LOAD FREQUECY CONTROL OF TWO AREA NETWORK, USING FUZZY LOGIC

[1]Ulasi, A. J. and [2]Ugorji, A. C.

[1]Department of Electrical/Electronic Engineering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State.
[2]Department of Electrical Engineering, School of Engineering, Federal Polytechnic, Nekede, Owerri, Imo State.
Email: [1] johnulasi@yahoo.com, [2] sunnyugorji@yahoo.com

ABSTRACT
A fuzzy logic based load frequency controller model for power systems is developed and simulated in this paper. The proposed simulation model is compared with the classical regulating systems in order to verify and show the advantages of the model and controller developed. The design process of the proposed fuzzy logic controller is given in detail step by step to show a direct and simple approach for designing fuzzy logic controllers in power systems. After the simulation it was observed that the fuzzy logic control came back to normality and continued stable after 20sec unlike the normal approach which didn't come back to stability though continued at a steady state after about 15sec. Both were distorted after 10secs.

Keywords: PI controller, Fuzzy Controller, Two Area Power System, Load Frequency Control.

1.0 INTRODUCTION

Load-Frequency (L-F) control is an important task in electrical power system design and operation. Since the load demand varies without any prior schedule, the power generation is expected to overcome these variations without any voltage and frequency instabilities. Therefore voltage and frequency controllers are required to maintain the generated power quality in order to supply constant voltage and frequency to the utility grid. The frequency control is done by load-frequency controllers, which deals with the control of generator loadings depending on the frequency (Anderson et al, 1993).

The main purpose of designing load-frequency controllers is to ensure the stable and re-liable operation of power systems. Since the components of a power system are non-linear, a linearized model around an operating point is used in the design process of L-F controllers. Some of the proposed methods in literature deal with system stability using fixed local plant models ignoring the changes on some system parameters (El-Hawary, 1998).

Fuzzy set theory provides a methodology that allows modeling of the systems that are too complex or not well defined by mathematical formulation. Fuzzy logic controllers based on fuzzy set theory are used to represent the experience and knowledge of a human operator in terms of linguistic variables that are called fuzzy rules. Since an experienced human operator adjusts the system inputs to get a desired output by just looking at the system output without any knowledge on the system's dynamics and interior parameter variations, the implementation of linguistic fuzzy rules based on the procedures done by human operators does not also require a mathematical model of the system. Therefore a fuzzy logic controller (FLC) becomes nonlinear and adaptive in nature having a robust performance under parameter variations with the ability to get desired control actions for complex, uncertain, and nonlinear systems without the requirement of their mathematical models and parameter estimation. Fuzzy logic based controllers provide a mathematical foundation for approximate reasoning, which has been proven to be very successful in a variety of applications (Maiers, et al, 1985).

As in many different areas, the use of fuzzy logic controller has been increased rapidly in power systems, such as in load-frequency control, bus bar voltage regulation, stability, load estimation, power flow analysis, parameter estimation, protection systems, and many other fields. Fuzzy logic applications in power systems are given in (El-Hawary, et al 1998) with a detailed survey.

Any load change in one of the L-F control areas affect the tie line power flow causing other L-F control areas to generate the required power to damp the power and frequency oscillations. The response time of the L-F controllers is very important to have the power system to gain control with increased stability margins. Therefore the proposed L-F controller must reduce the response time as well as reducing the magnitude of the oscillations when compared to that of classical types.

The results of the classical controller and the fuzzy logic controller are compared, and since the response time of the stabilizer of the load frequency is very important, a quicker and more stable solution is achieved with FL controller than the one found by controlling in a classical way

2.0 THE LOAD-FREQUENCY (L-F) CONTROL

The principle block of the power system studied in this paper is given in Figure 1. Two parts of this system can be considered. A considerable attention should be paid to the LFC (Load Frequency Control) section. Changes in real power mainly affect the system frequency, while reactive power is less sensitive to changes in frequency and is mainly dependent on changes in voltage magnitude. The LFC thus controls the real power and the frequency of the system. It also has a major role in the interconnection of different power plants (Saadat, 1999).

