ABSTRACT

In this thesis, different methods are proposed for overall improvement of frequency regulation of power system mainly with the help of demand side management (DSM) and battery energy storage system (BESS). At the beginning of the thesis, the different components of the power system are modeled including conventional and renewable generation units, battery storage unit and different modern equipment's for power system control. These components have impedances, time constants, gains, power ratings, capacities, start -up time etc, all of which are to be inputted into the computer model for simulation study. In view of the above information, this research uses different components of power system for frequency regulation analysis.

These modelling are used in the thesis to examine the role of demand side management (DSM) in automatic load frequency control (ALFC) in presence of distributed generations (DGs). DSM has been introduced in ALFC in terms of demand response (DR). DR is introduced in the ALFC model of two area power system consisting of wind energy conversion system (WECS). The frequency regulation due to load variation is studied and better results are obtained after introduction of DR.

In the next part of the thesis, the research investigated the dynamic behavior of a hydrothermal power network with the aid of demand side management (DSM). DSM provides prime to consumers about the usage of electricity and prevent cross subsidies among consumers with the aim to manage the supply and demand through an elegant program. In the present work DSM is incorporated in the automatic load frequency control (ALFC) of an interconnected hydrothermal power network to get better frequency regulation. Particle swarm optimization (PSO) technique is utilized to obtain optimal control parameter of the controller employed for DSM. The presence of DSM is found to be promising in the enhancement of dynamic stability of the hydro-thermal power network.

As DR found to be a promising technique for frequency regulation, so in the nest part of the thesis puts forward a lead compensator-based PI controller for DR loop which is included in the conventional ALFC model to improve the frequency control process of power system. Though DR is a good solution for ALFC but the vital problem in DR is the existence of communication delay between control center and appliances. The proposed lead compensator can generate phase lead at the output of the DR loop to eliminate the adverse effects of the

delay on the system performance. To verify the effectiveness of the proposed controller for ALFC problem, two different two-area transfer function models of power system are tested. At first the approach is analyzed for a wind integrated two-area thermal power system, later the same is extended for a two-area hydrothermal system. The system dynamic performances in presence of proposed compensator are obtained with all the controllers tuned. The Particle Swarm Optimization (PSO) technique is used to tune all the controller parameters of the DR loop as well as the ALFC loop. The results demonstrate the usefulness of the proposed lead compensator in the event of communication delay and step load variation. Finally, the performance of lead compensator in DR exhibits robust performance even with the variation in disturbance parameters and operating conditions in the system.

Furthermore, the thesis has taken a challenge to design a model predictive controller (MPC) for ALFC of two area, wind integrated thermal power system equipped with BESS and DR for frequency regulation task. Primarily, the incremental BESS model employs a new state of charge (SOC) based strategy to regulate the power from battery for saving battery life. Then DR, along with the SOC based BESS, is employed in ALFC for frequency regulation. A modified state space model of MPC incorporating all BESS variables is developed and employed in ALFC of the studied power system. The performance of the designed MPC is examined for inertia issues arising from wind in the conventional two area power system. Furthermore, the capability of BESS for frequency regulation and effect on the life of BESS with the proposed control strategy is measured through MPC based ALFC and results compared with system performance when integral controller in ALFC and inertia controller from wind are present. In addition to DR and BESS in ALFC, doubley fed induction generator (DFIG) based proportional derivative (PD) inertia controller also contributes in the power system for frequency support from wind energy section to avoid inertia issues. So, all the controllers of the test power system such as integral controller in ALFC and PD controller in wind are tuned concurrently for smooth frequency control. However, performance of MPC is tested for smooth frequency regulation by tuning PD controller gain of wind only while keeping MPC gain parameters as available in literature. particle swarm optimization (PSO) is used to tune the integral controller gain of ALFC for the studied power system to compare the results with MPC based ALFC. A transfer function model of wind integrated two area thermal power system is taken into consideration in the present study to verify the effectiveness of the battery variable concerning MPC design for ALFC collaborating with DR for smooth frequency control and provide safe battery life. Finally, results confirm the effectiveness of the designed

MPC based ALFC, collaborating with DR and SOC based incremental BESS through various case studies.

Finally, the thesis proposes a PSO based MPC for ALFC of microgrid (MG). The generalized state space analysis is considered to model the MPC including all controllable and uncontrollable generation unit. The proposed MPC is developed as a single input multi output system. The MPC is considered as parameter driven controller whose input parameter R_w is tuned with the help of widely used robust PSO technique to get better frequency control. Moreover, the proposed MPC is collaborated with demand response (DR) which in turn, is accompanied with a proportional plus integral (PI) controller with lead compensator-based delay compensator to avoid the delay issue in DR. So, the input parameter R_w of MPC for its online optimization, and PI controller gain parameters of DR are tuned by minimizing the performance index like integral time square error (ITSE) to get smooth frequency regulation for an isolated MG. To evaluate the effectiveness of the proposed scheme of frequency regulation, an isolated MG equipped with a conventional diesel unit, fuel cell, wind energy, solar energy and battery cell is taken as the test system. The effectiveness of the proposed scheme for frequency control is evaluated and compared with a robust fuzzy adaptive MPC. Finally, the results prove the efficacy of the proposed scheme through various case studies. In view of practical validation, the proposed frequency control scheme for the studied isolated MG is realized in real time through OPAL-RT OP5600 with RT lab version of 19.3.0.228.