Automatic Generation Control of Two Equal Areas with Traditional Controllers

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Article Info

Article history:

Received Nov 12, 2015
Revised Mar 3, 2016
Accepted Apr 4, 2016

Keyword:

Area control error
Automatic generation control
Load frequency control
Proportional integral derivative
Traditional controllers

ABSTRACT

Automatic generation control (AGC) is major issue in power system whose main purpose is to maintain the frequency and tie line power flow during normal period in an interconnected system. Thus, It is the responsibility of the power system engineers to ensure that adequate power is delivered to the load reliably and economically so that nominal condition will be re-established The main focus is to maintain the value of frequency in its prescribed limit. We use renewable source which are important as well as non renewable sources at the level of extinct. As renewable alone cannot reliable then we use interconnection of both for making the system reliable and more efficient. This research paper is devoted to explore the interconnection of the automatic generation control of hydro power system and wind system. The wind system is comprised with governor dead band, generation rate constraint and turbine dynamics where as the hydro system is comprised with generation rate constraint. The traditional PI controller does not have adequate control performance with the consideration of nonlinearities and turbine dynamics. To overcome this drawback, PID controllers helps in solving optimization problems by exploitation of random search. It will provide the system security also for maintain the frequency in prescribed limit with the help of simulation.

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1. INTRODUCTION

To increase the system reliability and make it more efficient and economic we use interconnection of the system [1]. The automatic generation control (AGC) is achieved by the area control error (ACE) which is function of frequency and tie line flow of the system. If one area is changing its load then the difference represented by load and generation area is called ACE [2]. As population is increasing day by day, the demand of power is increasing and this lead to increase power capacity. In India 65% power obtained from thermal power plants due to uncertainty of fossil fuel and these fossil fuels are at the level of extinct [3]. Thus we are moving towards renewable energy sources. And these sources are dependent on atmosphere intermittent [4]. Thus we need interconnection of renewable with other fossil fuel. A balance between demand and generation is important to maintain the system reliability and improve the quality of electric power. The main objective of electric power is to maintain frequency, voltage and power in prescribed limit. Due to change in load operating point may change very much during a duty cycle [5]. To get the integrated operation electric power should be maintained at a desired level by maintain frequency, voltage profile etc [6]. For the better performance of system good quality of power is required when we transmit the electric power. Both real and reactive power should be balance between generating end and distributed end. Thus, input generator maintained according to varying demand of power so frequency should be in sustained limit. As we have seen frequency is directly proportional to real power, and voltage is directly proportional to reactive power. The problem of controlling the tie line power and frequency is called load frequency control or pf control or generation control. Load frequency control is also a part of automatic generation control (AGC) [7]. AGC can also be achieved by manipulating one area with respect to other area with a control strategy which in real in used in turn control of real power [6]. AGC can be defined as it is used to restore the frequency to a nominal value when load is continuously changing. Control area is a part of power system where common generation scheme is applied. In control area both case steady and dynamic change frequency should be same. To maintain constant voltage profile both area will help to achieve the control of the system [8].

2. GENERAL AGC MODEL

In this we have defined the general model of automatic generation control (AGC) as shown in Figure 2 through this we can know the different parts of AGC and there function as well as there equation through which we can define the transfer function.

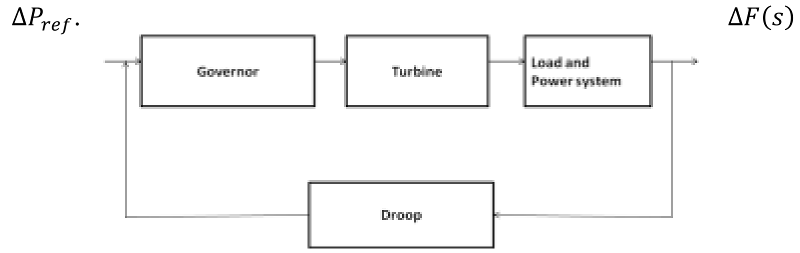

Figure 1. General AGC model

Turbine: Turbines are used to convert the energy obtained from steam, water etc. to the mechanical energy which is used to give supply to the generator. The turbine model is obtained by change in power of output to the change in opening of the steam valve.

$$\frac{\Delta P_G\,(s)}{\Delta Y_e(s)} = \frac{K_T}{1 + sT_T} \tag{1}$$

Generator: Generator takes the mechanical energy from turbine and converts it into the electrical energy. In this speed of rotor is directly proportional to frequency. We cannot store the bulk amount of power then we have to maintain gap between powers generated and power demand. The mathematical expression is:

$$\Delta Y_e(s) = \left(\Delta P_{ref}(s) - \frac{1}{R}\,\Delta F(s)\right)\frac{K_{sg}}{1 + sT_{sg}} \tag{2}$$

