A Review on Adaptive Load Frequency Control Techniques for Electric Vehicles

Vikas Rathore[1], Prof. Hemant Patidar[2]
Department of Electrical and Electronics Engineering[1,2]
Oriental University, Indore[1,2]

Abstract: Since power system loads might fluctuate, system controllers should strive to maintain consistent, high-quality service. An interconnected system's power flow and frequency are well-regulated by AGC. The AGC's primary function is to dampen the effects of disruptions by maintaining a steady system frequency. In AGC, voltage and frequency are typically the two variables under control. They are autonomous from one another and have their own control loops. In addition to frequency control, the secondary goals are to guarantee ideal transient behavior inside the linked Areas and to keep the steady-state error to zero. With electric vehicles serving as the load, this article provides a thorough overview of current methods for designing smart controllers to regulate load frequency in power systems. This paper presents a comprehensive review of baseline approaches in the domain with their salient features.

Keywords:- Multi- Area Power System., Electric Vehicles, Load Frequency Control, Machine Learning.

I.Introduction

The load connected to the electricity system is inherently variable, fluctuating continuously according to environmental and geographical factors. Furthermore, this variance results in a modification of system parameters. In order to ensure the stability of any system, the characteristics of the power system must be preserved within a specific limit and adhere to all predetermined restrictions. Automatic generation control (AGC) is a technique employed to manage and control the power transmission and frequency within a power system. Adaptive Frequency Control (AGC) maintains

the stability of the system by implementing distinct control loops for voltage and frequency, which are influenced by strain or load fluctuations.

In addition to regulating frequency, it is crucial to maintain a fixed steady-state error of zero and guarantee excellent transient behavior within the interconnected Areas. The goal is to develop a controller that can accurately manage the desired power flow and frequency in the power system.

The input mechanical power is leveraged to regulate the frequency of the generators, and the changes in frequency and tie-line power are measured to determine the degree of change in the rotor angle. An effectively designed power system should be able to provide adequate levels of power quality by maintaining the frequency and voltage characteristics within the desired range to the greatest extent possible.

Maintaining a relatively constant frequency is essential for the proper functioning of a power system. Deviation in frequency can immediately disrupt the functioning, reliability, and efficiency of a power system. Significant frequency fluctuations can cause equipment damage, impair load performance, and induce overload in transmission lines. These instances of significant deviations in frequency can finally result in a system failure. The operation and speed control of induction and synchronous motors are negatively impacted by fluctuations in frequency. A substantial decrease in frequency may lead to elevated magnetizing currents in induction motors and transformers, thereby causing an increase in reactive power consumption.

II Need for Load Frequency Control

With many loads linked to a system in a power system, speed and frequency vary with the characteristics of the governor with variations in loads. No need to modify the setting of the generator if maintaining constant frequency is not needed. When a constant frequency is needed the turbine speed can be adjusted by varying the governor characteristic.

Let both generating stations are interconnected through a tie line. If the load varies at X or Y & A generation has to maintain the constant frequency, at that time it is known as Flat Frequency Regulation.

- Secondly, where both X & Y have to maintain constant frequency. It is known as parallel frequency regulation.
- Thirdly where frequency maintenance is done of a certain Area by its generator & keeping constant the tie-line loading. It is called flat tie-line loading control.
- In Selective Frequency control, individually system handles the variation in load itself & without interfering, beyond its limits, the maintenance of the other one in that group.
- In Tie-line Load-bias, control all systems in the interconnection help in maintaining frequency no matter where the variation is created. It has a principal load frequency controller & a tie line plotter determining input power on the tie for proper control of frequency.

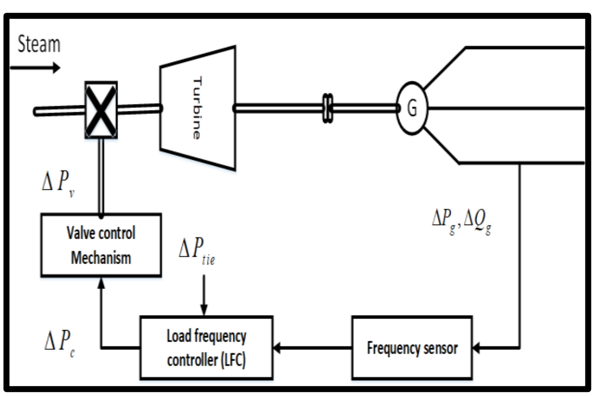

Fig.1 Block Diagram of Load Frequency Control

LFC Problem in Two Area Power System

For large scale, electric power systems with interconnected areas, Load Frequency Control (LFC) is important to keep the system frequency and the inter-area tie power as near to the scheduled values as possible. The input mechanical power to the generators is used to control the frequency of output electrical power and to maintain the power exchange between the areas as scheduled. A well designed and operated power system must cope with changes in the load and with system disturbances, and it should provide an acceptable high level of power quality while maintaining both voltage and frequency within tolerable limits. Load frequency control is a basic control mechanism in the power system operation. Whenever there is variation in load demand on a generating unit, there is a momentarily an occurrence of an unbalance between real-power input and output. This difference is being supplied by the stored energy of the rotating parts of the unit.

