Implementation of ANN on Load Frequency Control of Two Area Power System

R.Vijaykesar[1] | P.Rajeshkumar[2] | A. Naresh[3] | B. Kavya Santhoshi[4]

[1,2,3]UG Students, Department of Electrical and Electronics Engineering,, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.
[4]Assistant Professor, Department of Electrical and Electronics Engineering, Godavari Institute of Engineering and Technology (A), Rajamundary, Andhra Pradesh, India.

Abstract: Interconnected transmission network supplying the national power balance and synchronize the different manufacturing facilities are required to work. Areas that may occur in one of the failures that may occur to any load change and also affect other regions. One of the most important effects of this type of system in the exchange of bus voltage and mains frequency. Electric power transmission systems to provide high quality and constant power load changes caused by oscillation frequency and voltage values must be removed as soon as possible. Fixed frequency is an important factor for power systems quality. Subscribers connected to the energy system at a frequency of changes in energy demand leads to some of the harmonics. Load frequency control system should identify these changes and should not be considered a distortion. With two different regions of a Load Frequency control of power systems using fuzzy logic-based controller are examined. With a load of any change in the frequency of the power system investigated how affected. Then Fuzzy Logic Controller (FLC) changes, such as what is observed in using the system. The system has two different control area power system small signal model in Matlab / Simulink computer simulation program was created. FLC in the control and Integral Controller has been using the system. This produces two different results are compared with the controller. Artificial neural network controller is used in place of fuzzy logic controller for better results.

KEYWORDS:PI controller, Fuzzy Logic Control system, Artificial Neural Networks, dynamic model, Parameter identification, power plant.

DOI of the Article: https://doi.org/10.46501/GIETEE16

Available online at: https://ijmtst.com/icceeses2021.html

To Cite this Article: R.Vijaykesar; P.Rajeshkumar; A. Naresh and B. Kavya Santhoshi. Implementation of ANN on Load Frequency Control of Two Area Power System. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 108-113. https://doi.org/10.46501/GIETEE16

Article Info. Received: 20 May 2021; Accepted: 25 June 2021; Published: 30 June 2021

INTRODUCTION

Steam turbine generation units are used in the power system for some special features of fossil-fuelled power plants. When a load disturbance occurred in the system, frequency variation will cause a primary regulation action on generation units. The units will automatically adjust their outputs to fit for the new load demand. Variation of the governing valve position may exceed to the outlet pressure of the related boiler but boiler often has a long control time cycle after the pressure error was observed. PI controller and FL controller is usually used to speed up the regulation procedure of boiler and to improve the stability of the steam parameters upstream of steam turbine. Many researchers have studied the mathematic models of power plant for power system dynamic analysis. According to their research, low order models for turbine units are more popular for power system dynamic analysis. According to huge test experiences, single turbine model is not without a consideration of a main stream pressure variation. Boiler model is also needed for some circumstances. Control System of boiler and the PI controller and FL controller acting on both the boiler and turbine systems will have great impact on the pressure stability even output power of turbine units. But these control systems are not well considered in relative research. In this paper, a fossil-fuel power plant model is presented with PI controller and FL controller power system analysis. The model parameters are identified for a turbine coal fired generation unit. The model responses are compared to the model without PI controller and FL controller model to evaluate the impact of PI controller and FL controller model on system frequency stability. Frequency response models have received limited treatment in the literature. The basic concept of the model derived here is based on the idea of uniform or average frequency, where synchronizing oscillations between generators are filtered out, but the average frequency behaviour is retained. The synchronizing oscillations are, taken from the simulations of reference [l]. We seek to average these individual machine responses with a smooth curve that can be used to represent the average frequency for the system. Such a filtered or average frequency. Similar and related approaches have been pursued more recently [3, 4] through work on energy functions. The basic ideas are also important in the work on system Area control simulators [5, 6], as well as the work on long term dynamics [7, 8].In addition to these resources, certain ideas have also been adopted from the work on coherency based dynamic equivalents [9, 10], as well as the work on transient energy stability analysis. A Genetic Algorithm (GA) represents a heuristic search technique based on the evolutionary ideas of natural selection and genetics. Although randomized, using the historical information they direct the search into the region of better performance within the search space.

. In this paper, the PI and FL controller is developed and compared with respect to their overshoot or undershoot and settling time under various operating conditions for a two area steam turbine and boiler model.