The LFC is used to maintain a reasonable uniform frequency. The first step of control engineering consists of mathematical modeling. Two methods are well-known: the transfer function method and the steady state method. Linear systems cannot often be found in real situations, but a close approximation by linearization is suitable for simulation. A simulation model derived here using the transfer function model (Saadat, 1999). The block diagram that represents the approximation of the real system behaviors is shown in Figure 2. This is a small signal model used to represent the influence of load changes.

The source of mechanical power, commonly known as the prime mover, may be either hydraulic energy or steam. The mathematical model for the turbine relates function model. The block diagram that represents the approximation of the real system behaviors is shown in Figure 2. This is a small signal model used to represent the influence of load changes. The source of mechanical power, commonly known as the prime mover, may be either hydraulic energy or steam. The mathematical model for the turbine relates the changes in mechanical power output ΔP_m to changes in steam valve position ΔP_V. Both ΔP_m and ΔP_V are represented by x_2 and x_1, respectively, in Figure 2. The most simple prime mover model can be approximated with a single time constant such as the one given by τ_g where the variables x_1, x_2, x_3 and x_4 are equal to ΔP_V, ΔP_m, $\Delta\omega$ and output of the integral controller signal, respectively.

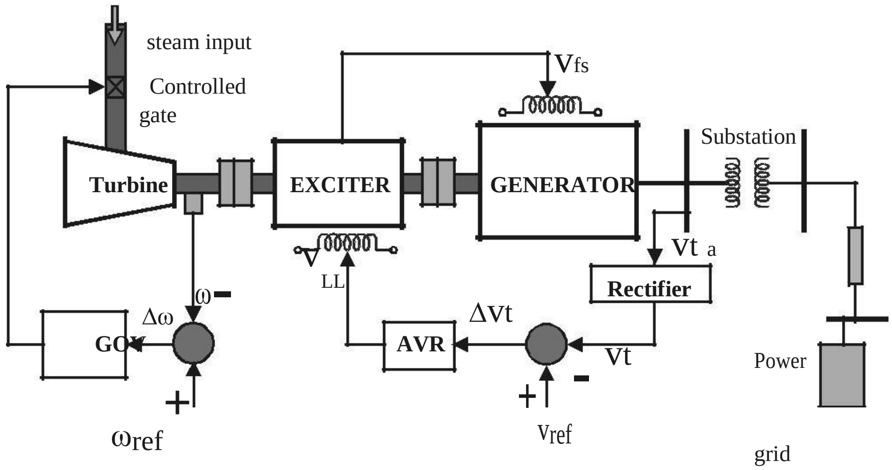

Figure 1: Control block for the power system

3.0 Fuzzy Logic Controller

Fuzzy logic is a thinking process or problem-solving control methodology incorporated in control system engineering, to control systems when inputs are either imprecise or the mathematical models are not present at all. Fuzzy logic can process a reasonable number of inputs but the system complexity increases with the increase in the number of inputs and outputs, therefore distributed processors would probably be easier to implement. Fuzzification is process of making a crisp quantity into the fuzzy (Ross, 1985). They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity, or vagueness, then the variable is probably fuzzy and can be represented by a membership function.

Since power system dynamic characteristics are complex and variable, conventional control methods cannot provide desired results. Intelligent controller can be replaced with conventional controller to get fast and good dynamic response in load frequency problems. Fuzzy Logic Controller (FLC) can be more useful in solving large scale of controlling problems with respect to conventional controller are slower. Fuzzy logic controller is designed to minimize fluctuation on system outputs. There are many studied on power system with fuzzy logic controller.