Load Frequency Control (LFC) is being used for several years as part of the Automatic Generation Control (AGC) scheme in electric power systems. One of the objectives of AGC is to maintain the system frequency at a nominal value (50 Hz).

A power system consists of a governor, a turbine, and a generator with the feedback of regulation constant. The system also includes step load change input to the generator. This work mainly, related to the controller unit of a two-area power system. The load frequency control strategies have been suggested based on the conventional linear Control theory. These controllers may be unsuitable in some operating conditions due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. To some authors, variable structure control maintains the stability of system frequency. However, this method needs some information for system states, which are very difficult to know completely. Also, the growing needs of complex and huge modern power systems require the optimal and flexible operation of them. The dynamic and static properties of the system must be well known to design an efficient controller.

III. Previous Work

This section presents the contemporary work in the domain.

[1] Mohamed, M.A., Diab, A.A.Z., Rezk, H, "A novel adaptive model predictive controller for load frequency control of power systems integrated with DFIG wind turbines", This paper introduces a novel frequency control system utilizing a mix of adaptive model predictive controller (AMPC) and recursive polynomial model estimator (RPME) integrated with double fed induction generator wind turbines. Inside each control duration, the RPME is identifying a discrete-time online autoregressive exogenous model. The latter is used through the AMPC to update the interior plant model in order to achieve a successful nonlinear control. The performance of the proposed system has been verified and contrasted with the conventional MPC system through a computer simulation-based MATLAB/SIMULINK. The simulation results demonstrated the superiority of the proposed system as for the conventional MPC system.

[2] Anestis G. Anastasiadis, Georgios P. Kondylis, Apostolos Polyzakis, Georgios Vokas, "Impacts of Increased Electric Vehicles into a Distribution Network". In this paper introduced that Grids face another and significant test: the approaching mass entrance of module Electrical Vehicles (EVs). By the by, the models of transmission and appropriation matrices are as yet centered around customary plan and operational standards. Thusly, it is important to anticipate the satisfactory answers for the issues which will ascend to the electrical and creation frameworks just like the impact on their business activity because of the continuous joining of EVs into the organization. For instance, significant clog issues may show up in as of now vigorously stacked frameworks just as voltage profile issues fundamentally in spiral organizations, especially

[3] Anil Annamraju and Srikanth Nandiraju, "Facilitated control of regular force sources and PHEVs utilizing Jaya calculation upgraded PID regulator for recurrence control of a sustainable infiltrated power framework". This paper talked about that in sustainable infiltrated power frameworks, recurrence precariousness emerges because of the unpredictable idea of sustainable power sources (RES) and burden aggravations. The customary burden recurrence control (LFC) methodology from traditional force sources (CPS) alone incapable to control the recurrence deviations brought about by the previously mentioned aggravations. with the JAYA streamlined LFC without PHEVs and with PHEVs yet no coordination.

[4] Neofytos Neofytou, Konstantinos Blazakis, Yiannis Katsigiannis, and Georgios Stavrakakis, "Demonstrating Vehicles to Grid as a Source of Distributed Frequency Regulation in Isolated Grids with Significant RES Penetration". In this paper, the effect of the module crossover electric vehicles (PHEVs) in the essential recurrence guideline is examined and the impacts PHEVs cause in non-interconnected confined force frameworks with critical sustainable power sources (RES) infiltration. Likewise, it is mulled over the necessities of clients for charging their vehicles. The V2G activity can be performed either with changes in the charging intensity of vehicles or by charging or releasing the battery. Thusly, an electric vehicle client can take an interest in V2G activity either during the stacking of the vehicle to the charging station or by associating the vehicle in the charging station with no further requests to charge its battery. In this paper, the reaction of PHEVs concerning the recurrence changes of the organization is demonstrated and mimicked. Furthermore, by utilizing the Power World Simulator programming, reproductions of the separated force arrangement of Cyprus Island, including the current RES entrance are acted to exhibit the adequacy of V2G activity in its essential recurrence guideline.

