A Critical Review on LFC Controller using Intelligent Control Techniques

Shelja[1], Pawan Kumar[2]
[1]Research Scholar, DCSA, NIILM University, Kaithal, Haryana
[2]Assistant Professor, NIILM University, Kaithal, Haryana

ABSTRACT:

Our power system is interconnected one where no of generators are connected together and run in unison manner to meet the demand. Here Control of frequency is paramount to counterbalance the power system by oversee the changes in frequency and load. A high-quality power system is the one, in which the voltage and frequency of the power stay in desired value irrespective of random load changes. The active power and frequency control are called load frequency control (LFC). Further, LFC remains a major challenging issue in an interrelated multi-area power system. Load frequency control (LFC) is required for reliable operation of a large interconnected power system. The main work of load frequency control is to regulate the power output of the generator within a specified area with respect to change in the system frequency and tie-line power; such as to maintain the scheduled system frequency and power interchange with other areas in a prescribe limits. This paper presents a comprehensive literature survey on LFC. LFC model over the multi-area multi-source interconnected power system are discussed briefly and is categorized under these three phases (1) Optimization based LFC, (2) Machine Learning based LFC and (3) other models.

KEYWORDS: Load frequency control, optimization, frequency deviation, Fuzzy Control, GA

INTRODUCTION

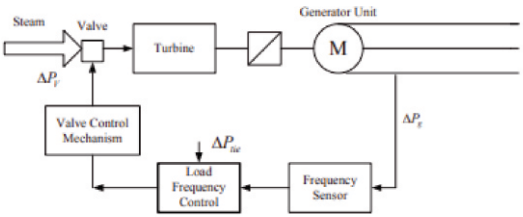
The objective of the load frequency control (LFC) is to maintain the

ISBN: 978-81-955611-3-1

scheduled frequency and scheduled tie-line power in a normal mode of operation, during the small perturbation in operating conditions. It maintains the generator-demand of an area in a prescribed limit by adjusting the governor output [1, 2]. The large interconnected power systems are composed of control areas or regions, representing a coherent group of generators. The different areas are inter-connected through tie-lines. The tie-lines are utilized for exchanging the energy between the consecutive two-areas and provides inter-area support in case of abnormal conditions of the power system [3]. On occurrence of load change, the mismatch in frequency and scheduled power interchange between areas takes place in the system. This mismatch has to be corrected by load frequency control (LFC), which is defined as the regulation of power output of generators within a tolerable limit [4]. Number of conventional controller like PID, PI, I are used in a control system, as this controller is simple to implement, easy to understand and having low cost. Nature of their control strategy is reliable and reported as robust for some operating conditions. However, the response of system with these controllers is slow and poor in comparison to the intelligent controller [5]. Many control techniques have been reported in literature to control the frequency and tie-Line power in LFC system; like adaptive neuro fuzzy inference system , GA based controller. The large, complex and inter-connected power systems suffer with a large number of nonlinear properties therefore, fuzzy logic controller is one of the better controller these systems.

SYSTEM FOR LFC: The reason of frequency drop is that the prime mover slows down to compensate for the imbalance in power; however, the speed is controlled by the power generation. As the speed change diminishes; the error signal becomes smaller, and the governor speed is made constant. However, it is impossible to fix the governor speed to a set point because the load is varying with time; therefore, we use a control system with an integrator. The control mechanism analyses the change and make corrections accordingly to remove offsets [5]. The ability of the system to come back to its normal value is termed as reset point. Therefore, the AGC is a scheme which restores the frequency to its nominal value automatically. In Fig. 1 the AGC for single area is shown, the AGC consist of a governor system which provides a signal to the turbine to adjust its speed to maintain the frequency constant.

ISBN: 978-81-955611-3-1



INTELLIGENT CONTROL TECHNIQUES:

Optimization is a mathematical regulation that concern the finding of minima and maxima of function, subjected to so call constraints. Today, optimization comprises a wide variety of techniques from operations research, artificial intelligence and computer science, and used to improve business processes in practically all industries. Optimization means the act of finding the best solution. Mathematical programming or optimization modeling is a branch of mathematical modeling which is concerned with finding the best solution to a problem. In further different methods have been proposed in the aim to regulate this problem. However, the difficulties in LFC are not only to design a robust controller but it also to optimize its parameters effectively for optimal solution to attain this objective, many optimization approaches are applied in LFC problem and are available such as: Genetics Algorithm (GA), Particle Swarm Optimization (PSO) technique, Bacterial Foraging Optimization (BFO), Differential Evolution Algorithm (DEA), Artificial Neural Networks (ANN), Fuzzy Logic Control (FLC) and other intelligent approaches.