MODELING OF STEAM TURBINE

In a steam turbine the stored energy of high temperature and high pressure steam is converted into mechanical (rotating) energy, which then is converted into electrical energy in the generator. The original source of heat can be a furnace fired by fossil fuel (coal, gas, or oil) or biomass. The turbine can be either tandem compound or cross compound. In a tandem compound unit all sections are on the same shaft with a single generator, while a cross compound unit consists of two shafts each connected to a generator. The cross compound unit is operated as one unit with one set of controls. The power output from the turbine is controlled through the position of the control valves, which control the flow of steam to the turbines. The valve position is influenced by the output signal of the turbine controller.High Pressure (HP), Intermediate Pressure (IP) and Low Pressure (LP) are the different turbine sections. The turbine considered for study in this paper is reheating type .Reheating improves efficiency [8].The effects of steam chest; reheated and nonlinear characteristics of control valve are considered. The fraction of turbine power generated by intermediate section is assumed as negligible on base value

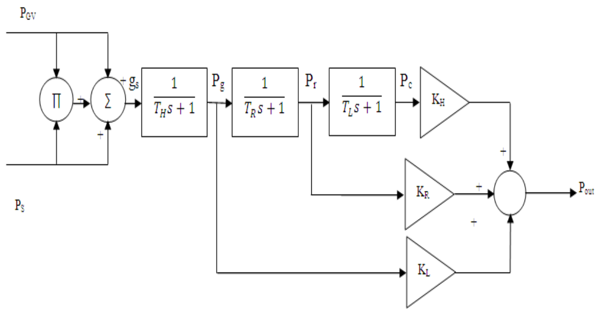

Fig.1 steam turbine model

Steam flow entered into steam turbine g_s is proportional to sum of the product of governing valve position variation P_{GV} and steam pressure variation of superheater Ps and two variations themselves. TH, TR and TL are time constants of three equivalent steam volume as high pressure volume, reheated volume and crossover volume, and Pg, Pr and Pc are average steam pressures of three volumes. Output power is a sum of output by three kinds of turbine cylinder. Power of each cylinder is considered to be proportion to its inlet steam pressure due to high pressure ratio. Relative with the rated output power the output portions of three cylinders are KH, KR and KL respectively.

PI CONTROLLER

In control engineering, a PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled by a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the PID controller in which the derivative (D) part of the error is not used.

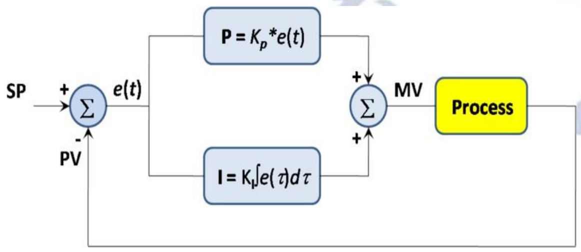

Fig.2 Block diagram of a PI controller

Integralcontrolactionaddedtotheproportionalcontrollerconvertstheoriginalsystem into high order. Hence the control system may become unstable for a largevalue of K_p since roots of the characteristic eqn. may have positive real part. In thiscontrol, proportional control action tends to stabilize the system, while the integralcontrol action tends to eliminate or reduce steady-state error in response to variousinputs.As the value ofT_i is increased,

- Overshoot tends to be smaller
- Speed of the response tends to be slower.

FUZZY LOGIC CONTROLLER

Fuzzy control systems are model-free estimators. Fuzzy experts like Lofti Zadeh describe fuzzy logic as a method of dealing with imprecision of practical systems. The design of a fuzzy logic controller is a three stage processes. It comprise of Fuzzification, inference mechanism and defuzzification. ‘‘Fuzzy controllers have got a lot of advantages compared to the classical controllers such as the simplicity of control, low cost and the possibility to design without knowing the exact mathematical model of the process. Fuzzy logic is one of the successful applications of fuzzy set in which the variables are linguistic rather than the numeric variables.

Linguistic variables, defined as variables whose values are sentences in a natural language (such as large or small), may be represented by fuzzy sets. Fuzzy set is an extension of a ‘crisp’ set where an element can only belong to a set (full membership) or not belong at all (no membership).Fuzzy sets allow partial membership, which means that an element may partially belong to more than one set

A fuzzy logic controller is based on a set of control rules called as the fuzzy rules among the linguistic variables. These rules are expressed in the form of conditional statements (Amer, 2015). Our basic structure of the fuzzy logic controller to control the speed of the induction motor consists of 4 important parts, viz., Fuzzification, knowledge base, decision-making logic and the defuzzification.

