Automatic Generation Control of Multi Area Power Plants with the Help of Advanced Controller

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Abstract:**The automatic generation control (AGC) of multi area combined power plant has been modelled with PID controller – Proportional Integral Derivative Controller. There are mainly Particle Swarm Optimization and Conventional Gradient Descent technique have been used to improve the performance of Automatic Generation Control system. The frequency change occurs in all the three areas due to load fluctuation in one area at a time. The transfer function model for the wind power plant has been developed assuming a constant wind speed. The interconnection of wind power plant with thermal and hydro power plant has been done and then the frequency control is done with PID controller for this interconnected system. The simulation studies using MATLAB have been done which show that the PID controller is effective for controlling the frequency change along with suitable frequency bias (Bi), speed regulation parameter (Ri), proportional gain (Kp), integral gain (Ki). Conventional Gradient Descent technique will take much more time when different parameters have to be calculated simultaneously. The advance intelligence based technique like Particle Swarm Optimization is more reliable, high efficient and fast technique to obtain different gains in load frequency control. PID controller gives the improved dynamic performance for multi area network with thermal-wind-hydro power plants. MATLAB software is used as a simulation tool as usual gives the compression between PI and PID controller.**

Keywords:Automatic Generation Control, Particle Swarm Optimization, Proportional Integral Derivative Controller, State Space Model, Generation Rate Constraint, Integral Squared Error

I. INTRODUCTION

The main function of electrical power system is to maintain and control a certain level of frequency and voltage. A balance between load demand and power generation is required to provide reliability and high quality of electricity. Wind-Thermal-Hydro power plant is mostly based on the atmospheric and cyclical conditions. In case of Wind power plant, it is depend on wind speed in a particular time period. Mathematical technique is not applicable in this type of combined area. The continuous time Linear Quadratic Regulator (LQR) concept has been applied in the present work for the design of optimal advanced controller for the frequency response enhancement of multi area interconnected power system. Computational intelligent technique like Particle Swarm Optimization method and Gradient Descent Technique are used. But it is more useful to go through a PSO method because it is more reliable and more efficient compare to GD method. The changes in power demand affect the frequency and tie line power flow between control areas. The main function of load frequency control is to maintain the system frequency at its scheduled value by regulating active and reactive power.

Automatic Generation Control is one type of regulation of power output of governablegenerators within a recommended area in response to change in system frequency or tie-line frequency. So it is use to control the frequency and preferred tie-linepower flow as well to accomplish zero steady state error. The main aspect behind the modelling of combined power system and design of AGC are to reduce wear and tear of the equipment then slow monotonic type of generation response of a controller must selected which is possible in AGC and frequency error for the steady state should be zero.A control signal made up of tie line flow deviation added to frequency deviation weighted by a bias factor would accomplish the required objective and it is known as area control error (ACE).

There are number of conventional and advanced controller which is used as per the requirement in a simulation. Here we will going to use Proportional Integral Controller (PID). There are number of advantages to use of this advanced controller instead of conventional controller. PID controllers have some attractive features like more reliable, having a quick operation and more efficient. It has an ability of changing the dynamics of the system and this thing is more useful for designing a power system. This controller obtain an error value by comparing a measured process variable and desired set-point and it will try to reduce an error as soon as possible. This note gives idea about simple implementation of a discrete proportional integral derivative controller. It is required to implement a control system whenever it is operating with applications and system output is controlled due to changes in reference value. Several examples of this type of applications are control of temperature, motor control, force, speed, flow rate, pressure or any other variable. PID controller can be used to control any significant up to that time when thisvariable can be affected by handling some other process variables.

The Characteristics of P, I and D in PID controller is as below. Proportional Control (*Kp*) is proposed to reduce the rise time. Here one thing is to be noted that rise time is only reduced but never eliminate the steady-state error. An integral control (*Ki*) is proposed to eliminate the steady-state error for a constant and transient response will decrease. A derivative control (*Kd*) is proposed to improve the transient response, increasing the stability of the system and reducing the overshoot. All these relations may not be exactly accurate just because of the *Kp*, *Ki* and *Kd*are dependent with each other. By changing in one of this value, it will effect remaining two parameters.

