Modeling of Load Frequency Control for A Hybrid Power System using PID Controller

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***Abstract*:-Interconnected power system is plays one the of critical role in modern electrical power system Engineering.the power load demand varies randomly both area frequency and tie-line power interchange also vary. For interconnection of two or more areas in power system, frequency should be maintained within the scheduled value, which can be achieved by employing one of the most prominent techniques called as Automatic Load Frequency Control (ALFC). In ALFC, frequency can be controlled in three ways, namely Flat frequency regulation, Parallel frequency regulation and Flat tie-line loading. Among these controls, Parallel frequency regulation is commonly used method, because constant frequency can be maintained by equalizing the power generation with the power demand. The objectives of LFC are to minimize the deviations in these variables (area frequency and tie-line power interchange) and to ensure their steady state errors to be zero. In this area of energy crisis, renewable energy is the most promising solution to increasing energy needs. But the power production by these resources cannot be controlled unlike in thermal plants. As a result, standalone operation of renewable energy is not reliable. Hence grid-connection of these along with conventional plants is preferred due to the improved performance in response to dynamic load. In this paper a particle swarm optimization tuned Proportional Integral Derivative(PSOPID) controller has been proposed.Load frequency control including PID controller with PSO optimizing method is proposed in order to suppress frequency deviations for a power system involving wind, hydro and thermal plants owing to load and generating power fluctuations caused by penetration of renewable resources. The proposed system involving four thermal plants,wind farm and hydro plant will be modelled using MATLAB.**

Keywords: - Automatic Load Frequency Control (ALFC), Hybrid power systems (Thermal and hydro, wind power plant),PID controller

I. INTRODUCTION

Generally, power system consists of three parameters which shall be within the limits for successful operation i.e. Frequency, Voltage and Load angle, among these frequency parameter plays vital role. Many different power frequencies were used in the 19th century. Very early isolated ac generating schemes used arbitrary frequencies based on convenience for steam engine, water turbine and electrical generator design. Frequencies between 16⅔ Hz and 133⅓ Hz were used on different systems (1).The main purpose of a power engineer is to provide power to the consumers reliably and economically with a better quality. Frequency and tie-line power should be kept within the limits by equalizing the power generation at the generating end and the power consumption at the load end, because there are two points available throughout the power system for keeping the frequency within the limits, one is at the generating end and the other is at the load end [2].

LPF problem arises when individual generation areas are interconnected by transmission lines called as tie-lines.Large-scale power systems are liable to performance deterioration due to the presence of sudden small load perturbation parameter uncertainties, structural variations, etc. Frequency deviation is undesirable because most of the AC motors run at speeds that are directly related to frequency (3), Thus it is imperative to maintain system frequency constant. This is done by implementing Load Frequency Control (LFC). There are many LFC methods developed for controlling frequency. They include flat frequency control (FFC), tie-line bias control (TBC) and flat tie-line control (FTC). In FFC, some areas act as load change absorbers and others as base load (4). The thermal areas have been modelled using transfer function. Speed governor, turbine and generator constitute the various parts namely the speed governing system, turbine model, generator load models (5).The Particle swarm optimization are tuned Proportional Integral Derivative (PSOPID) controller has been proposed.the proposed controller has been compared with the other classical controllers under different loading conditions(6-8).The main performance PID controller tuned with Particle swarm algorithm was better than classical controller in terms of transient stability. It is observed that fluctuations in frequency caused due to load variations are low with increase in penetration of renewable resources (9).The Load frequency control(LPF) including PSO-PID controller is proposed in order to suppress the frequency deviations for a power system involving wind, hydro and thermal plants owing to load and generating power fluctuations caused by penetration of renewable resources. A system involving four thermal plants, a wind farm and a hydro plant will be modelled using MATLAB simulation (10).

