A Review On Load Frequency Control of Two Area Power System Using Various Techniques

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Abstract- The objective of the control strategy is to generate and deliver power in an interconnected system as economically and reliably as possible while maintaining the voltage and frequency within permissible limits. In this paper the extensive discussion has been made on load frequency control. The survey includes the detail discussion of single area and double area power system and different control strategy that is the control techniques of conventional power system and soft computing techniques which can be used in load frequency control system.

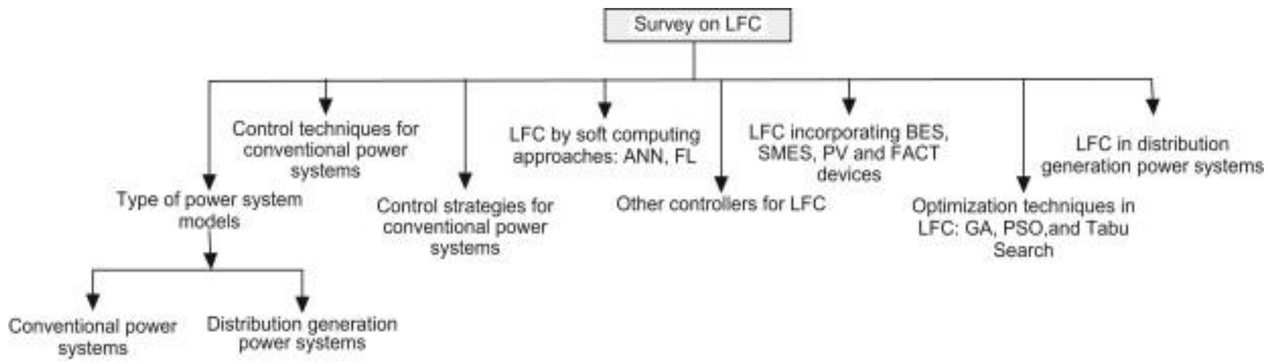
Keywords- *Interconnected system, automatic generation control, tie-line, PID controller and Fuzzy controller.*

I. INTRODUCTION

Modern Power Systems, with increasing electrical power demand are becoming more and more complicated. Large interconnected power systems consist of interconnected control areas which are connected through tie lines. Maintaining power system frequency at constant value is very important for the health of the power generating equipment and the utilization equipment at the customer end. The job of automatic frequency regulation is achieved by governing systems of individual turbine generators and Automatic Generation Control (AGC) or Load frequency control (LFC) system of the power system. Automatic generation Control (AGC) is used to maintain scheduled system frequency and tie line power deviations in normal operation and small perturbation. The changes in real power affect mainly the system frequency. In each area, an Automatic Generation Controller (AGC) monitors the system frequency and tie-line flows, computes the net change in the generation required (generally referred to as area control error – ACE) and changes the set position of the generators within the area so as to keep the time average of the ACE at a low value [new-1]. Therefore, ACE, which is defined as a linear combination of power net-interchange and frequency deviations, is generally taken as the controlled output of AGC. As the ACE is driven to zero by the AGC, both frequency and tie-line power errors will be forced to zeros [new-2]. Hence, AGC function can be viewed as a supervisory control function which attempts to match the generation trend within an area to the trend of the randomly changing load of the area, so as to keep the system frequency and the line power flow close to scheduled value. The growth in size and complexity of electric power systems along with an increase in power demand has necessitated the use of intelligent systems that combine knowledge, techniques and methodologies from various sources for the real-time control of power systems. The methods developed for control of individual generators, and eventually control of large interconnections, play a vital role in modern energy control centers. The AGC problem has been augmented with the valuable research contributions from time to time, like AGC regulator designs incorporating parameter variations, load characteristics, excitation control, and parallel ac/dc transmission links. The LFC issues have been tackled with by the various researchers in different time through AGC regulator, excitation controller design and control performance with respect to parameter variation/uncertainties and different load characteristics. As the configuration of the modern power system is complex, the oscillation incurred subjected to any disturbance may spread to wide areas leading to system blackout. In this context, advance control methodology such as optimal control, variable structure control, adaptive control, self-tuning control, robust and intelligent control were applied in LFC problem. The further research in this area has been carried out by use of various soft computing techniques such as artificial neural network (ANN), neurogenetic etc. To tackle the difficulties in the design due to nonlinearity in various segregated components of the controller. The controller parameters play a vital role for its performance, thus it should be tuned properly with suitable optimization techniques. In this context, the application of genetic algorithm (GA), particle swarm optimization (PSO), is exploited to address the optimization objective. Due to non-linearity in the power system components and also the uncertainty in the system parameters, the performance differs from actual models, so robust control design is indispensible to achieve acceptable deviation in frequency about the nominal operating point. Various robust control techniques such as Riccati equation, H∞, m-synthesis, robust pole assignment, loop shaping, linear matrix inequality (LMI) has been adopted to tackle the LFC problems. Now, there is rapid momentum in the progress of the research to tackle the LFC in the deregulated environment, LFC with communication delay, and LFC with new energy systems, FACTS devices, and HVDC links as well.