II.MATHEMATICAL MODELLING OF AGC FOR THREE AREA SYSTEMS

In this AGC of three power systems are interconnected through tie line for sharing the power to maintain and regulate the overall load. Each areas taken for investigation are of 2000 MW in this system. By using MATLAB/SIMULINK, The transfer function model has been designed. The generation rate and reheat are not taken into account for the simplicity of the system. The load frequency control system investigated consists of three generating areas of equal size and comprising wind, hydro and thermal system simultaneously. Generation Rate Constraint of the order of 3% per minute for thermal area and 270% per minute for rising and 360% per minute for lowering generation in hydro area has been considered.

Different parameters related to thermal-wind-hydro power system for a PI controller and PID controller are given in Table-I and Table II simultaneously. The wind power plant of nominal rating of 35 MW is also connected in the three area network and the transfer function model is designed for the wind power plantassuming a constant speed of wind. The generic speed governing system model is shown in Fig.1. The maximum value of *Kp* confirm the better tracking performance but there are some limitations like control effect. That's why the *Kp* must be limited. The dynamic performance of Wind Energy Conversion System (WECS) can be given by two- pole- one -zero transfer function as given below:

$$\text{Hpt (s)} = \frac{\text{Kpt (Tz s + 1)}}{(\text{T}\varepsilon\text{ s + 1})(\text{Tpt + 1})}$$

$T\varepsilon$andTpt are parasitic and main time constant respectively. The closed loop structure of WECS with PID control is as shown in Fig 2.

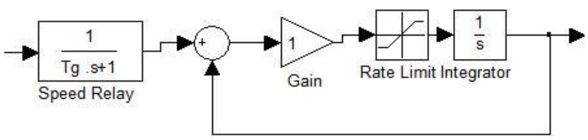


Figure 1. Generic speed governing system model

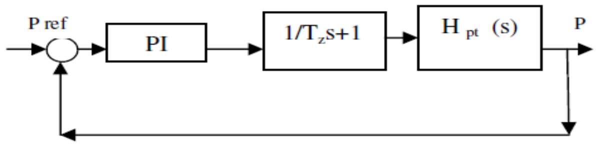


Figure 2. Wind Energy Conversion system

In this article combined unequal power system with thermal, wind and hydro power plants as below in Fig.3. The dynamic reactions have been achieved with 1% changing in load in one area at a time which is disturbing the frequency of other systems also. Here calculating the values of *Kp*, *Ki*, *Ri* and *Bi* of three different areas. The exploration and comparison between PI and PID controller method has been done. The stability of three area system have been improved by using advanced controller which is shown in given waveforms. Nominal parameters of these multi area are given in Table-III which is taken from the work of NareshKumari et al. [1].

III. RESULT AND DISCUSSION

The combined unequal area system is shown in this section. By obtaining a waveform, we can evaluated that AGC of multi area power system with a PID controller is much more stable than a AGC of multi area power system with PI controller. The dynamic responses have been achieved with1% load change in one area at a time which is disturbing thefrequency of other systems also.

After implementation of multi area model, we will optimize various parameters. Here in this modelling PID controller is used which is much more effective for controlling the frequency change along with suitable frequency bias feedback gain (*Bi*) and governor speed regulation parameter (*Ri*). We will also calculated different parameters like the proportional gain (*Kp*), integral gain (Ki), speed regulation parameter (*Ri*) and frequency bias (*Bi*) parameter simultaneously and the analysis and comparison of PSO and GD method has been done.

The main aim of this research article is to improvement of the efficiency of multi area power plant by using Proportional Integral Derivative Controller. PID controller gives the improved dynamic performance for hybrid area network with Thermal–Wind-Hydro power plants.

TABLE 1. DIFFERENT PARAMETERS OF THREE AREA FOR PI CONTROLLER

Inter Connected Area	Optimum Parameters	PI
Thermal Power System	Kp	0.1
	Ki	1
	Sampling Time	50e-6
Wind Energy Conversion System	Kp	0.1
	Ki	1
	Sampling Time	50e-6
Hydro Power Plant	Kp	0.1
	Ki	1
	Sampling Time	50e-6

TABLE 2.DIFFERENT PARAMETERS OF THREE AREA FOR PID CONTROLLER

Inter Connected Area	Optimum Parameters	PID
Thermal Power System	Kp	1
	Ki	1
	Kd	1
	Sampling Time	0.5
Wind Energy Conversion System	Kp	1
	Ki	1
	Kd	1
	Sampling Time	0.5
Hydro Power Plant	Kp	1
	Ki	1
	Kd	1
	Sampling Time	0.5

