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Load Frequency Control of Multi Area System with the Help of Intelligent Controller Gain Optimizer: A Review

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Abstract —Load Frequency Control (LFC) are used to regulate and control the output frequency signal of the electric generated power within an area in response to changes in system loads. The gain constants in the case of conventional controllers remain same throughout, for changes in the load value. However, Load cannot be the same throughout, load deviates from time to time. To get rid of these disadvantages related to conventional controllers, a lot many schemes have been put forth in literature. This work presents a new design of various types of load frequency controllers based on different types of Artificial Intelligent (AI) optimization techniques such as Fuzzy logic, ANN tuner for a multi area power system.

KEYWORDS: *LFC, ANN, ANFIS, PI, Fuzzy, Multi- Area Power System.*

I. INTRODUCTION

As the loading in a power system is not constant so the controllers for the system must be aimed to provide quality service in the power system. The power flow and frequency in an interconnected system is well regulated by AGC. The main purpose of the AGC is to retain the system frequency constant and almost inert to any disturbances. Generally, two things are being controlled in AGC i.e., voltage and frequency. Both have separate control loops and independent of each other.

Apart from controlling the frequency the secondary majors are to maintain a zero steady state error and to ensure optimal transient behavior within the interconnected Areas. The objective is to design a controller to apprehend preferred power flow and frequency in single Area power system.

The input mechanical power is utilized to control the frequency of the generators and the variation in the frequency and tie-line power are detected, which is the extent of the alteration in rotor angle. A decently outlined power framework ought to have the capacity to give the satisfactory levels of power quality by keeping the frequency and voltage size inside middle of as far as possible.

II. LITERATURE REVIEW

The following section discuss the past work in the field of load frequency control.

Ziming Yan, Yan Xu [1] in 2020 presented a data-driven cooperative method for load frequency control (LFC) of the multi-area power system based on multi-agent deep reinforcement learning (MA-DRL) in continuous action domain. The proposed method can nonlinearly and adaptively derive the optimal coordinated control strategies for multiple LFC controllers through centralized learning and decentralized implementation. The centralized learning is achieved by MA-DRL based on a global action-value function to quantify overall LFC performance of the power system. To solve the MA-DRL problem, multi-agent deep deterministic policy gradient (DDPG) is derived to adjust control agents' parameters considering the nonlinear generator behaviors. For implementation, each individual controller only needs local information in its control area to deliver optimal control signals.

Andrew Xavier Raj Irudayaraj, et al. [2] in 2020 2020 discussed that the large-scale penetration of intermittent Renewable Energy (RE) sources such as wind and solar power generation may cause a problem of frequency aberration of interconnected Hybrid Power System (HPS). This occurs when the load frequency control of interconnected system is unable to compensate the power balance between generation and load demand. Also owing to the enhancement of future transport, the Plug-in Electric Vehicle (PEV) plays a significant role to customer at demand side. Thus, the PEV can act as a power control to compensate the power balance in Renewable Energy integrated power system. This paper presents a physics inspired Atom Search Optimization (ASO) algorithm for tuning the parameters of Fractional Order Proportional-Integral-Derivative (FOPID) controller for Automatic Load Frequency control of HPS. In this proposed work, an attempt has been made to analyze the frequency stability of HPS using Matignon's theorem. The interconnected HPS consists of reheat thermal power system, RE sources such as wind and solar thermal power generation associated with energy storage devices namely aqua electrolyzer, fuel cell and electric vehicle. The gain and fractional terms of the controller were obtained by minimizing the Integral Time Absolute Error of interconnected system.