II.MODELING OF SINGLE AREA (THERMAL AREA) :

2.1 Mathematical model of Speed Governing System of Power System:

the mathematical model of speed governing system has command signal ΔPC initiates a sequence of events-the pilot valve moves upwards, high pressure oil flows on to the top of the main piston moving it downwards; the steam valve opening consequently increases, the turbine generator speed increases, i.e. the frequency goes up which is modelled mathematically (9)

$$\Delta Y_E(S) = [\Delta P_C(S) - \frac{1}{R}\Delta F(S)] \times (\frac{ksg}{1+Tsgs}) \qquad (1)$$

2.2. Specifications of Turbine models

The Turbine have Dynamic response of steam turbine is related to changes in steam valve opening ΔYE in terms of changes in power output. Typically, the time constant Tt lies in the range 0.4 to 2.5 sec.

2.3. The Generator Load Models:

The increment in power input to the generator-load system is related to frequency change as

$$\Delta F(S) = [\Delta P_G(S) - \Delta P_D(S)] \times (\frac{kps}{1+Tps}) \qquad (2)$$

2.4 structure of Entire Thermal Area:

Typical values of time constants of load frequency control system are related a Tsg<Tt<Tps shows in the required block diagram below.

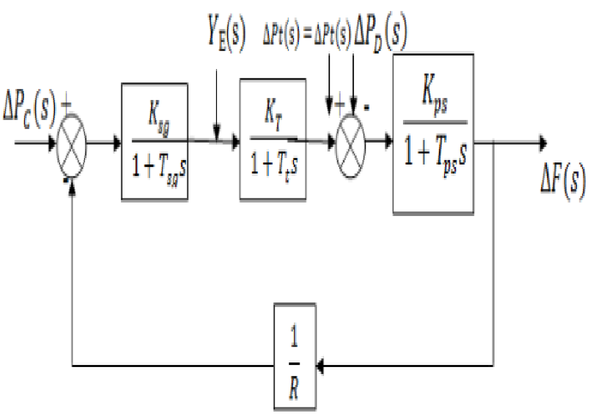

Fig.1 Block Diagram of Thermal

A complete block diagram of an isolated power system comprising turbine, generator, governor and load is easily obtained by combining the blocks.

Area	Rated power	D(puMW/HZ)	H(s)	Kps ,Tps
Tp1	2000	.015	6	100,25
Tp2	1500	0.22	4	50.25
Tp3	650	0.35	3	35,50
Tp4	3000	0.1	7	152,30

Table.1: Parameters of Thermal Areas

III. MODELING OF HYDRO POWERPLANT AREA

Modeling of hydro and wind consists The representation of the hydraulic turbine and water column in stability studies is usually based on certain Assumptions. The hydraulic resistance is considered negligible. The penstock pipe is assumed inelastic and water incompressible. Also the velocity of the water is considered to vary directly with the gate opening and with the square root of the net head and the turbine output power is nearly proportional to the product of head and volume flow.

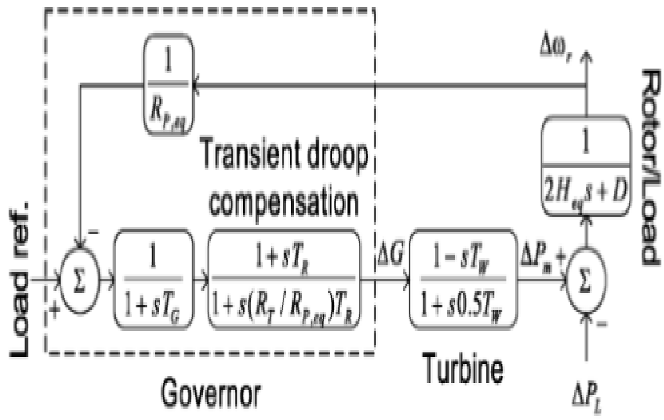

Fig.2 block diagram for hydro -wind area

Hydro plants are modelled the same way as thermal plants. The input to the hydro turbine is water instead of steam. Initial droop characteristics owing to reduced pressure on turbine on opening the gate valve has to be compensated.Hydro turbines have peculiar response due to water inertia; a change in gate position produces an initial turbine power change which is opposite to that sought. For stable control performance, a large transient (temporary) droop with a long resettling time is therefore required in the forms of transient droop compensation as shown in Fig.2 The compensation limits gate movement until water flow power output has time to catch up. The result is governor exhibits a high droop for fast speed deviations and low droop in steady state.

