Load frequency control in Single area with traditional Ziegler-Nichols PID Tuning controller

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Abstract- Load Frequency Control in power systems is very important in order to supply reliable electric power with good quality. In many industries, the speed of the machines depends on the frequency. Any deviation in the frequency may lead to mal-operation of the system. The load-frequency control (LFC) is used to restore the balance between load and generation in each control area by means of speed control. So load frequency control is the key problem in the power system. Works are being done to optimize the controllers to get faster and better results, the main goal of LFC is to minimize the transient deviations and steady state error to zero in advance. This paper investigated LFC using proportional integral (PI) Controller and ZN-PID Tuning controller for one area system. The results of the two controllers are compared using MATLAB/Simulink software package. Comparison results of conventional PI controller and ZN-PID Tuning controller System are presented.

Index Terms- Load Frequency Control, PI controller, ZN-P, ZN-PI, ZN-PID

1. INTRODUCTION

Nowadays, power systems with several industrial and commercial loads and generators need to operate at a constant frequency. Load Frequency Control is a very important issue in power system operation and control for supplying sufficient and reliable electric power with good quality. With an increasing demand, the electric power system becomes more and more complicated. For a successful operation of power system under abnormal conditions, mismatches have to be corrected via supplementary control. For satisfactory operation of a power system the frequency should remain nearly constant. The various areas or power pools are interconnected through tie lines. These tie lines are utilized for contractual energy exchange between power pools and also inter-area support in case of abnormal conditions. The power system is subjected to local variations of random magnitude and duration. As the load varies at any area in the system considered, the frequency related with this area affected and then the other areas are also affected through tie lines. Frequency transients must be eliminated as soon as possible. Mostly the boiler system effects and its control, governor dead band effects and generation rate constraint are neglected in the Load frequency control studies for simplicity, But for the realistic analysis of system performance, these should be incorporated as they have considerable effects on the amplitude and settling time of oscillations [1]. A large frequency deviation can damage equipment, corrupt load performance, reason of the overloading of the transmission lines and can interfere with system protection schemes, ultimately leading to an unstable condition for the electric power system. Maintaining frequency and power interchanges with neighboring Control areas at the scheduled values are the two main primary objectives of a power system LFC .In a sudden change in consumers' demands for power, voltage and frequency control, a complicating factor. Power systems have the desired level of tension, is desirable to have a fixed rate. At this point, the power system load frequency control, it is important for stability. Load frequency control with voltage and frequency of the system is set. Therefore, the system will be increased power quality [2].the control of active power system is related to the control of frequency, while the control of reactive power is related to control of voltage, the stability of frequency and voltage are important in identifying the quality of power supply, and the control of active power and reactive power has a basic and important role to satisfy application of power systems. The frequency of system is dependent on active power, and thence the frequency is a general factor in the network, any change in active power in any part of the network can reflect the whole of network, as a change in frequency which can be harmful [3]. Many control strategies for Load Frequency Control in electric power systems have been proposed by researchers over the past decades. This extensive research is due to fact that LFC constitutes an important function of power system operation where the main objective is to regulate the output power of each generator at prescribed levels while keeping the frequency fluctuations within prespecifies limits. A unified tuning of PID load frequency controller for power systems via internal mode control has been proposed

[4]. During the last decades the researchers have more attention to LFC although the main objective of the control strategy in an interconnected power system is, to generate both voltage and frequency within permissible limits. Recently, lot of research works were documented with an improved transient response by designing proper coupling effects between LFC and AVR and hence proves the necessity of AVR along with LFC. The flows of active power and reactive power in a transmission network are fairly independent of each other and hence this paper deals with individual control mechanism for LFC in order to improve the transient stability of power system [5].This paper PID controller has been designed for higher order system using Ziegler-Nichols frequency response method and its Performance has been observed. The most popular tuning technique is the Ziegler-Nichols method. However, besides being suitable only for system with monotonic step response, the compensated system whose controllers are tuned in accordance with the Ziegler-Nichols method have generally a step response with a high-percent overshoot. Ziegler and Nichols proposed the manual tuning of PID controller. The Ziegler Nichols tuned controller parameters are fine tuned to get satisfactory performance.