Governers: Governors are employed in power systems for sensing the bias in frequency which is the result of the improvement in load and eliminate it by changing the turbine inputs such as the characteristic for speed regulation and the governor time constant.

$$\Delta \mathrm{F(s)} = \frac{\mathrm{K_{pg}}}{1 + \mathrm{sT_{pg}}}\,(\Delta \mathrm{P_g(s)} - \Delta \mathrm{P_D(s)}) \tag{3}$$

ΔP_{ref} = input power.
$\Delta F(s)$= output frequency.
K_T= gain of turbine.
T_T= time constant of turbine.
K_{Sg}= gain of generator.
T_{Sg}=time constant of generaor.
R= governor speed regulation parameter.
K_{pg}= gain of governor
T_{Pg}= time constant of governor.

ΔP_D= load increment.
ΔP_g=turbine power output [9].

3. INTERCONNECTED TWO AREA SYSTEM

The large power system is interconnected through tie lines which are useful for the power exchange between two areas in abnormal condition as shown in Figure 2. The total generation shoud be equal to demand and the losses present in the system [10].

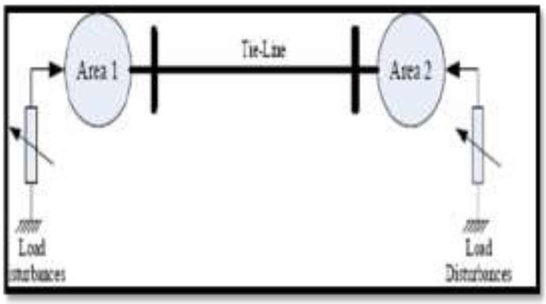

Figure 2. Interconnected system

4. PROBLEM FORMULATION

For the system mentioned in Figure 1, the aim is to find the best control strategy such that following objectives are met:

1. The steady state frequency error following a step load perturbation should be zero.
2. The steady state change in the tie flow following a step load change in an area must be zero.
3. An automatic generation controller providing a slow monotonic type of generation responses should be preferred in order to reduce wear and tear of the equipment.

when control structure is a major known our objective is to adjust the control parameter so as to achieve the best dynamic performance and this is only achieved by proper optimization of controller parameter.The objective function used for controller design is that which is used in ISE criterion and this is as follows:

J=∫t f (e12, e22, e32… en2) dt

where e1, e2, e3 … en are different errors.

In this case J=∫t (D f12 + D f22 + DPtie2)

5. RESEARCH METHOD

Two types of Controllers are used as traditional controllers

5.1. PI Controller

It is the fundamental concept of a PID controller as shown in Figure 3 in which the term D is not considered. The output equation of this PI controller is as below:

$$Kp\Delta + KI \int \Delta dt$$

Here, Δ = the deviation or inaccuracy of real calculated value (PV) from the SP-set point.

$$\Delta = -PV + SP$$

PI-Proportional Integral Controller is designed effortlessly in software like MATLAB/Simulink by the help of Laplace operator which is given by:

$$C = \frac{G\,(1 + \tau s)}{\tau s}$$

Here, $\frac{G}{\tau}$ = Integral Gain = K_I, G = Proportional Gain = K_P

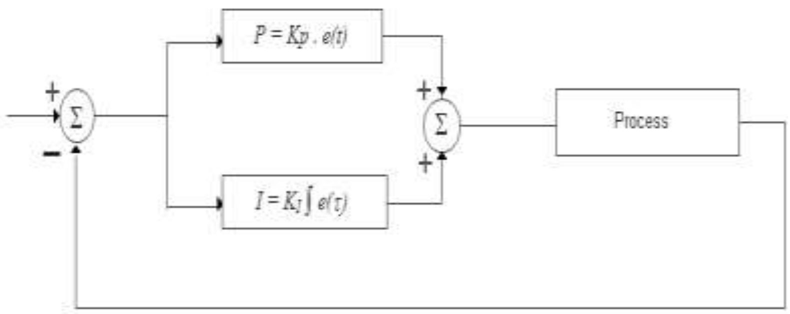

Figure 3. Block diagram of PI controller

Setting a value for proportional gain *G* is frequently changing between increasing settling time and decreasing overshoot. The absence of derivative action gives a more stability in the particular situation of noisy data in a steady state because derivative action is too much delicate towards the maximum frequency in the inputs. In the absence of derivative term, proportional integral controller based precise network is less sensitive to actual and comparatively speedy adjustments and because of that the entire power system will become more slower to meet at set point and give a very slow reaction in a the system disturbances.