IV.LOAD FREQUENCY CONTROL FOR A TWO -AREA SYSTEM

Load frequency control of power system makes critical role in electrical engineering. Power system can be divided into a number of load frequency control areas interconnected by means of tie lines. The control objective now is to regulate the frequency of each area and to simultaneously regulate the tie line power as per inter-area contacts. With the primary LFC loop a change in the system load will result in a steady state frequency deviation, depending on the governor speed regulation. In order to reduce the frequency deviation to zero we must provide a reset action by introducing an integral controller to act on the load reference setting to change the speed set point. The integral controller increases the system type by 1 which forces the final frequency deviation to zero.

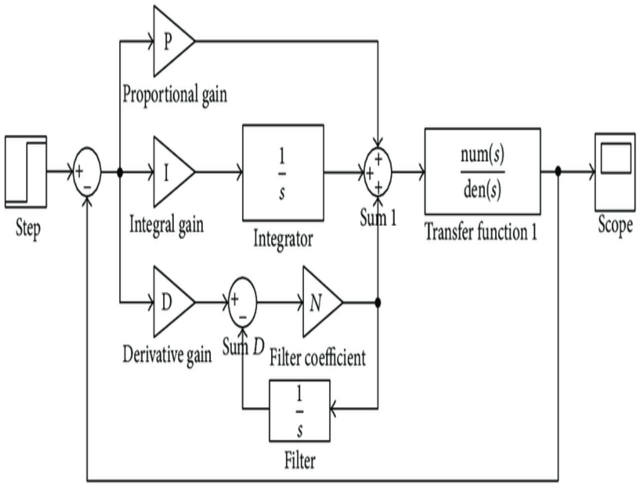

Fig. 3: Proportional plus Integral Load frequency Controll.

PID controller adjusted for a satisfactory transient response. It is seen from the above .discussion that with the speed governing system installed on each machine, the steady load frequency .characteristic for a given speed changer setting has considerable droop, from no load to full load .system frequency system specifications are rather stringent and,therefore so much change in frequency cannot beAs in case of frequency, proportional plus integral controller will be installed so as to give zero steady state error in the tie line power flow as compared to the contracted power. It is conveniently . Symbols used with suffix 1 refer to area 1 & those with suffix 2.

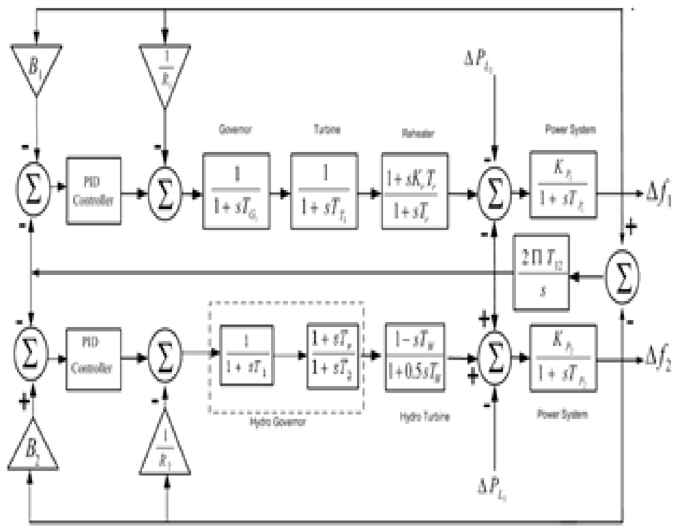

FIG.4: Modeling of Two Area power system. (thermal-hydro)

V. PARTICLE SWARM OPTIMIZATION

The PSO methodology is suitable for taking care of nonlinear issue.The methodology is focused around the swarm conduct, for example, flying creatures discovering sustenance by rushing.An essential variety of the PSO calculation satisfies desires by having a masses (called a swarm) of candidate result (called particles). These particles are moved around in the interest space according to a few essential formulae. The advancements of the particles are guided by their own particular specific best known position in the request space and furthermore the entire swarm's best known position. Modeling of Δf1and Δf2 applied on partial swarm optimization algorithm.