There are three principal elements to a fuzzy logic controller:

- Fuzzification module (Fuzzifer)
- Rule base and Inference engine
- Defuzzification module (Defuzzifier)

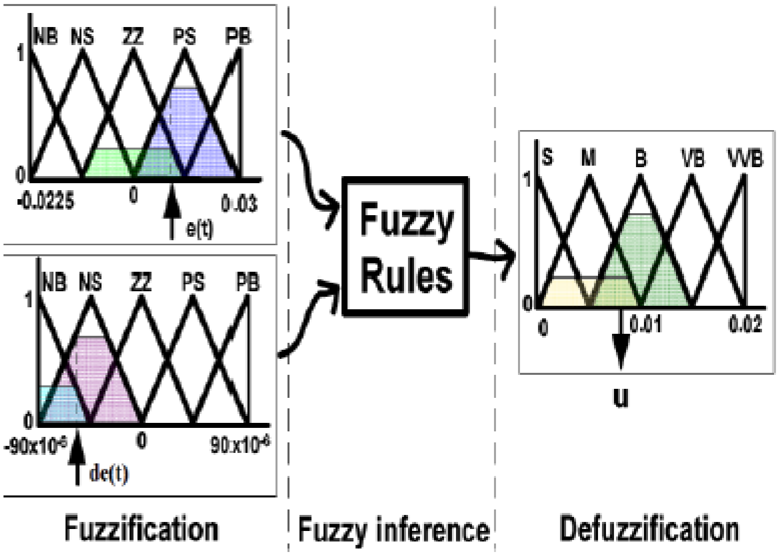

Figure 2: Fuzzy inference system for two area fuzzy controller

Fuzzy control is based on a logical system called fuzzy logic. It is much close in spirit to human Thinking than classical logical systems. The LFC has been reported in several papers is to maintain Balance between production and consumption of electrical power. Due to the complexity and Multi-variable nature of power systems, a conventional control method has not provided satisfactory solutions. The fuzzy logic control has tried to handle the robustness, reliability and nonlinearities associated with power system controls. Therefore a fuzzy logic controller (FLC) becomes nonlinear and adaptive in nature having a robust performance under parameter variations with the ability to get desired control actions for complex uncertain, and nonlinear systems without their mathematical models and parameter estimation.

The error (e) and change in error (de) are inputs of FLC. Two inputs signals are converted to fuzzy numbers first in fuzzifier using five membership functions; Positive Big (PB), Positive Medium (PM), Positive Small (PS), Zero (ZZ), Negative Small (NS), Negative Medium (NM), Negative Big (NB) with the rule in the table below.

Table 1: Fuzzy Rule for the Load Frequency Control

Input	*e(k)*					
ce(k)		NB	NM	ZE	PM	PB
	NB	NB	NB	NM	NM	ZE
	NM	NB	NB	NM	ZE	ZE
	ZE	NM	NM	ZE	PM	PM
	PM	ZE	PM	PM	PB	PB
	PB	ZE	ZE	PM	PB	PB

Finally resultant fuzzy subsets representing the controller output are converted to the crisp values using the central of area (COA) defuzzifier scheme. This fuzzy rule is now implemented in the MATLAB Simulink model given below (figure 3) for two area network systems with the data in Table 2.