[5] Tawfiq Hussein and Awad Shamekh, "Plan of PI Fuzzy Logic Gain Scheduling Load Frequency Control

in Two-Area Power Systems". In this paper, the utilization of the relative fundamental (PI) calculation consolidated with the fluffy rationale method has been proposed as cutting-edge gain planning load recurrence control (GLFC) in two-region power frameworks. The proposed regulator contains two-level control frameworks, to such an extent that it comprises of an unadulterated indispensable compensator, which is associated, in corresponding with a PI regulator.
[6] T. Mohammed, J. Momoh, and A. Shukla, "Single zone load recurrence control utilizing fluffy tuned PI regulator". This investigation means to build up a Load Frequency Control (LFC) for a solitary territory power framework utilizing a fluffy rationale tuned PI regulator. A deviation of recurrence esteem from the norm (±0.5Hz) emerges when genuine force age neglects to gracefully request alongside network misfortunes. Different LFC considers have been finished misusing control procedures extending from old-style control plans to delicate investigation methods. In this proposed investigation framework elements are demonstrated in MATLAB Simulink. Traditional PI regulator is planned and tuned with two strategies: utilizing Ziegler Nichols (ZN) tuning and PID tuner application from the MATLAB control framework tool compartment.

[7] S. Jennathu Beevi1, R. Jayashree, S. Shameer Kasim, "ANN Controller for Load Frequency Control". This paper talked about in this paper the Artificial Neural Network (ANN) Controller for load recurrence control of Multi-zone power framework is introduced. The exhibitions of ANN Controller and customary PI regulators are thought about for Single territory and Multi-region power framework with non-warm turbines. The viability of the proposed regulator is looked at by applying load aggravations. The dynamic reaction of the heap recurrence control issue is considered utilizing the MATLAB Simulink bundle. The outcomes show that ANN Controller displays better execution.

[8] V. S. Sundaram and T. Jayabarathi, "Burden Frequency Control utilizing PID tuned ANN regulator in power framework". This paper examined a control plan of ANN-based corresponding basic subordinate (PID) regulator is created here to keep up the framework recurrence at ostensible worth. Because of some entanglement of the present-day mechanical framework, the ordinary PID regulator isn't skilled to meet our prerequisite. The neural organization is having extraordinary ability in understanding intricate, nonlinear numerical issues. This paper presents the plan of the neuro-PID regulator model to improve the reaction and execution of a customary PID regulator.

[9] S. Baghya Shree, N. Kamaraj, "Crossbreed Neuro-Fuzzy methodology for programmed age control in rebuilt power framework". In this paper, a crossover mixes of Neuro and Fuzzy is proposed as a regulator to settle the Automatic Generation Control (AGC) issue in a rebuilt power framework that works under liberation platform on the two-sided strategy. In each control region, the impacts of the potential agreements are treated as a lot of new information signals in an adjusted conventional dynamical model. The unmistakable bit of leeway of this procedure is its high harshness toward huge burden changes and aggravations within the sight of plant boundary inconsistency and framework nonlinearities.

[10] D. K. Sambariya and Vivek Nath, "Burden Frequency Control Using Fuzzy Logic Based Controller for Multi-territory Power System". This paper talked about that Load recurrence control (LFC) is required for solid activity of an enormous interconnected force framework. The principle work of burden recurrence control is to direct the force yield of the generator inside a predetermined region as for change in the framework recurrence and tie-line power, for example, to keep up the booked framework recurrence and force an exchange with different territories in an endorse limits. In this paper, the investigation of the LFC framework for a single region and twofold territory non-warm framework is completed. Fluffy rationale regulator is utilized for controlling the recurrence and tie-line power deviation.

The power of the fluffy rationale regulator is seen for various stacking conditions.

Conclusion:

Load Frequency Control (LFC) is a technique used to regulate and control the output frequency signal of electrically produced power within a specific region in regard to variations in system loads. The present study examines the impact of electric vehicles on the variance in load frequency. This paper provides a comprehensive analysis of different intelligent optimization methods for load frequency control, specifically designed for electric vehicles linked to Power Systems. This paper presents the fundamentals of the subject along with contemporary research in the domain.

References

[1] Mohamed, M.A., Diab, A.A.Z., Rezk, H. *"A novel adaptive model predictive controller for load frequency control of power systems integrated with DFIG wind turbines"* Neural Comput & Applic 32, pp. 7171–7181 Springer, 2020.

