methods such as genetic algorithm, Particle Swarm Optimisation etc. to tune the controller parameters.

- Future research can be made for control of modern Wind Energy Conversion System (WECS) through the Power electronic control of Synchronous and Induction Generator drives.