Yasser Ahmed Dahab, Hussein Abubakr, Tarek Hassan Mohamed [3] in 2020 discussed that the goal of this paper is to introduce an adaptive load frequency control (LFC) technique for power systems. The concept of the proposed adaptive technique is built on the on-line tuning of the gain of an integral controller using Electro-Search optimization (ESO) supported by a modification called the `balloon effect'. The main target is to regulate the frequency of isolated and interconnected power systems. The balloon effect is designed to obtain the input/output signals of the power system plant at any moment; then, these signals are utilized to calculate the value of the open loop transfer function of the plant at the same time. The simulation results demonstrate the effectiveness and success of the proposed controller tuned by the ESO approach with a balloon effect and provide better performance of frequency regulation than a fixed controller, as well as other methods such as standard Jaya and ESO methods. [4] In this paper presented that Grids face a new and important challenge: the oncoming mass penetration of plug-in Electrical Vehicles (EVs). Nevertheless, the architectures of transmission and distribution grids are still focused on traditional design and operational rules. Consequently, it is necessary to predict the adequate solutions for the problems which are going to rise to the electrical and production grids as well as the effect on their commercial operation as a result of the gradual integration of EVs into the network. [5] This paper discussed that in renewable penetrated power systems, frequency instability arises due to the volatile nature of renewable energy sources (RES) and load disturbances. The traditional load frequency control (LFC) strategy from conventional power sources (CPS) alone unable to control the frequency deviations caused by the aforementioned disturbances. Therefore, it is essential to modify the structure of LFC, to handle the disturbances caused by the RES and load. [6] This paper discussed that the rapid development of technology used in electric vehicles, and in particular their penetration in electricity networks, is a major challenge for the area of electric power systems. The utilization of battery capacity of the interconnected vehicles can bring significant benefits to the network via the Vehicle to Grid (V2G) operation. [7] In this paper the use of the proportional integral (PI) algorithm incorporated with the fuzzy logic technique has been proposed as advanced gain scheduling load frequency control (GLFC) in two-area power systems. The proposed controller comprises two-level control systems, such that it consists of a pure integral compensator, which is connected, in parallel with a PI controller. However, and based on load demand, the PI parameters are updated online by means of fuzzy logic rules. With this control technique, it becomes possible to eliminate steady state errors as well as to maintain good transient responses. The task of keeping a stable and overall satisfactory mode of operation in interconnected electric power systems is the main goal of any control strategy. [8] This study aims to develop a Load Frequency Control (LFC) for a single area power system using a fuzzy logic tuned PI controller. A deviation of frequency value from the standard (±0.5Hz) arises when real power generation fails to supply demand along with network losses. Various LFC studies have been done exploiting control strategies ranging from classical control schemes to soft analysis techniques. [9] This paper discussed in this paper the Artificial Neural Network (ANN) Controller for load frequency control of Multi area power system is presented. The performances of ANN Controller and conventional PI controllers are compared for Single area and Multi area power system with non-reheat turbines. [10] This paper discussed a control scheme of ANN based proportional integral-derivative (PID) controller is developed here to maintain the system frequency at nominal value. Due to some complication of modern industrial system, the conventional PID controller is not capable to meet our requirement. Neural network had great capability in solving complex, nonlinear mathematical problems. This paper introduces the design of neuro-PID controller model to improve the response and performance of conventional PID controller. [11] In this paper, a hybrid combination of Neuro and Fuzzy is proposed as a controller to solve the Automatic Generation Control (AGC) problem in a restructured power system that operates under deregulation pedestal on the bilateral policy. In each control area, the effects of the possible contracts are treated as a set of new input signal in a modified traditional dynamical model. The prominent advantage of this strategy is its high insensitivity to large load changes and disturbances in the presence of plant parameter discrepancy and system nonlinearities. [12] This paper discussed that 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. In this paper, study of LFC system for single area. [13] This paper discussed while the number of internal combustion vehicles is stagnating, and is even expected to decrease in a few decades, the number of electric vehicles is predicted to increase. Most of the electric cars are designed for daily urban use, thus in the near future, bigger cities might have some ten percentage of electric cars running on their streets during the day.

III. 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 of constant frequency is not needed. When 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 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 the constant frequency. It is known as parallel frequency regulation.
- Thirdly where frequency maintenance is done of a certain Area by its own 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.

