Load Frequency Control in Single-Area Power System Using Integral Control and Proportional Integral

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Abstract

Load Frequency Control (LFC) had a vital role in the power system. To supply excellent quality electricity, LFC was required as the frequency stabilizer in the power plant because electrical energy should have a stable frequency (49–51 Hz in Indonesia). The unstable frequency in the power plant could potentially damage the household electronic devices that used the electricity from the power plant. The electrical energy frequency was influenced by generator speed rotation. When the load was high, the generator would have a slower rotation speed. The opposite also occurred; when the load was low, the generator rotation speed would increase. Thus, a surge in frequency would happen and could damage electronic devices. Load Frequency Control (LFC) was the solution to this problem. This article used Load Frequency Control (LFC) equipped with Integral Control and Proportional Integral (PI) simulated using MATLAB-SIMULINK and then conducted a comparison on both controllers.

Keywords
Load Frequency Control, Integral Controller, PI Controller, Power System

1. Introduction

An excellent electrical energy system is the system that could serve the load request with stable voltage and frequency. This requirement is needed for the electrical devices to function; the unstable voltage and frequency make electrical appliances unable to perform well or experience damage [1].

A power system that supplies electricity to the industry or society has to have stable frequency and enough power. Therefore, Load Frequency Control (LFC) becomes essential to control the energy supply with good quality [2]. The frequency control is conducted in the governor by managing the output from the turbine that receives a signal from the change in electrical frequency. If the electrical load increases, the frequency decreases; therefore, the governor will accelerate the turbine rotation so that the generator obtains a required rotation speed to restore the frequency in the standard threshold of 49–51 Hz. When the load decreases, the frequency increases; thus, the governor will reduce the turbine rotation to decrease the frequency into the standard threshold [3]. As we all know, the rate in the electrical network is a factor that determines the quality of the electrical system because the unstable frequency holds the damage potential for both consumers and the power system. The damage in the power plant is more dangerous because it shut the generator down and generating blackout [4].

To date, there are methods to control the frequency stability, from conventional controllers to modern ones. Integral controller and Proportional Integral (PI) are conventional controllers. These methods, however, work only in the single-area power system. These controls also have disadvantages such as long settling time and high overshoot in the frequency. The simulation results from both controllers were compared using MATLAB-SIMULINK.

2. Method

2.1 Integral Control

Integral control in the LFC consisted of a frequency sensor and an integrator. The frequency sensor's function was to detect the error frequency in the energy system when there was a change in the load or frequency surge. The error signal then forwarded to the integrator that was called 'Area Control Error.' The sign would be processed by the integral control action loop to return the system in the steady-state position and the error frequency to return to zero.

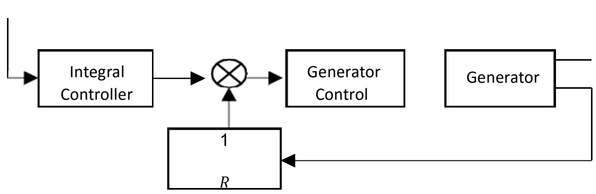

Figure 1. Integral Control

2.2 Proportional Integral (PI) Control

Proportional Integral (PI) Control produced two signal outputs: error signal proportional and integral error signal proportional [5]. The advantage of PI control was that it reduced the steady-state error and turned it into zero. PI control was mainly used to delete the steady-state error from the result of integral control. Other than response speed and system stability, PI control had a negative influence. PI control was mostly used in the system that does not have a system speed problem. Because PI controller could not predict the error in the system then PI control cannot reduce the rise time and delete the oscillation.

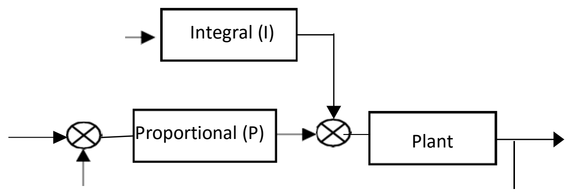

Figure 2. PI Control

2.3 Load Frequency Control Single Area Model

The purpose of LFC was to control the power stability in the power plan through the frequency control system. Changes in the load generated changes in the frequency. The frequency error will be processed into signal and inputted to the governor's turbine. The governor balanced the input and output by changing the turbine output. Figure 4 presents a single zone power plant chart.

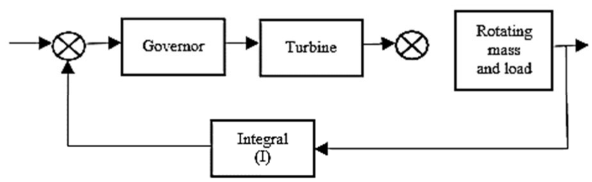

Figure 3. Single-Area Power System Chart Block

3. Result

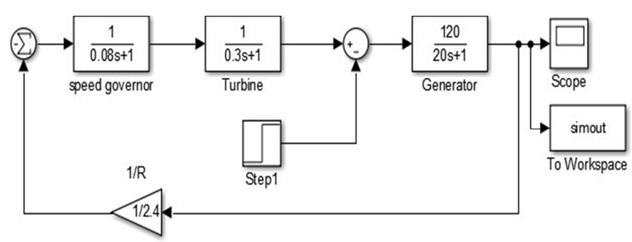

Figure 4. Diagram of Single-Area Load Frequency Control Without Control

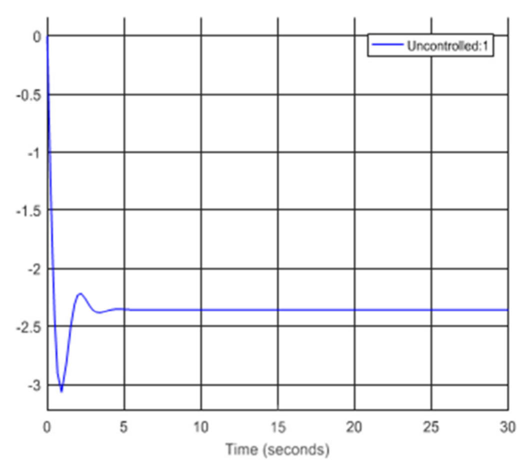

Figure 5. Frequency Response from Model Without Control in Single-Area Load Frequency Control