[2] Anestis G. Anastasiadis, Georgios P. Kondylis, Apostolos Polyzakis, Georgios Vokas, "*Effects of Increased Electric Vehicles into a Distribution Network*", Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES18, Athens, Greece, pp. 586–593, Energy Procedia 157, ScienceDirect, 2019.
DOI: 10.1016/j.egypro.2018.11.223

[3] Anil Annamraju and Srikanth Nandiraju, "*Coordinated control of conventional power sources and PHEVs using jaya algorithm optimized PID controller for frequency control of a renewable penetrated power system*", Protection and Control of Modern Power Systems, Spinger open, 2019.
DOI: https://doi.org/10.1186/s41601-019-0144-2

[4] Neofytos Neofytou, Konstantinos Blazakis, Yiannis Katsigiannis, and Georgios Stavrakakis, "*Modeling Vehicles to Grid as a Source of Distributed Frequency Regulation in Isolated Grids with Significant RES Penetration*", Energies 2019, volume 12, mdpi journals, 2019.
DOI: 10.3390/en12040720

[5] Tawfiq Hussein and Awad Shamekh,"*Design of PI Fuzzy Logic Gain Scheduling Load Frequency Control in Two-Area Power Systems*", Designs 2019, Volume 3, Edition 26, mdpi journals, 2019.
DOI: 10.3390/designs3020026

[6] T. Mohammed, J. Momoh and A. Shukla, "*Single area load frequency control using fuzzy-tuned PI controller*," *2017 North American Power Symposium (NAPS)*, Morgantown, WV, pp. 1-6, IEEE, 2017.
DOI: 10.1109/NAPS.2017.8107352.

[7] S. Jennathu Beevi1, R. Jayashree, S. Shameer Kasim, "*ANN Controller For Load Frequency Control"*, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 4 Issue I, 2016.

[8] V. S. Sundaram and T. Jayabarathi, "*Load Frequency Control using PID tuned ANN controller in power system*," *2011 1st International Conference on Electrical Energy Systems*, Newport Beach, CA, pp. 269-274, 2011.
DOI: 10.1109/ICEES.2011.5725341.

[9] S. Baghya Shree, N. Kamaraj,"*Hybrid Neuro Fuzzy approach for automatic generation control in restructured power system*", Electrical Power and Energy Systems 74, pp. 274–285, Elsevier, 2016.
DOI: http://dx.doi.org/10.1016/j.ijepes.2015.05.029

[10] D. K. Sambariya and Vivek Nath, "*Load Frequency Control Using Fuzzy Logic Based Controller for Multi-area Power System*", British Journal of Mathematics & Computer Science", 13(5), PP. 1-19, SCIENCEDOMAIN international, 2016.
DOI: 10.9734/BJMCS/2016/22899

[11] S. K. Jain, A. Bhargava and R. K. Pal, "*Three area power system load frequency control using fuzzy logic controller*," 2015 International Conference on Computer, Communication and Control (IC4), Indore, pp. 1-6, IEEE, 2015.

DOI: 10.1109/IC4.2015.7375614.
[12] H. Shayeghi, H. A. Shayanfar,"*Application of ANN Technique for Interconnected Power System Load Frequency Control*", 2015 International Conference on Computer, Communication and Control (IC4), 2015.
[13] S. K. Jain, A. Bhargava and R. K. Pal, "*Three area power system load frequency control using fuzzy logic controller*," 2015 International Conference on Computer, Communication and Control (IC4), Indore, 2015, pp. 1-6, IEEE, 2015.
DOI: 10.1109/IC4.2015.7375614.
[14] Poonam Rani, Mr. Ramavtar Jaswal, "*Automatic load frequency control of multi-area power system using ANN controller and Genetic algorithm",* International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 9, 2013.
[15] David B. Richardson, "*Electric vehicles and the electric grid: A review of modeling approaches, Impacts, and renewable energy integration*", Renewable and Sustainable Energy Reviews 19, pp 247–254, Elsevier, 2013.
DOI: http://dx.doi.org/10.1016/j.rser.2012.11.042
[16] K. A. Ellithy, K.A. El-Metwally, "*Design of Decentralized Fuzzy Logic Load Frequency Controller*", I.J. Intelligent Systems and Applications**,** MECS volume 2, pp 66-75**,** 2012.
DOI: 10.5815/ijisa.2012.02.08
[17] S. Prakash and S. K. Sinha, "*Four area Load Frequency Control of interconnected hydro-thermal power system by Intelligent PID control technique*," 2012 Students Conference on Engineering and Systems, Allahabad, Uttar Pradesh, pp. 1-6, IEEE, 2012.
DOI: 10.1109/SCES.2012.6199090.
[18] V. S. Sundaram and T. Jayabarathi, "*Load Frequency Control using PID tuned ANN controller in power system*," 2011 1st International Conference on Electrical Energy Systems, Newport Beach, CA, pp. 269-274, IEEE 2011.
DOI: 10.1109/ICEES.2011.5725341.