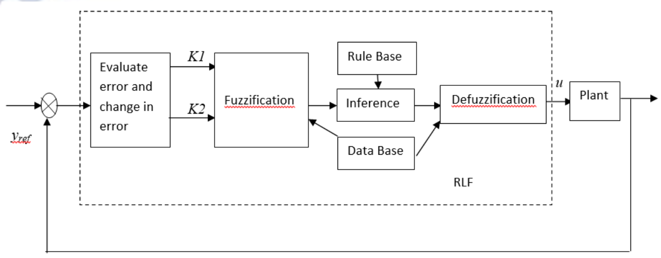

Fig.3 Basic Stage of Fuzzy Logic Controller Design

The necessary inputs to the decision making unit blocks are the rule-based units and the data based block units. The fuzzification unit converts the crisp data into linguistic formats. The decision making unit decides in the linguistic format with the help of logical linguistic rules supplied by the rule base unit and the relevant data supplied by the data base.

The error and the change in error is modelled using the equation as.

$$e(k) = w_{ref} - w_r$$

$$\Delta e\ (k) = e\ (k) - e\ (k\text{-}1)$$

The output of the decision-making unit is given as input to the de-fuzzification unit and the linguistic format of the signal is converted back into the numeric form of data in the crisp form. The decision-making unit uses the conditional rules of 'IF-THEN-ELSE'. In the first stage, the crisp variables e (k) and Δ e (k) are converted into fuzzy variables. The fuzzification maps the error, and the error changes to linguistic labels of the fuzzy sets.

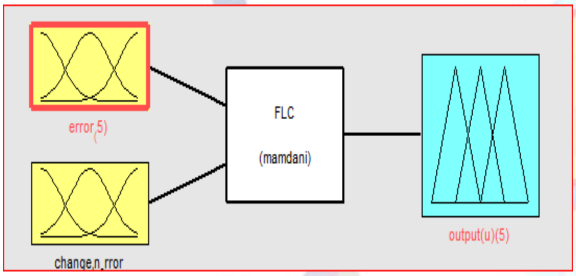

Fig.4: FIS Fuzzy editor with 2 inputs and 1 output

ARTIFICIAL NEURAL NETWORKS

Numerous advances have been made in developing intelligent systems, some inspired by biological neural networks]. Researchers from many scientific disciplines are designing artificial neural networks to solve a variety of problems in pattern recognition, prediction, optimization, associative memory, and control. Conventional approaches have been proposed for solving these problems. Although successful applications can be found in certain well-constrained environments, none is flexible enough to perform well outside its domain. ANNs provide exciting alternatives, and many applications could benefit from using them. This article is for those readers with little or no knowledge of ANNs to help them understand the other articles in this issue of Computer.

The long course of evolution has given the human brain many desirable characteristics not present Invon Neumann or modern parallel computers. These include massive parallelism, distributed representation and computation, learning ability, Generalization ability

TWO AREA STEAM TURBINE MODEL SIMULATIONS RESULTS

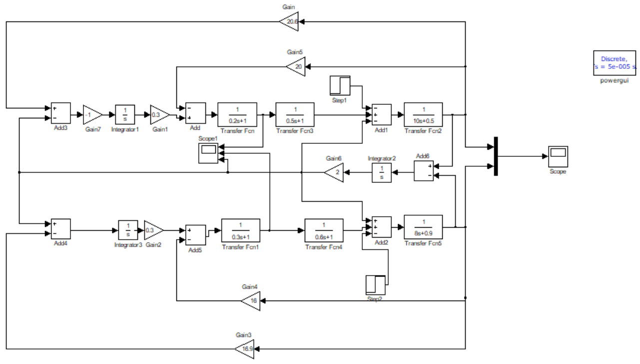

Fig 5: LFC with PI Controller

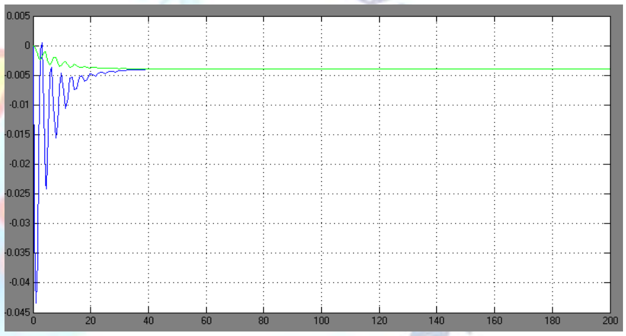

Fig.6: Change in frequency due to change in load without controller

Since no controller is used the two systems doesn't reach its steady state position (Δf=0)