TABLE 3. NOMINAL PARAMETERS OF THREE AREA

f=60 Hz	Kr=0.5
Tg=0.08s	Tt=0.3sec
Ptie max=200 MW	Kp=120 Hz/puMW
Tr=10s, T12=0.544	Tp=20s
H=5 sec	Pr=2000MW
D=0.00833 p.u.MW/Hz	R=2.4Hz/p.u.MW
Density of air = 1.25 kg/m3 Gear ratio = 70	Tpt = 10.55
Radius of turbine blade= 45m	Kpt = 0.012
Average wind velocity = 7 m/s	Ti = 3 sec
H = 5 sec	Tp = 20 sec

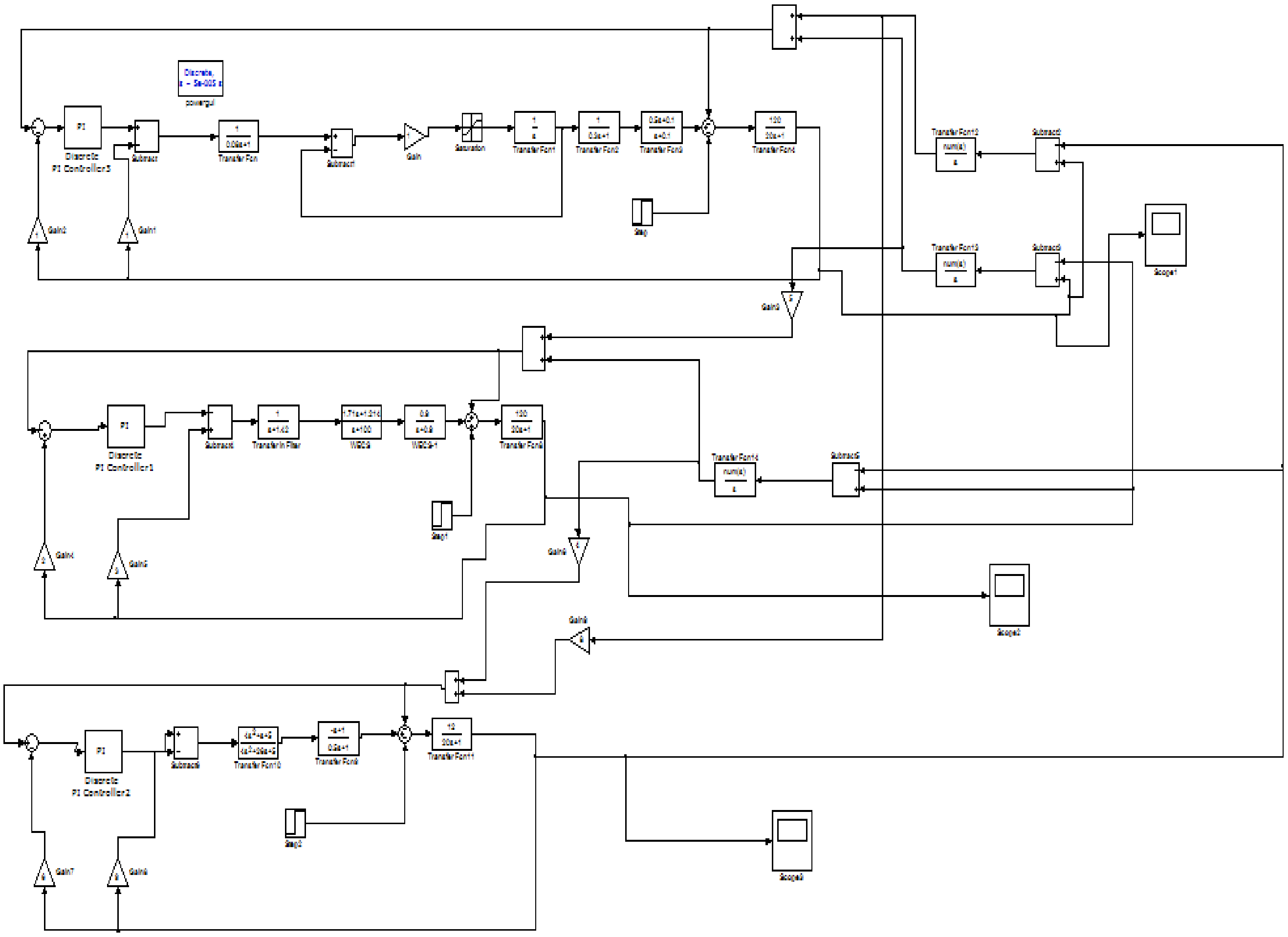


Figure 3. Three area interconnected Thermal, Wind and Hydro power system model with PI controller