5.2. Proportional Integral Derivative Controller (PID)

Proportional integral derivative controller as shown in Figure 4 more reliable, efficient and is used for a quick operation. It changes the dynamics of the system and that's why it is more useful for designing a power system. This PID controller obtains an error value by comparing a required set-point and calculated process variable and it will try to reduce an error as soon as possible.This note gives idea about a simple implementation of a discrete PID controller. It is necessary to execute a control system at whenever it is operating with applications and system output is controlled because of changes in reference quantity or state is required. There are number of requirements of this type of uses likewise force, velocity, pressure, flow rate, temperature control, motor control or different variables. The Proportional Integral Derivative controller can be used to control any significant up to that time when this variable can be affected by handling some other process variables [10].

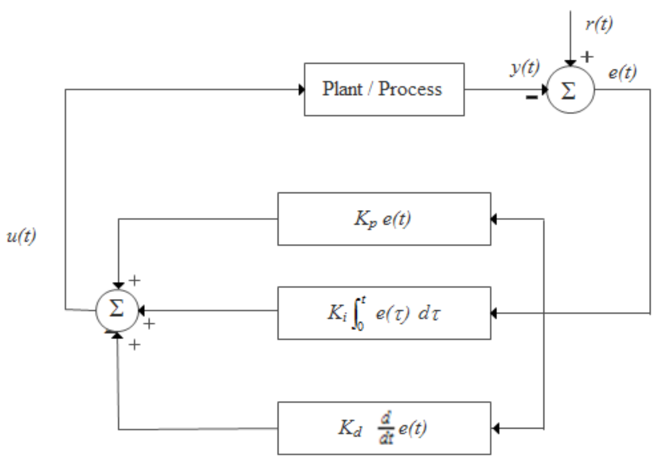

Figure 4. Block diagram of PID

6. RESULTS AND ANALYSIS

The area shown in the diagram is two equal areas with PI and PID controlleras shown in Figure 5 and Figure 6. The result shown with PID is better than the PI controller. The output shown by PID is better than PI as shown by Figure 7 and Figure 8. The overshoot time is better for PID than PI.