VI. SIMULATION AND RESULTS:

The modeling of load frequency control with PID controller is done by using Matlab in below figures. Simulatiom result of two area interconnected two thermal power systems and with out wind integration is show in below figure. And also hydro and wind are clearly analyzed in below results. And also analyse the Interconection of thermal power plant with wind and thermal and hydropower plant. Here the time taken to reach steady state value is in the order of seconds, because in thermal and hydro power systems consistsmechanical equipments which has more time constants when compared with the electrical devices.The conventional integral controller gains for the hydro area nd thermal area are found to be KI1=-1.2 and KI2=-0.5 respectively. Using conventional PI controller, optimum gainsKP1=-0.01, KI1=-0.6 for hydro area and KP2=-0.1, KI2=-0.5 for thermal area and KW1=0.02,Kl3=0.7 for wind area.The optimum value of integral controller gains for the hydro area and thermal area are KI1=-0.84 and KI2=-0.98.PID controller specifications: Proportional Gain Constant (Kp): 0.6351 Integral Gain Constant (Ki): 1.26 Derivative Gain Constant (Kd): 1.26.For 4 No.of thermal power plants TP1=2000Kw, Tps=25 s, Kps= 100: Tp2=1500 ,Tps =25 s Kps =50: Tp3=650 ,Tps =35s Kps =50: Tp4=3000 ,Tps =30 s Kps =15:

A) Load Frequency Control for two interconnected thermal power plant without wind:

In the 1st section it was Two thermal systems have been interconnected and the composite block diagram is simulated in Simulink or matlab as shown below figure.5

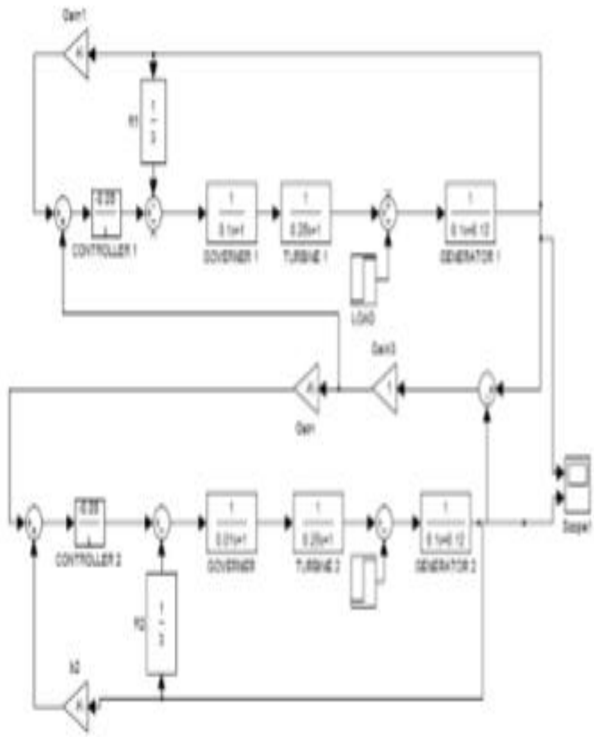

Fig.5: LFC for Two area thermal without wind

Response for two area thermal without and with wind are shown below. The repose of integration of two thermal area power system gives better values settling time and rising time and time delay integration of two thermal areas with wind farms