IV. METHODOLOGY

- **ANFIS**

ANFIS stands for Adaptive Neuro-Fuzzy Inference System. The ANFIS controller combines the advantages of fuzzy controller as well as quick response and adaptability nature of ANN Fundamentally, ANFIS is about taking a fuzzy inference system (FIS) and tuning it with a back propagation algorithm based on some collection of input-output data. This allows your fuzzy systems to learn. A network structure facilitates the computation of the gradient vector for parameters in a fuzzy inference system. Once the gradient vector is obtained, a number of optimization routines is applied to reduce an error measure (usually defined by the sum of the squared difference between actual and desired outputs). This process is called learning by example in the neural network literature.

- Some Constraints are as follows:

Since ANFIS is much more complex than the fuzzy inference systems discussed so far, all the available fuzzy inference system options cannot be used. Specifically, ANFIS only supports Sugeno systems subject to the following constraints:

- First, order Sugeno-type systems.
- Single output derived by weighted average defuzzification.
- Unity weight for each rule.

An error occurs if your FIS matrix for ANFIS learning does not comply with these constraints. Moreover, ANFIS is highly specialized for speed and cannot accept all the customization options that basic fuzzy inference allows, that is, one cannot make own membership functions and defuzzification functions; that to make do with the ones provided.

The fuzzy inference system that has been considered is a model that maps:

- Input characteristics to input membership functions,
- Input membership function to rules,
- Rules to a set of output characteristics,
- Output characteristics to output membership functions, and
- The output membership function to a single-valued output, or
- A decision associated with the output.

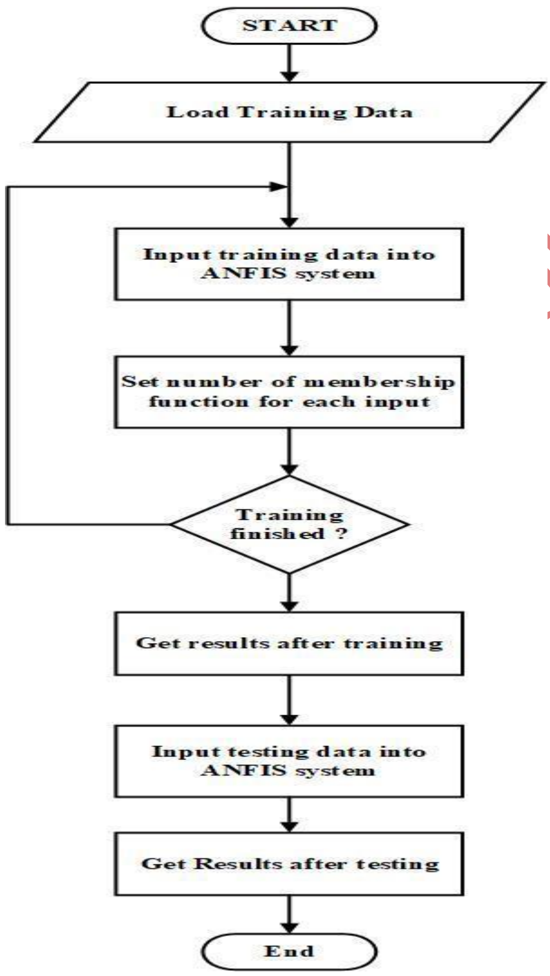

Figure 1 Flowchart of ANFIS training.

In the figure 1 above a flowchart of ANFIS training is presented. The diagram clearly explains the steps involved in proposed training. At first the data is imported for training and testing. After loading data to workspace, the training is initiated by suppling data as input to ANFIS system. After this stage membership of all the inputs are decided.

The training is further moved by the checking weather whole data is used in process or not. If yes than training will be finished else the process will repeat till it training finishes. After completion of training the results are saved in the form of. fis model. After this step the testing data is imported for the use of testing ANFIS model. The results obtained after this testing are saved and is further used for evaluation and then the process is stopped. The results can be improved by changing number of membership functions and type of membership function [29].

V. CONCLUSION

This paper has made an 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 four groups named optimization based LFC, Machine learning

based LFC and others. Further, the research gaps and challenges of the LFC models were also explained in this paper.

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