2. LOAD FREQUENCY BASED MODEL DIAGRAM OF POWER SYSTEMS PLANT

More than one control area power systems with a single control zone is actually a combination of power systems and the problems of each region, combining a control structure. Figure 1 is a single zone with a power system block diagrams. Here, the system, a regulator regulating the speed of synchronous generator, synchronous generator and the load is composed. ΔPL load variation, the time constant of speed regulator Tg, Tt inlet valve time constant, inertia constant in seconds H, D damping factor, and R represents the coefficient of speed regulation. Continuous operation of the system in equilibrium conditions in Figure 1. Changes in the system parameters are zero. Exchange system by disturbing the balance of power in the load ΔPL leads to changes in speed and power produced

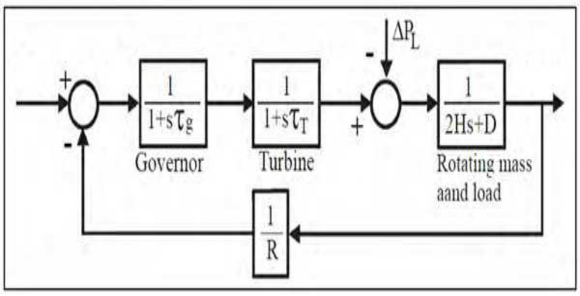

Fig 1 Load Frequency Based Model Diagram of Power Plant [2]

3. LOAD FREQUENCY CONTROL

Power systems are used to produce electrical power from natural or renewable energy. Load frequency control is really important in power systems to supply reliable and better electric power at consumer end. However, the consumers of the electric power vary the loads randomly and frequently. Change in load leads to adjustment of generation so that there is no power imbalance whereas controlling the power generation is a problem. To nullify the effects of the haphazard load changes and to keep the voltage as well as frequency within prespecified values a control system is essential. The frequency is closely related to the real power balance whereas voltage is related to reactive power. The real power and frequency control is referred to as load frequency control. If in a system there are changes in load then those changes will affect both frequency and bus voltages [9]. The satisfactory operation of power system the frequency should be maintained constant. The considerable drop in frequency in any electrical network could result in high magnetizing currents in induction motors and transformers regulate the frequency which is a common factor throughout the system. Moreover, the change in active power depends on frequency deviations and hence, the change in frequency in any point of the interconnected power system may affect the active power throughout the system. As a consequence the LFC is installed in power network to meet out the Maintain optimal power flow between control areas, maintain the frequency to its nominal value and maintain economical power generation in individual generating units. Single area power system m consists of a governor, a turbine and a generator with feedback of regulation constant. LFC as the name signifies adjusts the power flow between different areas while holding the frequency constant. LFC is actually a loop that regulates output in the range of megawatt and frequency of the generator, System also includes step load change input to the generator.

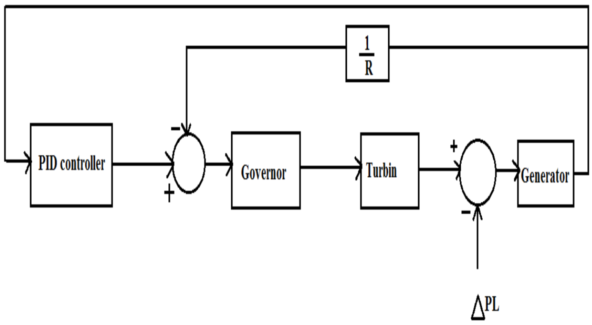

Fig 2 power system plant model

So far, PID controllers have widely been used in process control. With simple structure, they yet can effectively control various large industrial processes [10]. There are many tuning approaches for these controllers, but each has own disadvantages or limitations. As a result, the design of PID controllers still remains a remarkable challenge for researchers. In simple words, the PID controller is used to improve the dynamic response as well as reduce or eliminate the steady-state error. The derivative term normally adds a finite zero to the open loop plant transfer function and can improve the transient response in most cases [6]. the LFC is installed in power network to meet out the following objectives [12] ,Maintain the frequency to its nominal value, Maintain optimal power flow between control areas, Maintain economical power generation in individual generating units. The integral term adds a pole at origin resulting in increasing the system type and therefore reducing the steady-state error. Furthermore, this controller is often regarded as an almost robust controller. As a result, they may also control uncertain processes.