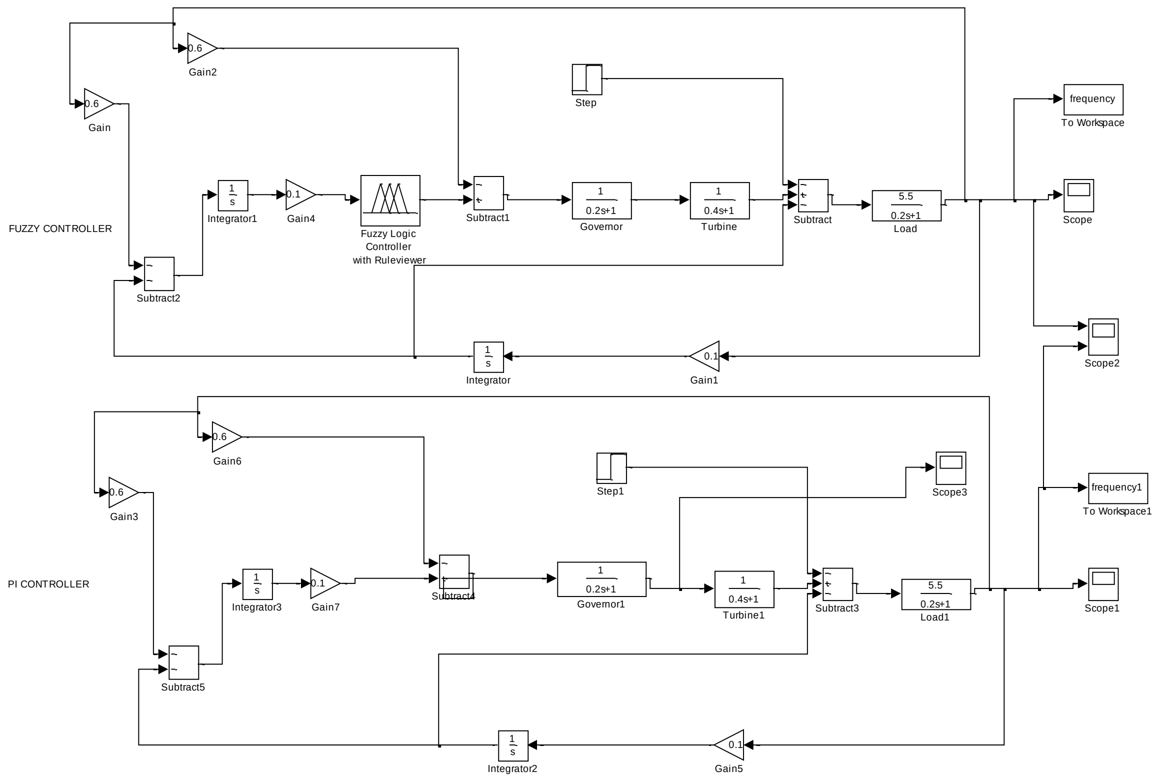

Figure 3: Simulink model for two area network using MATLAB platform

Table 2: Parameters for Simulation

PARAMETERS	SYSTEM 1	SYSTEM 2
Power system gain constant , K_{ps}	120	100
Power system time constant, τ_{ps}	20	22
Speed Regulation R	2.5	3
Normal frequency , f	50	50
Governor time constant, τ_{sg}	0.2	0.3
Turbine time constant, τ_t	0.4	0.5
Integration time , constant, Ki , $K_i = 1/4\tau_p\ K_{ps}\left(1+\frac{Kps}{R}\right)^2 = K_{crit}$	0.1	0.15
T12 = 0.08		
ΔX_E = Change in valve position		
ΔP_G = Change in generation.		
Δf = Change in frequency.		
ΔP_{TL} = Change in tie – line power.		

