CHAPTER 2
LITERATURE REVIEW

Synthesis and analysis of Automatic generation control (AGC) in power systems has an immense background and a lot of literature is available [1-3]. Over the past decades primary AGC schemes have evolved, and continue efforts are made in proposing novel intelligent AGC techniques with an enhanced capability to regulate system frequency and tie-line power close to nominal values. The early contributions in the field of AGC are listed in references[4]–[6].

2.1 OVERVIEW OF LOAD FREQUENCY CONTROL RELATED TO CONVENTIONAL AGC

Nasser Jaleeli et.al. [4] depicts what AGC may be required to do, and what may not be conceivable or convenient for it to do. The reasons and goals of AGC are restricted by physical components required all the while and, subsequently, the significant attributes of these components are portrayed.

AGC of a multi-area control system with traditional Integral controllers is carried out by J. Nanda, M. Parida, and A. Kalam [5]. Integral square error technique is used for the optimization of PI controllers.

D.M Vinod Kumar [6] displayed various approaches based on intelligent controllers for conventional single area and two area inter-connected AGC. The study has given rise to more research in the field of intelligent controllers as compared to the classical ones.

L.C Saikia et.al. in their paper [7] presented a performance comparison of various classical controllers for multi-area AGC. It is revealed from the.

investigations that Integral-Double Derivative controller yields better response as compared to other classical controllers

Elgerd and Fosha. [8], [9] in their work introduced the concept of optimal control theory to tackle the problem of load frequency control of interconnected power systems. Various nonlinearities for the AGC design have been considered.

2.2 AGC RELATED TO DEREGULATION

In a customary power system, generation, transmission, and distribution are possessed by a solitary element called a vertically integrated utility, which supplies energy to the clients at directed rates. Around the end of the twentieth century numerous nations looked to reduce coordinate government association and, to increment financial proficiency, began to change the power system administration structure, known as deregulation. There are a few control situations and AGC plans relying upon the power system structure. Diverse associations are presented for the arrangement of AGC as an ancillary service in nations with rebuilt control systems. The AGC benefit and related exchanges can be administered by an independent system operator (ISO), independent contract administrator (ICA), transmission system operator (TSO), or another capable association.

The traditional LFC in view of area control error is hard to actualize in a deregulated power system environment. As of late, a few control situations in light of strong and ideal methodologies have been proposed for the AGC framework in deregulated power system.

Christie and Bose [10] have tried to recognize likely deregulation situations and the specialized issues connected with LFC and distinguish specialized arrangements, for example, models and algorithms, required for the operation of this key segment of national framework even with significant basic changes.

Bakken and Grande [11] have exhibited a model of the interconnected power system to show how AGC may help the system operator in taking care of the expanded strain. In any case, the established LFC in light of the ACE was hard to execute in a deregulated environment. An option was subsequently presented where units were chosen naturally taking after load changes on the HVDC connections. This rump following controller (RFC) upheld by manual control appeared to be a promising alternative.

Ramandeep Kaur [12] analyzed the AGC of two area deregulated system with PI and PID controllers. Dynamic performance of the system is observed in terms of system parameters like frequency, area control error and tie line power control.

Wen Tan [13] in his paper determined the stability of multi-area decentralized load frequency control by examining the inbuilt structure of the power system. It is observed from the study that good damping performance is achieved.

Wen Tan [14] and Hong presented the robust analysis against parametric variations for multi-area power system under deregulation. It is demonstrated that singular value and an Eigen value method is convenient for the analysis for multi-area AGC under deregulation.

2.3 AGC RELATED TO FUZZY CONTROL THEORY

These days, on account of Robustness, and dependability, Fuzzy logic is broadly utilized as a part of the fields of science and innovation, including an extensive variety of control issues in power system control and operation. Not at all like the conventional control hypotheses, which are basically in view of the linearized numerical models of the controlled systems, fuzzy control system tries to set up the controller directly in light of the estimations, experiences, and information of area specialists/administrators.

A few studies have been accounted for the fuzzy logic based AGC system in the writing [15]–[17]. There are numerous fuzzy controllers for AGC purposes,

differing in the types of input and output and their membership functions. It is up to the user to choose which controller structure would be ideal for the AGC design.

B.Venkata Prasanth and Dr. S.V Jayaram Kumar [15] presented a new method for reducing transients of load frequency for an isolated power system. The deviation in frequency and its derivatives are chosen as input factors, the response of uncontrolled system with scope of estimations of regulation constant (R) and for different load perturbations were acquired. It is demonstrated that with the use of fuzzy control theory, the frequency transients were removed very quickly.