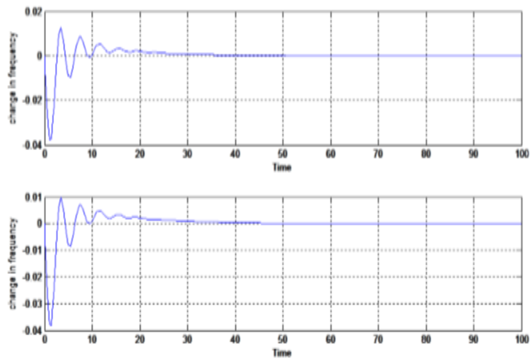

Fig: 6 Responses for two areas without wind

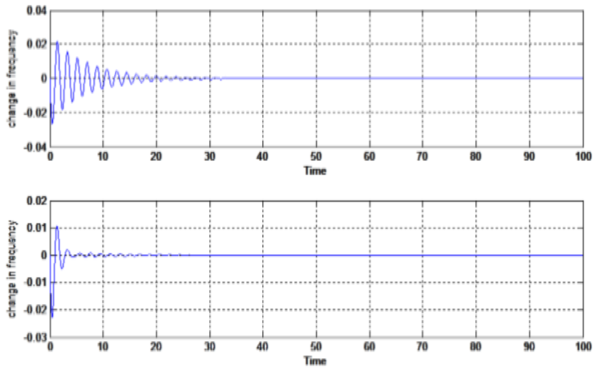

Fig: 7 Response of two areas thermal with wind integration

B)Load frequency control of Thermal and Hydro System (two area system)

In this there are four thermal power systems and along with one hydro power plant unit are combined and composite block diagram is simulated and is shown in below figure.8

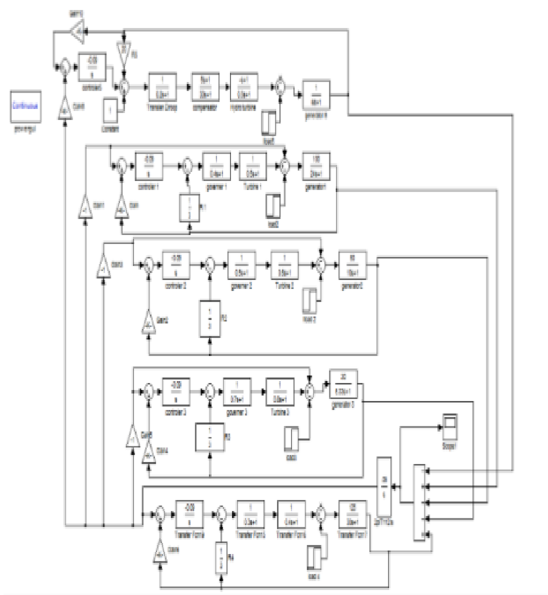

Fig.8: Thermal and Hydro interconnected. system (two area control)

