

“Load Frequency Control in Power Systems Employing Smart Controller Gain Optimizer”

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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 paper presents a comprehensive review on the emergence of machine learning techniques to design smart controllers acting as gain optimizers for power systems.

KEYWORDS: *Load Frequency Control (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 is 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. 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.

Machine learning technique is not new to the field of science and technology. It has been utilizing by various fields to solve complex algorithmic problems. With its excellent development, it has found its way in the field of electrical engineering also. It has been widely used for load forecasting, stability analysis, in solving economic load dispatch etc. to name a few of them. Due its strong learning ability, expert systems are easily overtaking digital techniques. Techniques like ANN, ANFIS etc, which are different forms of machine learning, prove to be very reliable along with providing fast results. The ANN has advanced methods such as optimal control adaptive control, multi-variable control and different approaches such as microprocessor-based controllers and digital signal processing have been investigated or under investigation. 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.

III. PREVIOUS WORK

Some of the key highlights and salient work in the domain of the load frequency control in power systems utilizing machine learning based techniques are listed herein.

In [1], authors discussed that power demand in any area is constantly expanding causing changes in system's Frequency and henceforth messes major up in system stability. Interconnected power systems have extraordinary favorable circumstances to keep up the dependability, safeguard progression of supply and moreover keep up the Frequency to its ostensible worth. The control of the interconnected power systems is finished via Automatic Generation Control (AGC), which is made out of two sections, Automatic Voltage Regulator (AVR) and Load Frequency Control (LFC). This paper exhibits the plan and execution of essential and fuzzy logic controller (FLC) for a two zone power system taking the steady state error and percent overshoot as examination boundaries.

In [2], authors discussed that 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. With regards to the above problem, this work proposes a novel coordinated LFC strategy with modified control signal for frequency stability enhancement of the Japanese power system.

In [3], authors discussed that development of model for load frequency control in power system with large-scale integration of renewable energy". Because of huge scope in renewable energy installation, recurrence guideline is getting more significant and more troublesome in power system. Battery energy storage system (BESS) is the one answer for this issue. It is expected that adequacy of introducing BESS into power systems relies upon control systems of recurrence guideline. In any case, the ideal size of BESS has been talked about without thought of supply-request control in the power system, particularly under the largescale renewable energy installation.

In [4], authors discussed the utilization of the relative fundamental (PI) calculation consolidated with the fuzzy rationale method has been proposed as cutting-edge gain load frequency 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.

In [5], authors discussed single area load frequency control using fuzzy-tuned PI controller ". 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 ($\pm 0.5\text{Hz}$) 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.

In [6], authors discussed 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 model. The outcomes show that ANN Controller displays better execution.

In [7], authors discussed Load Frequency Control using PID tuned ANN controller in power system ". This paper examined a control plan of ANN-based PID controller 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.

In [8], authors discussed Hybrid Neuro Fuzzy approach for automatic generation control in restructured power system ". 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 prominent advantage of this procedure is its high harshness toward huge burden changes and aggravations within the sight of plant boundary inconsistency and framework nonlinearities.

In [9], authors discussed Frequency Control Using Fuzzy Logic Based Controller for Multi-area Power System ". This paper talked about that that Load frequency control (LFC) is required for reliable operation of a large interconnected power system. The principal work of Load frequency 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-reheat thermal system is carried out. Fuzzy logic controller is used for controlling the frequency and tie-line power deviation. The robustness of the fuzzy

logic controller is seen for different loading condition.

In [10], authors discussed Impact of electric vehicle charging on power grid ". 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. And these vehicles need to be recharged in the evening or during night, so the electric vehicles, including the high-performance electric cars, will interact with the power grid in this period. The impact of the charging process is predicted to be apparent on the distribution system, mostly on the low voltage grid, by influencing the network voltage profiles and the loading of the grid elements.

IV. CONCLUSION

It can be concluded from the previous discussions that 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. The various techniques in the domain have been discussed in this paper.

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