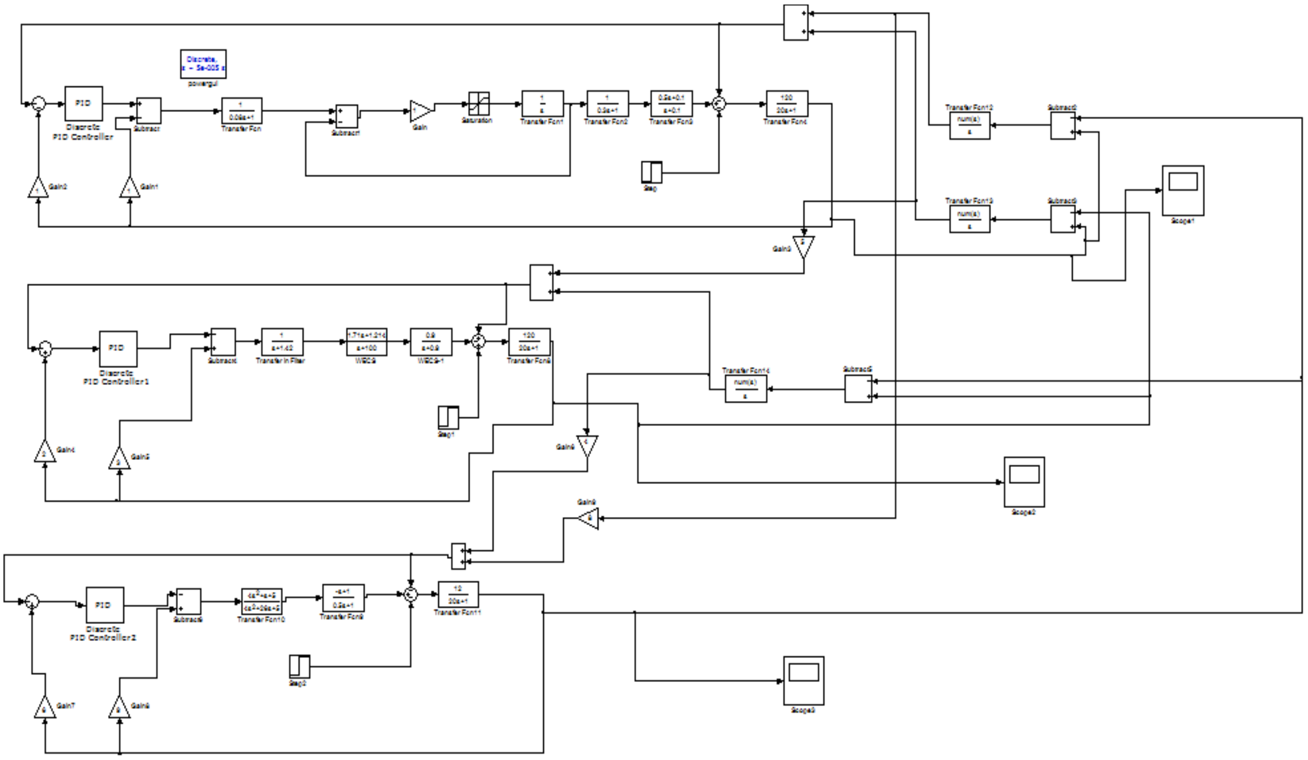
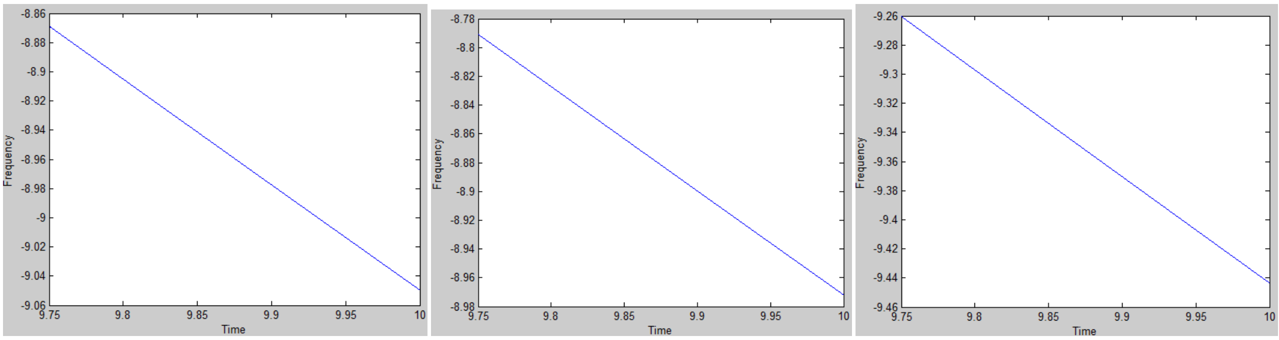
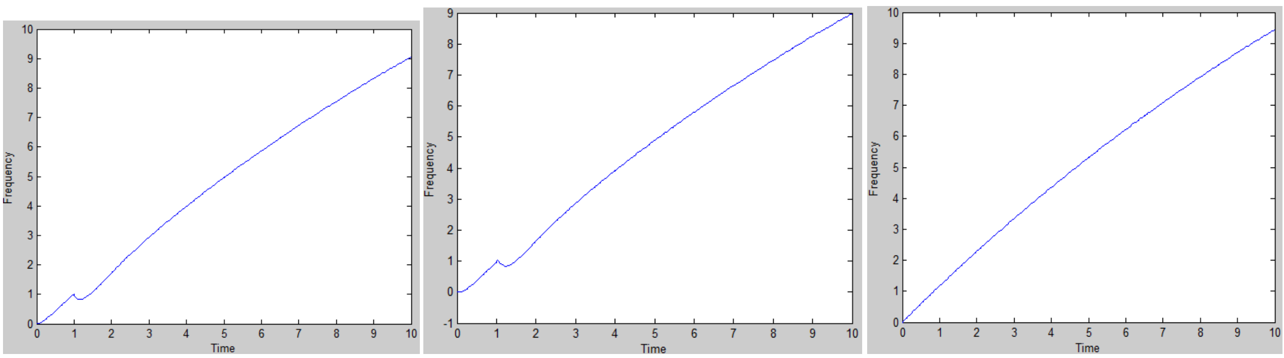