OPTIMIZATION BASED LFC:

In 2016, Shankar and Mukherjee [6] have dealt with the LFC learning on interconnected two-area and single-area power system with expanded power sources. In order to initialize the memory and to generate jumping, the classical controller's gain has to be optimally tuned. This was made by introducing a new HSA algorithm, which was the music-inspired algorithm that integrates the quasi opposition based learning technique. From the results, it was found that the PID controller in the view of performance has achieved better for the learned power system approaches. Further, the performance of the interconnected two-area power system with AC–DC TL has validated betterment while comparing with AC based TL. In 2016, Guha

ISBN: 978-81-955611-3-1

et al. [7] has intended to resolve LFC problem within an interconnected power system network that deployed with classical PI/PID controller by means of GWO algorithm. In the modeling of system, the GRC of the steam turbine was also involved and the aforementioned system's dynamic stability has been examined investigated under the GRC presence. The optimization of controller gain has been made. by means of GWO algorithm that deploys the ITAE assisted fitness function. Subsequently, the analysis was performed in terms of sensitivity by altering the operating load conditions and parameters of system in the interval ±50%. The experimental outcomes have shown the superior tuning capability of GWO than EPSDE, CLPSO and other equivalent population-based optimization approaches[8].

MACHINE LEARNING BASED LFC:

In 2017, Azeer et al. [9] has considered the issue of LFC by means of intellectual controllers. Three turbine types were considered called the hydraulic turbine, non-reheat steam turbine, and reheat steam turbine. The implementation and analysis of two-area power systems underwent unexpected load changes in every area. The main intension was on eliminating errors occurred due to disturbances in TL power and frequency so as for ensuring a financial power generation. The designing of FL, PID, and ANN-NAR MA-L2 compensating methods were done and was experimented successfully. On considering these three cases, the steadystate errors existed within the systems was neglected. The outcomes gained were challenging and have shown the reasonable intelligent controller's performance in attaining LFC. In 2018, Khan et al. [10] has presented a novel model for LFC on the basis of self-tuning fuzzy Proportional Derivative model. This research work has used the proposed controller for controlling the high-penetration mini-hydropower system's frequency. The designing of diesel generator and mini-hydropower system were made within the microgrid for satisfying the demand at low stream flow. Though, when the hydropower generation goes beyond the consumer demand, the diesel generator was shut down. The controlling of frequency was handled by captivating excessive generation via secondary load bank from hydropower system. The system performance using the novel control structure was measured by means of experimentation under variations in dynamic frequency. The experimental outcome has explained the deployment of the implemented LFC with highperformance and robust frequency control while comparing over traditional fixed-gain PD controller. In 2015, Prakash and Sinha have considered the two areas hydro-thermal power system associated

ISBN: 978-81-955611-3-1

via TL. An automatic generation control for the two area interconnected power systems was handled by the intelligent controllers such as ANN, FL, and hybrid fuzzy NN techniques.

GA BASED LFC:

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 [11– 14]. The use of basic genetic algorithm on a digital computer to identify a hydro-generator plant is discussed in [12]. Dangprasert etal proposed GA based intelligent controller for LFC problem . The GA based fuzzy gain scheduling approach for power system LFC is discussed in [15-16]. Magid and Dawoud proposed their study on optimal adjustment of the classical AGC parameters using GA [14]. 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 [13]. The authors proposed GA for parameter optimization of PID sliding mode LFC for AGC in multi-area power systems with nonlinear element in [17]. Rerkpreedapong etal obtained a higher order robust dynamic performance with LFC design based on GA and LMIs [13]. Next, Ghoshal proposed GA/GA-SA-based fuzzy AGC scheme in a multi-area thermal plant and LFC by fuzzy PI controller is proposed in [18-23].

CONCLUSION:

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. This paper has made a examination over the different contributed papers related to the topic on LFC in multi-area multi-source interconnected power system. The LFC was very much essential for regulating the voltage and frequency in the power system. In this, various models related to this research work in the literature were discussed and categorized under groups named optimization based LFC and Machine learning based LFC.

ISBN: 978-81-955611-3-1

REFERENCES

[1] Usman A, Divakar BP. Simulation study of load frequency control of single and two area systems. In: IEEE Global Humanitarian Technology Conference (GHTC, '12'). 2012;214-219.

[2] Yesil E, Gzelkaya M, Eksin I. Self tuning fuzzy PID type load and frequency controller. Energy Conversion and Management. 2004;45(3):377-390.