II. LOAD FREQUENCY CONTROL

The operation objectives of the load frequency control are to maintain reasonably uniform frequency, to divide the load between generators, and to control the tie-line interchanged schedules. the change in frequency and tie line real power are sensed, which is a measure of the change in rotor angle δ, i.e the error Δδ to be corrected. The error signal, i.e, Δf and ΔPtie , are amplified , mixed , and transformed into a real power command signal ΔPV, which is sent to the prime mover to call for an increment in the torque. The prime mover, therefore, brings changes in the generator output by an amount ΔPg which will change the values of Δf and ΔPtie within specified tolerance. When constant frequency is needed the turbine speed can be adjusted by varying the governor characteristic. The relationship between active power and frequency, three level automatic generation controls have been proposed by power system researchers [1]. Generally, ordinary LFC systems are designed with Proportional-Integral (PI) controllers [2]. Many studies have been carried out in the past on this important issue in power systems, which is the load frequency control. As stated in some literature , some control strategies have been suggested based on the conventional linear control theory [3-7]. These controllers may be improper in some operating conditions. This could be due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. In this study, different intelligent techniques such that Fuzzy Logic, *Genetic Algorithm* (GA) and *Particle Swarm Optimization* (PSO) algorithms will be used to determine the parameters of a PID controller according to the system dynamics. In the integral controller, if the integral gain is very high, undesirable and unacceptable large overshoots will be occurred. However, adjusting the maximum and minimum values of proportional (kp), integral (ki) and integral (kd) gains respectively, the outputs of the system (voltage, frequency) could be improved. In this simulation study, two area power system with two different parameters are chosen and load frequency control of this system is made based on PID controller. This work is an improvement of which assumes that the two areas of the power system have the same parameters which is not usually practical assumption for the real power system networks [8]. conventional PID controllers tuned by ZieglerNicholas technique, fuzzy technique and Particle Swarm Optimization. This work is also an improvement of by using the three different tuning techniques (Fuzzy Logic, GA and PSO) and by using saturation for the control valve while the previous work uses only one technique and don't take the saturation into consideration [9-11]. This work is also an improvement of that two power system areas connected are used instead of single power system area in the previous works [12-14]. The overshoots and Settling times with the proposed Genetic-PID controller are better than the outputs of the



computing techniques such as artificial neural network (ANN), fuzzy logic, genetic algorithm (GA), particle swarm optimization(PSO) algorithms, etc. has been explored. In this context to address the non linearities, system uncertainties, the intelligent LFC scheme may be the suitable alternative, then the traditional controls. Over the years, number of soft computing techniques has been applied in LFC problem for better control objective.

III.1. ARTIFICIAL NEURAL NETWORK (ANN)

The ANN is a black box which correlates the non-linear relationship between output and input without information of system structure. The ANN has been applied to achieve better control strategies especially in a non-linear complex power system. Beaufaysetal. [48] discussed the application of layered neural networks in nonlinear power systems, while Birchetal. [49] investigated the use of neural networks to act as the control intelligence in conjunction with a standard adaptive LFC scheme. Chaturvedi etal have developed an automatic load frequency controller using ANN to regulate the power output and system frequency by controlling the speed of the generator through water or steam flow control [50]. Demirorenet designed the controller, taking into account the governor dead band effect and reheat effect in two area inter connected power system [51]. Ahamed et al have viewed AGC problem as a stochastic multistage decision making problem or a Markov Chain control problem and have presented algorithm for design of AGC based on a reinforcement learning approach [52]. Talaqetal proposed an adaptive controller which requires less training patters as compared with a neural network based adaptive scheme and performance is observed better than fixed gain controller [53].

III.2. GENETIC ALGORITHMS (GAS)