Frequency Deviation (Hz) Vs Time (s) for Hydro & Thermal system with p controlle

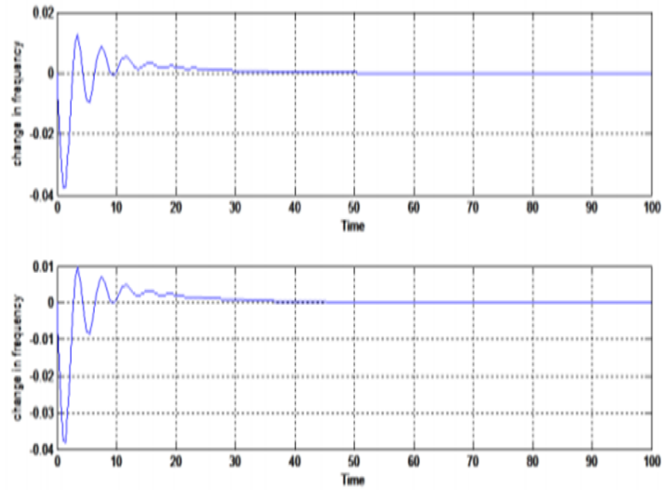

Fig9: Responses for two areas without wind

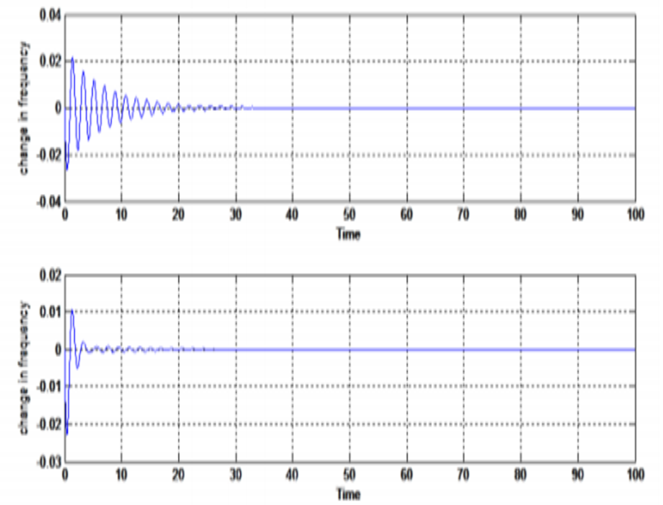

Fig.10: Out put Response of thermal - hydro with pid controller

C) Load frequency control of for Thermal, Hydro and Wind system (multi area control)

To compensate the intermittent nature of renewable, grid connection of the same is imperative for reliable power generation. It is possible to divide an extended power system into sub areas in which the generators are tightly coupled together so as to form a coherent group, i.e. all the generators respond in unison to changes in load or speed changer settings. Such a coherent area is called control area in which frequency is assumed to be same throughout in static and dynamic conditions.

For the purpose of developing a suitable control strategy, a control area can be reduced to a single speed governor, turbo generator and load system consisting of four thermal areas, a hydro area and wind farm is controlled by a controller. By a batch control, the load is divided amongst various power plants in the ratio of their capacities by control system. This entire power system is modelled as shown in fig.11.the output ΔF of this subsystem gets reflected in grid voltage.