4. TUNING OF PI CONTROLLER

Now days the use of conventional integral controllers is very rare in Load Frequency Control of power system as they produce very slow dynamic response for the system. With the wide development of control system, many different controllers have been invented which are much more effective than integral controllers. in this paper tuning of PI controller value of K for system,matlab simulink model show in the fig 3 for system KI is 1.5 or gain is 0.425.

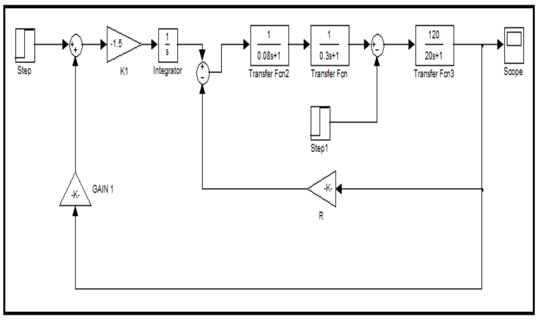

Fig 3 Matlab Simulink Model of PI Controller

5. TUNING OF PID CONTROLLER WITH ZIEGLER-NICHOLS (Z-N) METHOD

The most popular tuning methodology was proposed by Ziegler and Nichols in 1942. PID controller‘s on line auto tuning that is based on Ziegler Nichols tuning method. . It is a simple method of tuning PID controllers and can be refined to give better approximations of the controller. The controller constants Kp, Ki and Kd can be obtained for a system with feedback. The advantage of Z-N PID controller tuning is also carry out for higher order systems. The PID type controller remains the most popular in industry. However, finding approximate gain parameters for this controller is still a difficult task. ZN continuous cycling method is the most excellent conventional tuning method used to predict the gain parameters of PID controllers. Matlab simulink model show in the fig 4. The polynomial characteristic equation of LFC designed as shown in the equation (1) and PID Parameter data is following kp 3.925,ki 8.1472 and kd 15.762 use in this paper.

$$G(S)\,H(S) = \frac{1}{R\,(2Hs+D)(1+\tau gS)(1+\tau tS)} \qquad (1)$$

τ

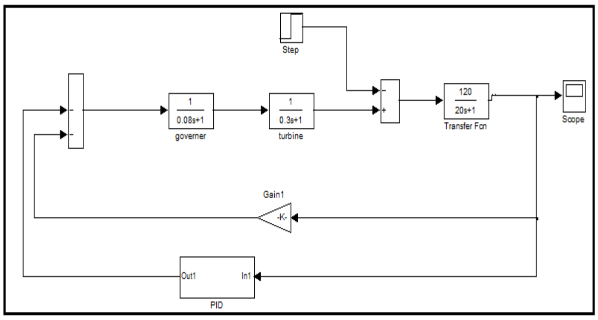

Fig 4 PID controller parameters using Ziegler–Nichols Method

6. SIMULATION RESULTS

The simulation has been conducted in MATLAB (R2010a) for single area power system with PI and Z N PID tuning controller is design for Power plant model using MATLAB Simulink. The frequency deviations in POWER area studied under PI controller and ZN-P, ZN-PI AND ZN-PID controller actions. The single area power system parameters consisting of the speed governor, turbine and generator are given in Table 1. Here the governor free operation is assumed and load demand ΔPL = 0.02.

Table 1: Parameters of power system area-1

S.No	Description	Parameter name	value
1	Governor gain	K_h	1
2	Governor time constant	τ_g	0.08
3	Turbine gain	T_h	1
4	Turbine Time Constant	τ_t	0.3
5	Load model	k_y	120
6	Load time constant	t_y	20

For conventional PI controllers Ki is taken as 1.5 and R = 3.935 .The values of PID Parameters as obtained by ZN-PID optimization: Kp = R = 3.935; Ki = 8.1472; Kd = 1.5761; Simulation results for the single area power system are shown in Table 2. As can be observed, the settling time and overshoots with the proposed PI and ZN-P,ZN-PI AND ZN-PID TUNING controller are much shorter than that of with the conventional PI controller ,result are show in the fig 5,fig 6,fig 7 and fig 8. Therefore, the ZN-PID controller provides better performance than conventional PI controller for the single area power system Show in the Fig 9.