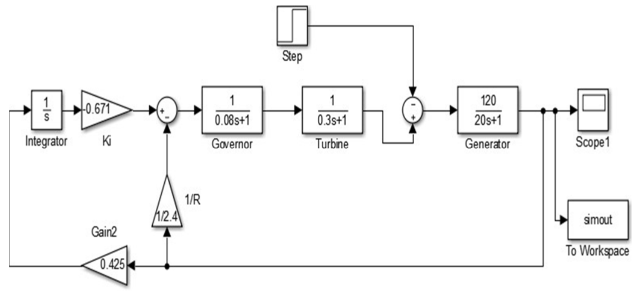

Figure 6. Diagram of Single-Area Load Frequency Control with Integral Control

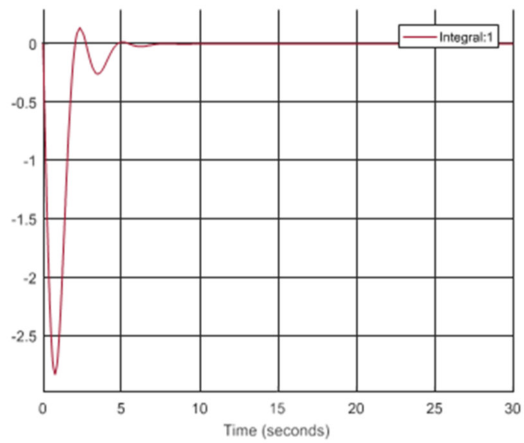

Figure 7. Frequency Response from Integral Control

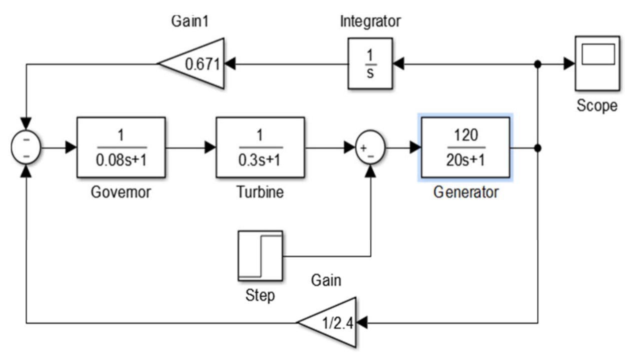

Figure 8. Diagram of Single-Area Load Frequency Control with Proportional Integral (PI) Control

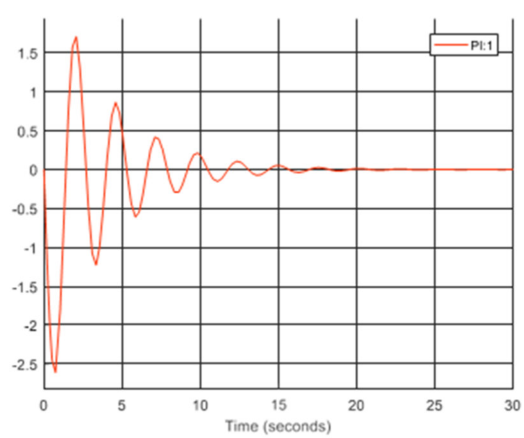

Figure 9. Response Frequency Result from PI Control

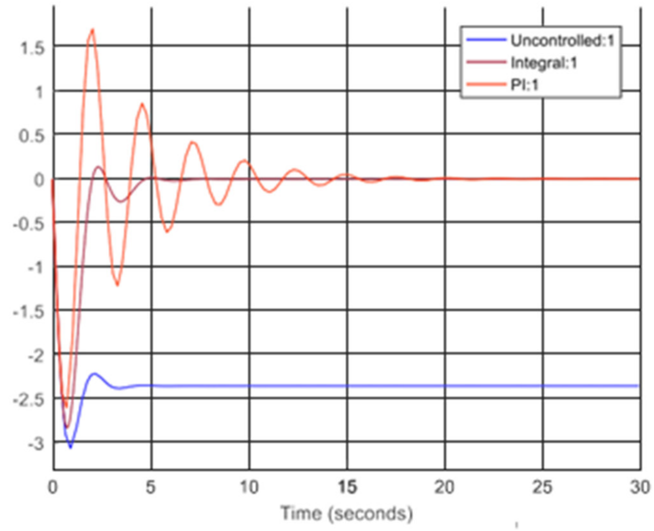

Figure 10. Results Comparison of Simulation Response from the Three Methods

4. Conclusion

From the research, it can be concluded that Integral control dan Proportional Integral (PI) control could be used to stabilize the frequency. The best frequency response was the response from the Integral control with small overshoot and 7.5 seconds settling time. Proportional Integral (PI) control experienced too many oscillations and high overshoot. Besides, it had the longest settling time that was 22.5 seconds. The frequency response without control had 5.9 seconds settling time but experienced a steady-state error.

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