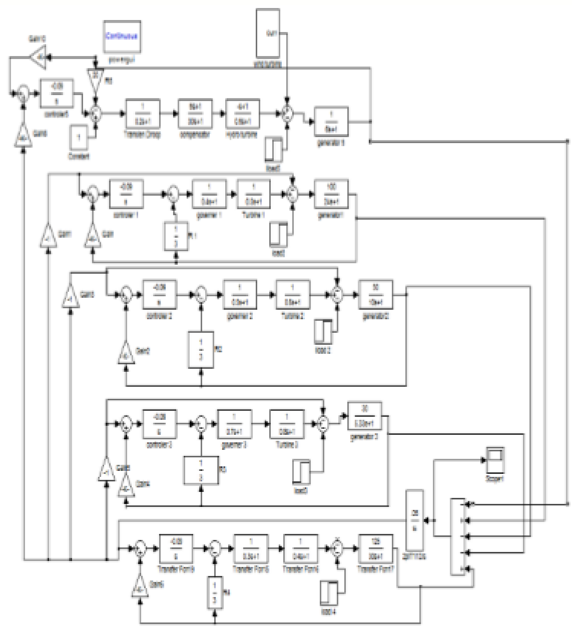

Fig.11: LFC for Thermal, Hydro and Wind system

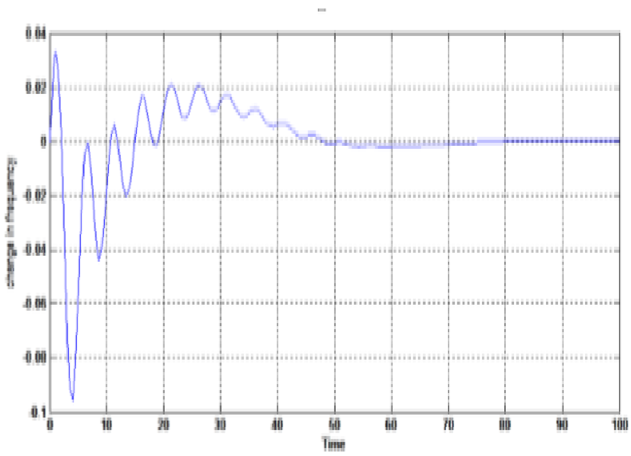

Fig.12:Response of multi area with wind pi controller

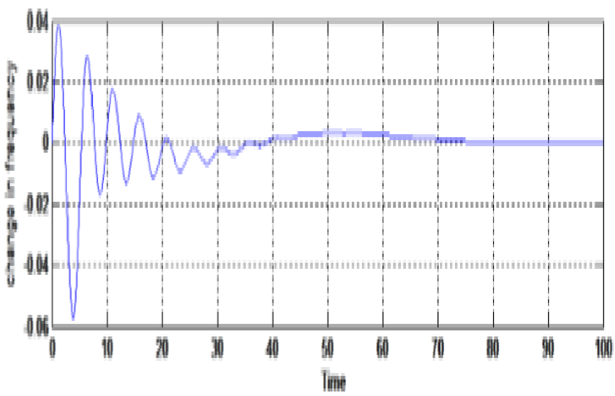

Fig.13: Response of multi area with wind pid controller

D) Out put Time response For Multi area with inter connection of thermal, hydro and wind power plant by using PID control :

1.Peak overshoot : 10%
2 .Settling time : 36 S
3 .Delay time: 1.1 S
4 .Rise time :2.0 S
5 .Peak time: 3.2 S

VII.CONCLUSION:

Load frequency control(LFC) was playes very important role, when a large amount of renewable power and non renewable supplies which are hydro, thermal and wind power generation etc. In this paper Load Frequency Control with considerable penetration of renewable has been analysed in the presence of Thermal, Hydro and Wind Systems with PID controllers by using optimizing technique called PSO. In electricity power industry, there is an ongoing need for efficient and effective LFC techniques to counter the ever increasing complexity of large-scale power systems and robustness against parameter uncertainties as well as plant/model mismatch and external load change. In this paper, a interconnected thermal and hydro and wind power system is considered at the first instance with conventional controllers like PI and PID , out of these the PID controller provide best solution. a widely used two-area hydro thermal system problems with I, PI and PSO optimized controller are presented. Among these, with PSO-PID has got the best dynamic response of frequency and tie-line powers. Future work may be carried out by including the study of the effect of changes in loading and system and use different Types of optimizing techniques like fuzzy control non conversation naval control methods for optiming the PID controller for Load frequency control .

APPENDIX

Nominal parameters of the systems are:f = 60 Hz; Tsgi = 0.06s; Tti = 0.4s; Tri = 10 s; Kri = 0.6; Kpi = 110 Hz/pu MW; Tpi = 0.06 s; Tw = 1 s; bg = 0.4; cg = 1; Xc = 0.8 s;Yc = 1s;Tcr = 0.015s;Tfc = 0.26s;Tcd = 0.2s;T12 = 0.09pu, MW/rad;Hi = 6s;Di = 8.29 × 10–3pu,MW/Hz;Bi = − βi = 0.425 pu MW/Hz; Ri =2.4 pu Hz/MW; nominal loading = 50%; Ks = 1.8; Ts = 1.8s.

For 4 No.of thermal power plants TP1=2000Kw, Tps=25 s, Kps= 100: Tp2=1500 ,Tps =25 s Kps =50: Tp3=650 ,Tps =35s Kps =50: Tp4=3000 ,Tps =30 s Kps =15:

PID controller specifications: Proportional Gain Constant (Kp): 0.6351, Integral Gain Constant (Ki):1.26, Derivative Gain Constant (Kd): 1.26

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