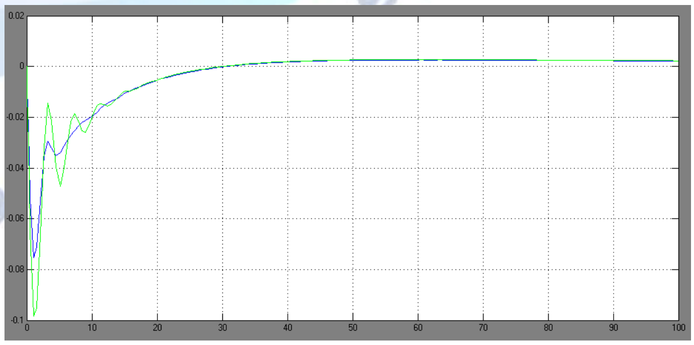

Fig.7: Change in frequency reduced to zero due to PI controllers

Since PI controller is present in the two area system even if there is a change in load (at area-1) the change in frequency settled to zero Δf=0 i.e. the system reached its steady state position. It's settling time Ts=27sec.

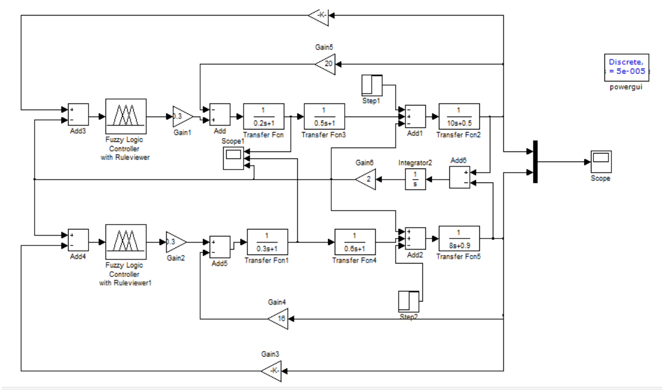

Fig.8: LFC with FUZZY Logic Controller

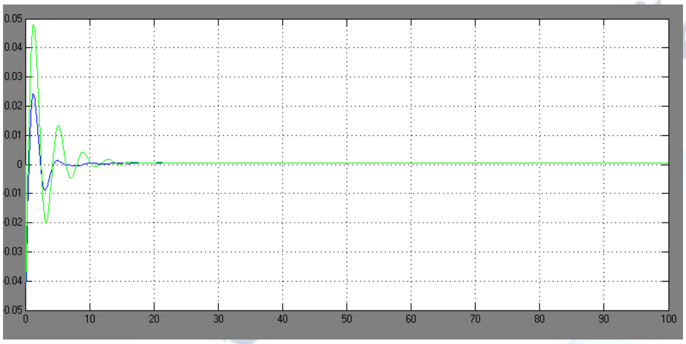

Fig 9: Change in frequency reduced to zero using fuzzy controller

Fuzzy controller is present in the two area system even if there is a change in load (at area-1) the change in frequency settled to zero Δf=0 i.e. the system reached its steady state position. It's settling time Ts=14 sec. and the peak over shoot is at 0.05 Hz.

From the simulation result we have seen that the Fuzzy controller are adjusted for a satisfactory response and frequency deviation returns to zero with settling time of approximately 18 seconds which is less than PI controller.

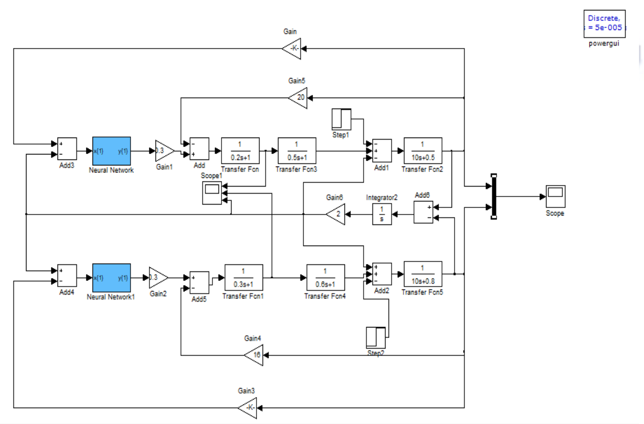

Fig.10: Simulation of 2 area load frequency controller using ANN controller

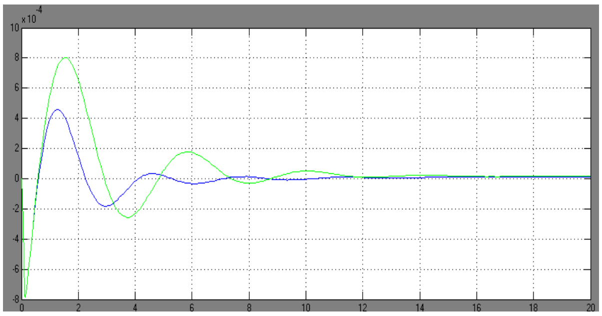

Fig.11: Change in frequency reduced to zero using ANN controller

ANN controller is used in the power system the frequency of the two areas reached its steady state position (Δf=0) after change in load. Here we can also observe that steady state is reached quickly compare to PI controller and peak overshoot, peak undershoots are reduced. The settling time Ts=12Sec. and the peak over shoot is at 0.009 Hz.