Figure 4. Three area interconnected Thermal, Wind and Hydro power system model with PID controller



Area 1 - Thermal Area 2 -Wind Area 3 - Hydro

Figure 5. Frequency response of three area interconnected Thermal, Wind and Hydro power system model with PI controller



Area 1 - Thermal Area 2 -Wind Area 3 - Hydro

Figure 6. Frequency response of three area interconnected Thermal, Wind and Hydro power system model with PID controller

IV. OVERVIEW OF PI AND PID CONTROLLER

PI controllers are frequently used in number of applications when speed of the response is not required. So the PI controller is used only when large transport delays present in the system, large instabilities and noise are present during the system operation.

Proportional Integral Derivative (PID) controller is much more reliable, efficient and having a quick operation. It has a capability of changing the dynamics of the system and this thing is more useful for designing a power system. This PID controller obtain an error value by comparing a measured process variable and a desired set-point and it will try to reduce an error as soon as possible.

This note gives idea about a simple implementation of a discrete Proportional-Integral-Derivative (PID) controller. It is required to implement a control system whenever it is operating with applications and system output is controlled due to changes in reference value or state is needed. Number of examples of this type of applications are control of temperature, motor control, flow rate, speed, force, pressure or other 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.

V. CONCLUSION

We will simultaneously going to optimize the proportional integral derivative controller and system parameters like proportional gain (*Kp*), integral gains (*Ki*), speed regulation parameter (*Ri*) and frequency bias (*Bi*) parameter of different areas for load frequency control. Changing in frequency occurs in all the three areas due to load variation in one area at a time. The transfer function model for the wind power plant has been developed considering a constant wind speed. The interconnection of wind power plant with thermal and hydro power plant has been done and then the frequency control is done with advance control using PID for this interconnected system. On the base of simulation model, we can say that the proportional integral derivative controller is effective for regulating the frequency change along with suitable frequency bias feedback gain (*Bi*) and governor speed regulation parameter (*Ri*).

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