Table 2 comparative analysis for different controller

Parameter	PI Controller	ZN-P Controller	ZN-PI Controller	ZN-PID Controller
Settling Time	12.8	5.07	9.8	3.48
Overshoot	2.64	1.89	1.88	1.3

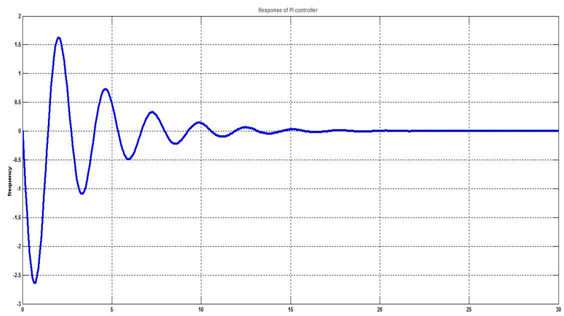

Fig 5 Frequency Deviation of Single area with PI controller

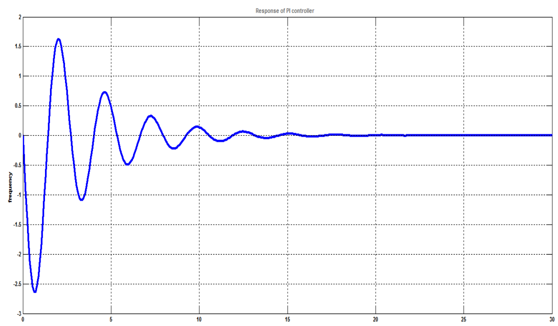

Fig 6 Frequency Deviation of Single area with ZN-P controller

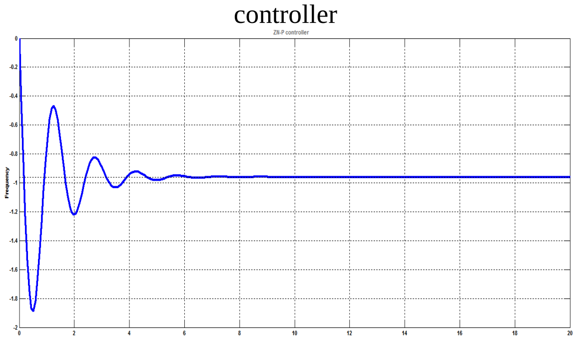

Fig 7 Frequency Deviation of Single area with ZN-PI controller

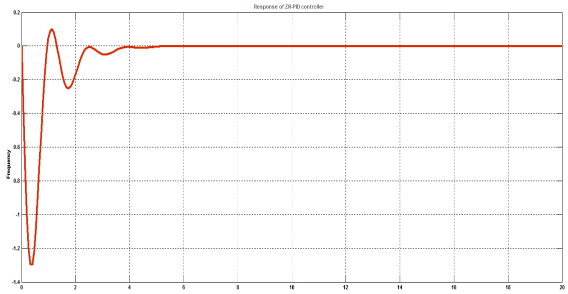

Fig 8 Frequency Deviation of Single area with ZN-PID controller

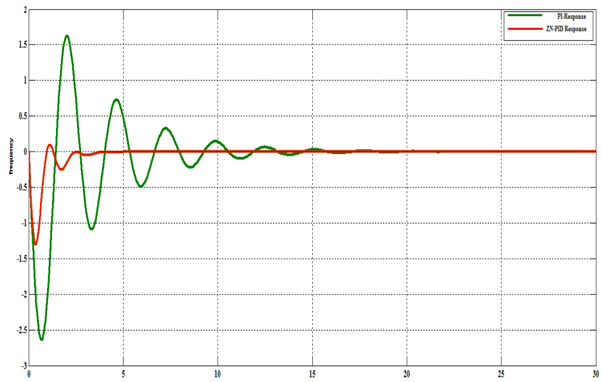

Fig 9 Comparison of Frequency Deviation of Single areas with PI and ZN-PID controller

7. CONCLUSION

In this paper, the tuning of PI controller and Ziegler-Nichols PID Tuning controller was proposed to solve the load frequency control problem of single area power system. Simulation results show that Ziegler-Nichols PID Tuning controller is frequency deviations of power system has a better performance than the PI controller because reduced the settling time and minimize overshoot,PI controller as a not adaptive controller or at least as a limited controller since limited of parameters and still the output has a little more amount of settle time and overshoot. Z-N Tuned PID controller with simple approach can provide better performance comparing with the conventional PI controller. So simulation results show the superior performance of the system using Z-N Tuned PID control.

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