CONCLUSIONS

For supplying stable and reliable electric power, load frequency control is an important issue in power system operation and control. Automatic load frequency control is used to maintain the generator power output and frequency within the prescribed values. In this work the two area load frequency controller is considered. In this project, a two-control area power system with frequency oscillations caused by load changes with the reduction of FLC and ANN are investigated. Power system modeling and FLC Matlab / Simulink program was carried out using Simpower toolbax function. ANN technique is developed using programming. FLC's and ANN performance compared with conventional integral controller. The results with PI controller has more peak overshoot and it takes more time to reach steady state. In case of fuzzy controller it has less peak overshoot is 0.05Hz and takes 14sec time to reach steady state. In case of ANN controller it has less peak overshoot is 0.009Hz and takes 12sec time to reach steady state.

REFERENCES

1. Power system Stability and Control by Prabhakundur.
2. Power System Engineering byNagrath Kothari
3. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Trans Power Apparatus & Systems, Vol. 92, No. 6, 1973, pp. 1904- 1915.
4. L. N. Bize, J. D. Hurley, "Frequency Control Considerations for Modem Steam and Combustion

Turbines", IEEE Engineering Society Winter Meeting, 1999, pp. 548-553.
5. Dai Yipping, Zhao Ting, TianYunfeng, Gao Lin, "Research on the influence of primary frequency control distribution on power system security and stability", Second IEEE Conference on Industrial Electronics and Applications, 2007, pp.222-226.
6. P. M. Anderson, M. Mirheydar, "A low-order system frequency response model", IEEE Transaction on Power Systems, Vol. 5, No. 3, 1990, pp. 720-729
7. K. J. Astrom, K.Eklund, "A simplified non-linear model of a drum boiler-turbine unit", International Journal of Control, Vol. 16, No. I, 1972,pp. 145-169.
8. de Mello, F.P., "Dynamic models for fossil fuelled steam units in power system studies", IEEE Transactions on Power Systems, Vol. 6, No. 2,1991, pp. 753-761.
9. Dai Yipping, Zhao Ting, TianYunfeng, Gao Lin, "Research on the primary frequency control characteristics of generators in power system",Second IEEE Conference on Industrial Electronics and Applications,2007, pp. 569-574.
10. QH WU, "Learning coordinated control of power systems using interconnected learning automata", Electrical power & Energy systems, Vol. 17, No. 3, 1995, pp.91-99.
11. Gao Lin, Dai Vi-ping, Xia lun-rong, "A New Framework for Power System Identification Based on an Improved Genetic Algorithm", 2009 4th IEEE Conference on Industrial Electronics and Applications, May 25-27,2009, Xi'an, China.
12. Gao Lin, Dai Vi-ping, Xia Jun-rong, "Parameter Identification of Hydro Generation System with Fluid Transients Based on Improved Genetic Algorithm", 2009 Fifth International Conference on Natural Computation, 14-16 August 2009, Tianjin, China.
13. Dinesh, L., Sesham, H., & Manoj, V. (2012, December). Simulation of D-Statcom with hysteresis current controller for harmonic reduction. In *2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM)* (pp. 104-108). IEEE
14. J. Huang and K. A. Corzine, "Extended operation of flying capacitor multilevel inverter," *IEEE Trans. Power Electron.*, vol. 21, no. 1, pp. 140–147, Jan. 2006.
15. Manoj, V. (2016). Sensorless Control of Induction Motor Based on Model Reference Adaptive System (MRAS). *International Journal For Research In Electronics & Electrical Engineering*, *2*(5), 01-06.
16. V. B. Venkateswaran and V. Manoj, "State estimation of power system containing FACTS Controller and PMU," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282281.
17. Manohar, K., Durga, B., Manoj, V., & Chaitanya, D. K. (2011). Design Of Fuzzy Logic Controller In DC Link To Reduce Switching Losses In VSC Using MATLAB-SIMULINK. *Journal Of Research in Recent Trends*.
18. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of switching losses in VSC using DC link fuzzy logic controller *Innovative Systems Design and Engineering ISSN*, 2222-1727.