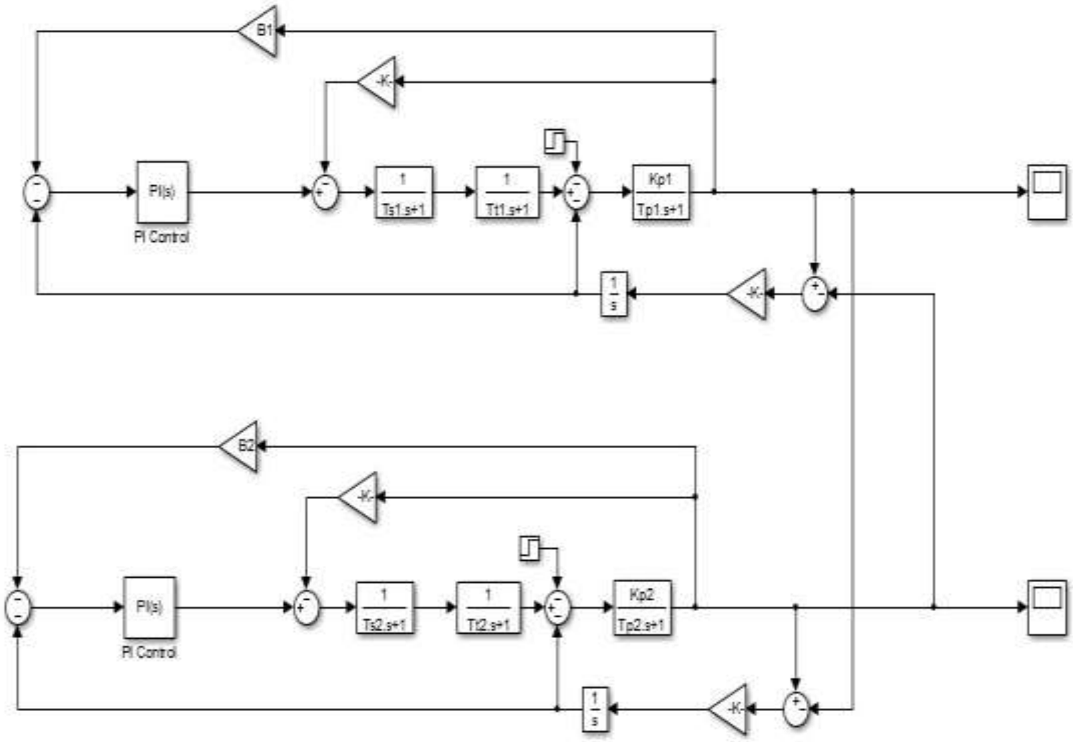

Figure 5. Simulation of Hydro and wind area with PI controller

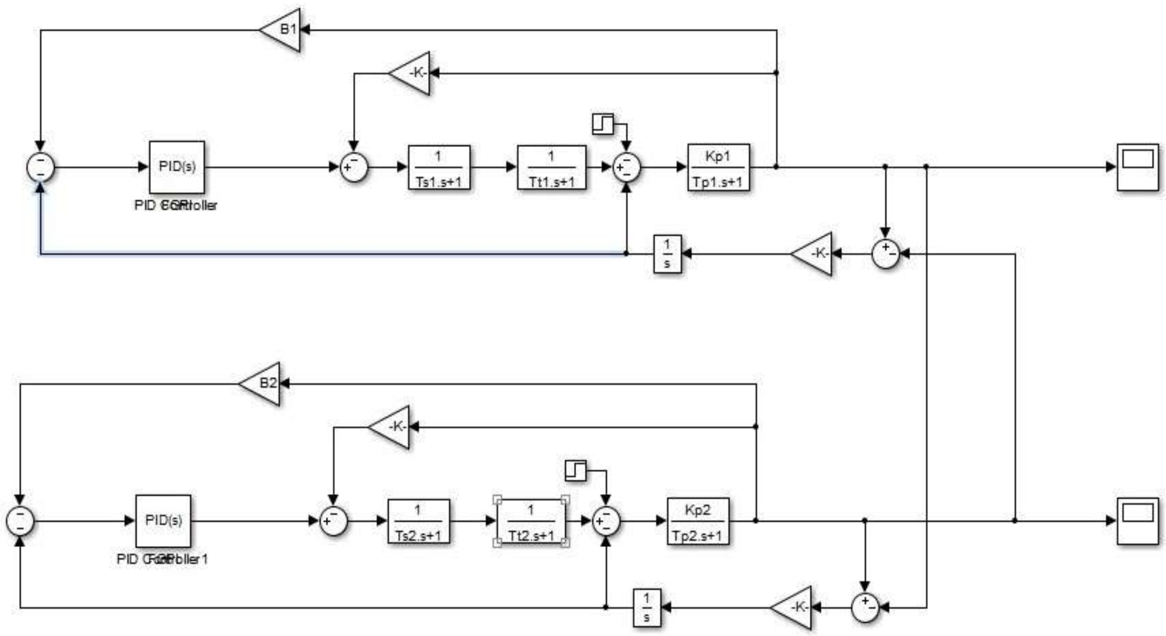

Figure 6. Simulation of Hydro and wind area with PID controller

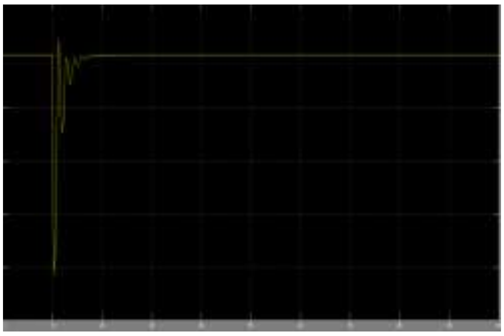
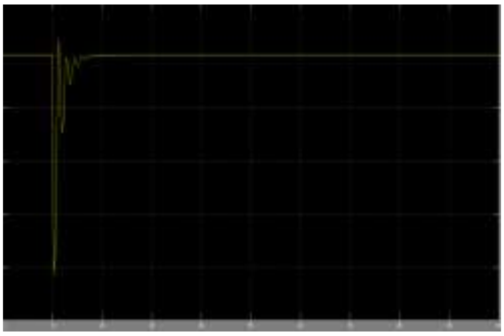

Figure 7. Area 1 and area 2 with PI contrller


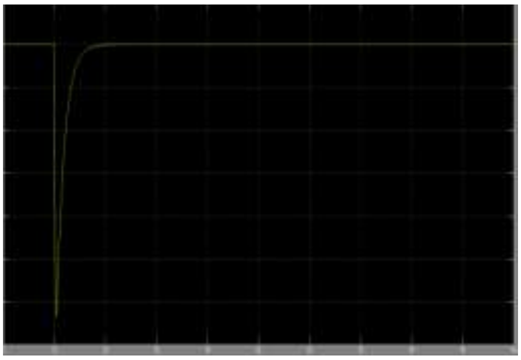

Figure 8. Area 1 and area 2 with PID controller

7. CONCLUSION

The Automatic Generation Control of a two area power system having power generation from wind sources in area-1 and from hydro sources in area-2 has been studied.The scheduled power generations from wind or Hydro are adjusted to match the system normal operating load.The simulation results conclude that:

a. PID controller yields fast settling time which advocates the smooth settlement of the quality power supply.
b. PID controller shows very good dynamic response than Traditional PI controllers.
c. PID controller explore very good result as compared to all the other controllers.

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