G.A Chown and R.C Hartman [16] in their paper portray the performance of a fuzzy controller for AGC. The fuzzy controller consequently demonstrated a change of more than half in the reduction of control contrasted with the original AGC controller.

J.Nanda et.al [17] described an AGC of interconnected Hydro-thermal system in the continuous discrete mode employing traditional integral and fuzzy controllers. The dynamic response under step disturbances is compared, considering integral and fuzzy controllers. It is shown that FLC gives a superior performance in comparison to the traditional PI controllers.

G.Hou [18] described a T-S model of FLC for AGC system after deregulation considering the effect of the nonlinearity and bilateral contracts .The scheme is compared with conventional PI controller which shows a better response.

Various researchers in their work [19]-[25] have proposed intelligent algorithms for tuning the fuzzy logic controllers for efficient performance utilizing the available expert knowledge of the AGC system. The Fuzzy controllers are optimized using numerous evolutionary computational algorithms.

Papers [19], [20] presents a novel approach for designing and optimizing the Fuzzy Controllers using GA.

J.S. Saini et. al. in [21] gave a technique of optimizing the membership functions and scaling factors of a FLC subjected to various set point alterations using a comprehensive fitness function based on performance indices.

S.K Sinha et.al [22], in their work displayed the utilizations of Genetic Algorithm and Particle Swarm Optimization procedures to enhance the execution of the Automatic Generation Control (AGC) in a three area power system.GA and PSO have been utilized for fine-tuning the parameters of an FLC. The controllers give enhanced performance under different working conditions.

Guolian [23] in his paper utilized Fuzzy PI controllers based on PSO for four area AGC in deregulating environment. Nonlinearities such as valve position limits and GRC were taken into account.Simulation results demonstrate that the proposed approach accomplishes better results as compared to the traditional PI controller in four area reheat thermal and hydro AGC system.

Pati and Sahu [24] presented AGC of a two area interconnected power system. The gains of PID controllers are evolved by utilizing a new hybrid differential evolution PSO (DEPSO) technique. Step disturbance of 1 % is applied in Area 1 to analyze the response of various structures of PID controllers. The outcomes uncover a superior execution for DEPSO optimized Fuzzy PID Controllers.

M. H. Khooban [25] proposed a new technique for on-line fuzzy tuning of PI controllers based on Self-Adaptive Modified Bat Algorithm (SAMBA).The strategy is applied to four area AGC and the performance is compared to the conventional controllers. It is demonstrated that the SAMBA controller is robust and stable against system uncertainties.

2.4 AGC (CONVENTIONAL AND DEREGULATED SCENARIO) RELATED TO INTELLIGENT TECNIQUES

The most recent advance in the AGC synthesis to tackle the difficulty of using complex/nonlinear power system models or insufficient knowledge about

the system is the application of intelligent concepts such as neural networks, fuzzy logic, genetic algorithms, and other evolutionary and heuristic optimization techniques. Various optimization techniques have been reported in the literature for the optimal design of the controller parameters and the performance indices.

The literature survey [26]-[29] indicates that, various intelligent algorithm based approaches including evolutionary computational algorithms were used during the early days of AGC.

Y.L. Abdel-Magid and M.M. Dawoud [27] gave an optimization technique using GA for a two area non- reheat thermal system . The optimization was carried out using the integral of the square of the error and the integral of time multiplied absolute value of the error.

It is observed through the survey that Genetic Algorithm and other Bio-inspired techniques [30]-[41] are immensely used for the design and optimization of AGC.

R.K Sahu [31] presented a new approach where parameters of PID controllers are optimized using hybrid Firefly Algorithm and Pattern Search (hFA–PS) technique for AGC of multi-area systems with GRC. The performance of the proposed controller is compared with other techniques such as Bacteria Foraging Optimization Algorithm (BFOA), GA and Ziegler Nichols based PI/PID controllers for the same system. The robustness of the system is demonstrated by varying the system parameters and loading conditions.

R.N Patel [32] in his work designed a Fuzzy logic controller and a combined intelligence technique using GA and PSO is used for Optimization of the FLC to improve the performance of the AGC.

Roy R, Ghosal S, et.al, [33] in their paper presented some novel evolutionary computation methods to optimize the gain parameters under transient performances. A new algorithm namely, modified chaotic ant swarm optimization (MCASO) and real coded GA (RGA) was amongst the best.

It is observed through the survey that Genetic Algorithm and other Bio-inspired techniques [34]-[41] are immensely used for the design and optimization of AGC.