[3] Nanda J, Mangla A. Automatic generation control of an interconnected hydro-thermal system using conventional integral and fuzzy logic controller. In: Proceedings of the 2004 IEEE International Conference on Electric Utility Deregulation, Restructuring and Power Technologies, (DRPT 2004). 2004;1:372-377

[4] Farahani M, Ganjefar S, Alizadeh M. PID controller adjustment using chaotic optimisation algorithm for multi-area load frequency control. IET - Control Theory Applications. 2012;6(13):1984-1992. DOI: 10.1049/iet-cta.2011.040

[5] D. K. Sambariya1 and Vivek Nath, "Load Frequency Control Using Fuzzy Logic Based Controller for Multi-area Power System" in British Journal of Mathematics & Computer Science, 13(5): 1-19, 2016, Article no.BJMCS.22899 ISSN: 2231-0851.

[6] V. Gholamrezaie, M. G. Dozein, H. Monsef and B. Wu, "An Optimal Frequency Control Method Through a Dynamic Load Frequency Control (LFC) Model Incorporating Wind Farm," in *IEEE Systems Journal*, vol. 12, no. 1, pp. 392-401, 2018.

[7] Y. Xu, C. Li, Z. Wang, N. Zhang and B. Peng, "Load Frequency Control of a Novel Renewable Energy Integrated Micro-Grid Containing Pumped Hydropower Energy Storage," in *IEEE Access*, vol. 6, pp. 29067-29077, 2018.

[8] Shankar and V. Mukherjee, "Quasi oppositional harmony search algorithm based controller tuning for load frequency control of multi-source multi-area power system", Electrical Power & Energy Systems, vol. 75, pp. 289-302, February 2016.

[9] Dipayan Guha, Provas Kumar Roy and Subrata Banerjee, "Load frequency control of interconnected power system using grey wolf

ISBN: 978-81-955611-3-1

optimization", Swarm and Evolutionary Computation, vol.27, pp.97-115, April 2016.

[10] H. Bevrani and P. R. Daneshmand, "Fuzzy Logic-Based Load-Frequency Control Concerning High Penetration of Wind Turbines," in IEEE Systems Journal, vol. 6, no. 1, pp. 173-180, 2012.

[11] H. A. Yousef, K. AL-Kharusi, M. H. Albadi and N. Hosseinzadeh, "Load Frequency Control of a Multi-Area Power System: An Adaptive Fuzzy Logic Approach," in IEEE Transactions on Power Systems, vol. 29, no. 4, pp. 1822-1830, 2014.

[12] Deepesh Sharma, "Load Frequency Control: A Literature Review," in international journal of scientific & technology research volume 9, issue 02, february 2020 issn 2277-861

[13] S. A. Azeer, R. Ramjug-Ballgobin, S. Z. Sayed Hassen," Intelligent Controllers for Load Frequency Control of Two-Area Power System", IFAC-PapersOnLine, vol.50, no.2, pp.301-306, December 2017.

[14] M. Reyasudin Basir Khan, Jagadeesh Pasupuleti, Razali Jidin," Load frequency control for mini-hydropower system: A new approach based on self-tuning fuzzy proportional-derivative scheme", Sustainable Energy Technologies and Assessments, vol.30, pp.253-262,December 2018.

[15] RerkpreedapongD, HasanovicA, FeliachiA. Robust load frequency control using genetic algorithms and linear matrix inequalities. IEEE Transactions on Power Systems 2003;18(2):855–61.

[16] WrateCA, WozniakL . Hydro-generator system identification using a simple genetic algorithm. IEEE Transactions on Energy Conversion 1997;12(1):60–5.

[17] KarnavasYL, PapadopoulosDP. AGC for autonomous power system using combined intelligent techniques .Electric Power Systems Research 2002;62 (3):225–39.

[18] Abdel MagidYL, DawoudMM. Optimal AGC tuning with genetic algorithms. Electric Power Systems Research 1996;38(3):231–8.

[19] Juang CF, Lu CF. Power system load frequency control by genetic fuzzy gain scheduling controller .Journal of the Chinese Institute of Engineer 2005;28 (6):1013.

ISBN: 978-81-955611-3-1

[20] Juang Chia Feng, Lu Chun-Feng. Power system load frequency control with fuzzy gain scheduling designed by new genetic algorithms. In :Proc.2002 IEEE international conference on fuzzy systems, vol.1;2002.p.64–68.

[21] Pingkang Li, etal. , Genetic algorithm optimization for AGC of multi area power systems. In: Proceeding, of IEEE TEN CON'02, 2002;p.1818–1821.

[22] Juang CF, LuCF. "Load frequency control by hybrid evolutionary fuzzy PI controller". IEE Proceedings Generation, Transmission and Distribution 2006; 153(2):196–204.

[23] Amit Pandey. Archana Gupta "A Literature Survey: Load Frequency Control of Two Area Power System Using Fuzzy Controller" ISSN (PRINT): 2395-7786, (ONLINE):2395-7794, VOLUME-1, ISSUE-1, 2015.

ISBN: 978-81-955611-3-1