The GA is a global search optimization technique based on operation of natural genetics and Darwinian survival of the fittest with a randomly structured information exchange. The GAs have been widely applied to solve complex nonlinear optimization problems in a number of

engineering fields in general and in the area of AGC of power systems in particular [54,55,56– 62]. The use of basic genetic algorithm on a digital computer to identify a hydro-generator plant is discussed in [55]. Dangprasert etal proposed GA based intelligent controller for LFC problem [63]. The GA based fuzzy gain scheduling approach for power system LFC is discussed in [64-65]. Magid and Dawoud proposed their study on optimal adjustment of the classical AGC parameters using GA [57]. The use of controllers to regulate the power output and system frequency by controlling the speed of the generator with the help of fuel rack position control is presented in [56]. The authors proposed GA for parameter optimization of PID sliding mode LFC for AGC in multi-area power systems with nonlinear element in [66]. Rerkpreedapong etal obtained a higher order
robust dynamic performance with LFC design based on GA and LMIs [54]. Next, Ghoshal proposed GA/GA-SA-based fuzzy AGC scheme in a multi-area thermal plant [62]. The hybrid GA-SA technique yields more optimal gain values than GA. DuandLi proposed on line fuzzy logic controller realization by GA in AGC problem [67]. The LFC by fuzzy PI controller is proposed in [68]. The optimization of control parameters for robust decentralized frequency stabilizer by using micro GA is presented in [69]. A new design of multi objective evolutionary algorithm based decentralized load frequency controllers for interconnected power system with AC-DC parallel tie lines is proposed Comparison of artificial intelligence methods for LFC study is discussed in detailed in [71]. The authors have discussed the design of load frequency controller in multi-area power system by use of multi-agent reinforcement learning approach in [72]. The LFC problem for four-area power system with discrete-sliding mode control using GA for proper tuning of the gains is discussed in [73]. The multi-objective optimization based GA used to optimize the gains of PI/PID-controllers for LFC of three-area thermal power systems is presented in [74].

III.3. PARTICLE SWARM OPTIMIZATION (PSO) ALGORITHMS

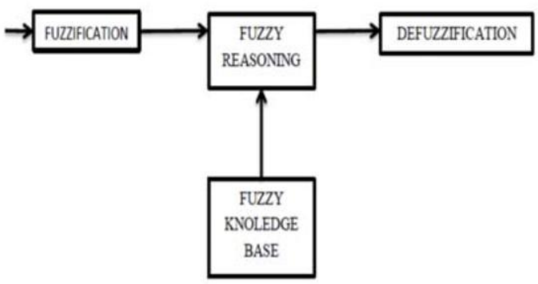
The PSO conducts searches using a population of particles which correspond to individuals in the GA. The PSO is a population based stochastic optimization technique, inspired by social behavior of bird flocking or fish schooling. To ease the design effort and there by improve the performance of the controller, the design of fuzzy PI controller by hybridizing GA and PSO is presented in [68]. With the use of control scheme based on adaptive neuro fuzzy inference and PSO with gains being updated in real time, a better dynamic and steady state response is obtained in [75]. Similarly the design of multi objective PID controller for LFC based on adaptive weighted particle swarm optimization in two area power system is described in [76-77]. Since PSO is less susceptible to local optima unlike GA, SA, the heuristic evolutionary search technique based hybrid particle swarm optimization has been adopted for determination of optimal PID gains for LFC in four area power systems having deregulation environments [78].

III.4. FUZZY CONTROLLER

Fuzzy set hypothesis and fuzzy rationale secure guidelines of a nonlinear plotting. Utilization of fuzzy sets gives a premise to a organized path for the requisition of indeterminate and inconclusive prototypes. Fuzzy controller is focused around a legitimate structure termed fuzzy rationale is very nearer in soul to human intuition and regular dialect than established intelligent systems. These days fuzzy rationale is utilized as a part of very nearly all parts of manufacturing and science. From those LFC is one. The primary objective of LFC in connected power networks is to secure the harmony among handling and utilization. In light of the multifaceted nature and multi-parameterized states of the power system, traditional controller strategies possibly will not give acceptable results. Then again, their strength and unwavering quality make fuzzy controllers helpful in understanding an extensive variety of control issues. The fundamental constructing units of a Fuzzy Logic Controller are a fuzzification unit, a fuzzy rationale thinking unit, a learning base, and a defuzzification unit. It is the procedure to change the convinced fuzzy control movements to a fresh control movement.

Assumptions in FLC system:

- The input and output variables can be witnessed and calculated.
- An acceptable result, not certainly a best, is adequate.
- A linguistic design may be created centered on the facts of a human expert.
- The human expert helps in modeling the linguistic model based on his knowledge The basic building block of a fuzzy logic controller consist of four parts namely fuzzification of input followed by fuzzy reasoning and rule base to make perfect decisions. Then this block is being followed by knowledge base which defines all variables and parameters. The last block is the de-fuzzification block whose main function is to convert the fuzzy outputs to definite crisp values.



CONCLUSION

The techniques and strategies of LFC for conventional systems attracted much discussion in the recent past. An effort has been made to present critical and comprehensive revive on this subject. Emphasis has been given how to tackle the LFC issues in power system. A detail survey has been done and presented. Light has been thrown on categorizing various power system structure/ layout reported in the literature that focuses on LFC control techniques adopted and their shortcomings. This survey paper will serve as a valuable reference for researchers to work on LFC problem in two area power system.

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