4.0 Simulation and Results

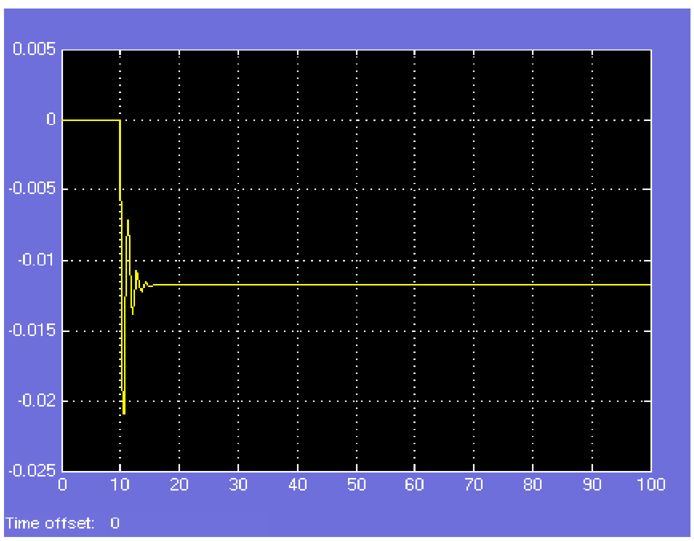

Figure 4: Frequency behavior in Area 1 without fuzzy logic

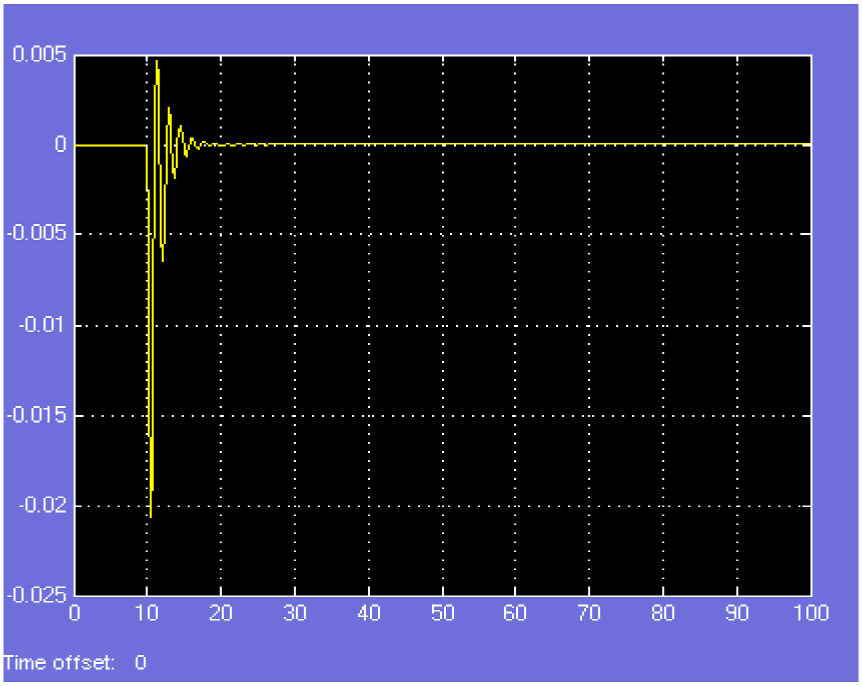

Figure 5: Frequency behavior in Area 1 with fuzzy logic

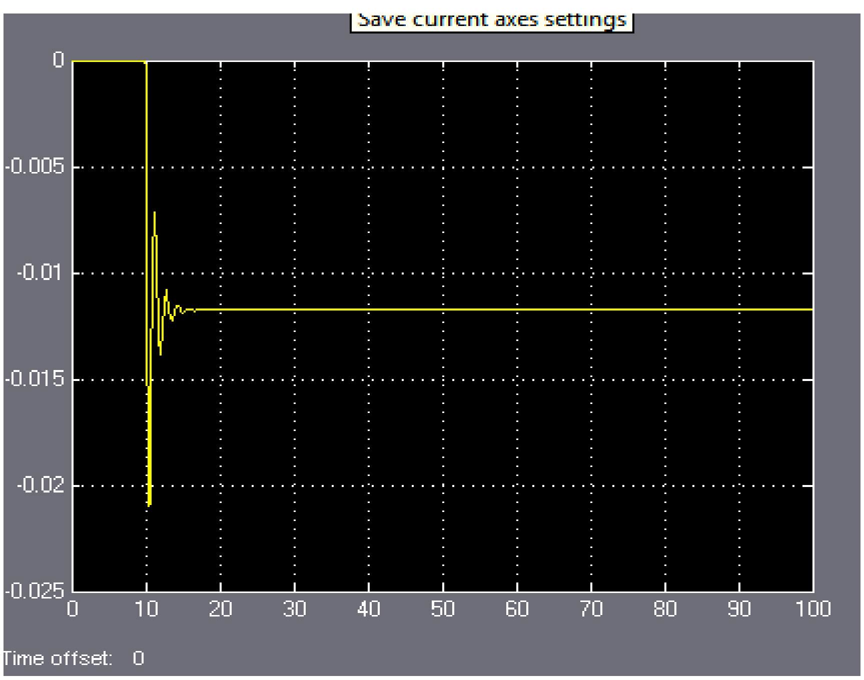

Figure 6: Frequency behavior in Area 2 without fuzzy logic

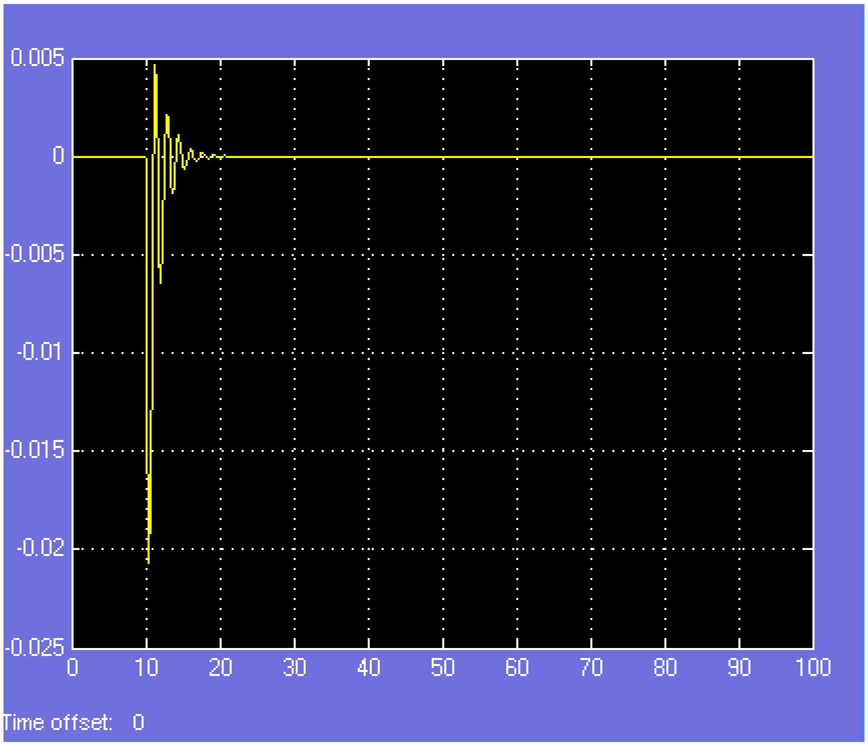

Figure 7: Frequency behavior in Area 1 with fuzzy logic

It can be observed that both in Area 1 and Area 2 the frequency started normal till it got to 10sec and the frequency dropped and continued at a steady state without coming back to normality (normal at zero). This means that after 10sec there is a permanent distortion in the system which when even controlled retained stability but still not normal. Unlike that without fuzzy logic control, the fuzzy logic control came back to stability and normality after approximately 20sec and was distorted also after 10sec both in Area1 and Area 2.

It can also be observed that without using fuzzy logic control we have slight more overshoot in distortion that when the fuzzy logic control is used. This shows that without the fuzzy logic control there is bound to be more problem than when the fuzzy logic (automatic) control mechanism is used.

CONCLUSION

In this study an approach of fuzzy logic controller has been investigated for two area frequency control of power system. Results have been compared for step load change against different controller technique mention in the following summary. The result shows the intelligent controller (Fuzzy logic controller) is having more improved dynamic response as compared with the conventional or normal control system. It has less distortion and also came to stability and normality.

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