Yannis L.Karnavas [37] utilized Genetic Algorithm to obtain the optimal parameters of the load frequency controllers and frequency biases. The performance of the Genetic tuned two area AGC system were found better to those of the same AGC system found in the literature.

Kanika Wadhwa and S.K Gupta [38] manages Automatic Generation Control (AGC) in a three area thermal power system under deregulated environment, in view of Bacterial Foraging (BFO) technique the concept of Disco participation matrix is used to simulate the two-sided contracts in three area AGC. The simulation demonstrates that BF upgraded controller give preferable results over conventional controllers.

Dash et.al [39], executed a 2DOF controller for AGC. Cuckoo search algorithm is used to optimize the gains of the secondary controller.

Sharma et.al [40] implemented a new Grey wolf optimization technique for optimizing the PID controller designed for a three area AGC using solar thermal power plant in one of the areas. It is revealed from the investigations that GWO optimized PID controller gives a better performance.

Survey on the latest research on AGC portrays the implementation of combined intelligence techniques in the field of AGC. Theories on various hybrid controllers [42]-[45] are available which has surpassed the limitation of the conventional and classical controllers used in multi-area AGC design.

G. Panda [42] introduced a Hybrid Neuro Fuzzy technique considering GRC for two area AGC. The performance of the controller is shown to be superior to PI and Fuzzy Logic controller with an ability to handle nonlinearities.

Panda and Mohanty [43] in their paper exhibited a HBFOA–PSO technique for AGC of an interconnected power system

Khuntia and Panda [44] introduced a new application of ANN based ANFIS technique to AGC of a three unequal area hydrothermal system. The

ANFIS controller consolidates the benefits of fuzzy controller and additionally fast response and flexibility nature of ANN.

Various researchers in their work have checked the Robustness of the proposed controllers for AGC by incorporating different types of non-linearities, Sandeep Bhongade et.al [46], introduced an Artificial Neural Network (ANN) based controller for multi-area AGC in a deregulated power system. The impact of SMES unit and GRC has been considered. Also in paper [47] effect of SMES unit is considered for restructured power system.

P.Ram [48] deals with the AGC of hydrothermal system having hydro unit with electric governor and thermal unit with reheat turbine and mechanical governor. Artificial Intelligence technique such as ANN and Neuro-fuzzy is used for the controller design further, GA is used for optimization purpose

Donde et al., [49] considered the impact of bilateral contracts on the dynamics on two area AGC. With deregulation of the power generation division, the need for an upgraded and open correspondence foundation to bolster an expanding variety of ancillary services was evident. Different advancement methods have been accounted for in the writing for the optimal design of the controller parameters.

Kumar and Tyagi [50] proposed an optimal controller in view of Action-Dependent Heuristic Dynamic Programming (ADHDP) approach for multi area Automatic Generation Control (AGC).

S. Debbarna [51] presents fractional-order Proportional–Integral–Derivative (FOPID) controller for multi-area AGC under deregulation with generator rate constraints (GRC). The performance of FOPID is compared with integer order (IO) controllers and is found to provide better dynamic performance. Further Bacterial foraging (BF) technique is used for optimizing the gains of the FOPID controller.

Saurabh Chanana [52] gave a price based AGC using unscheduled interchange price signals in Indian electricity system.

A.Dhamanda [53], in their research paper applied the evolutionary computing technique extended to the four area interconnected power of thermal generating unit

H.Bevrani et.al [54], displayed another intelligent scheme based on Bayesian network (BNs), to plan AGC in a multi-area power system. The outcomes demonstrate that the new controller introduces an alluring performance.

C.T Pan [55], in their work proposed adaptive controller design for AGC. The controller satisfies the hyper-stability condition using PI adaptation under parametric changes.

Debbarma et.al [56], introduced a 2-DOF-PIDD controller for three area AGC. Firefly algorithm (FA) based optimization is utilized to evolve the controller parameters.

In paper [57], author presents a novel approach using redox flow batteries and interline power flow controller for multi-area AGC in restructured scenario.

2.5 WIDELY USED INTELLIGENT TECHNIQUES

Numerous literatures are available on the intelligent algorithms and new researches are coming up at a very high pace. References [58]-[64] describe the various techniques adopted by the researchers to use BFO and GA. Some standard books [60], [61] and [64] gives a deep insight of the various techniques based on nature inspired optimization algorithms.

A detailed literature survey has been done with respect to the distinct controllers starting from the earlier conventional to the present hybrid intelligent controllers for multi-area AGC, both under conventional and restructured scenario. To reduce the frequency oscillations during transients and maintain the system stability within short period during the sudden load disturbance, and parametric variations, an intelligent controller which is robust and insensitive to disturbances is proposed.