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# Multi-Area Load Frequency Control (LFC) for Power System using PID Controlled Power System Stabilizer (PSS)

**Muddasar Ali, M. Ejaz Hassan**

***Abstract: Nowadays power demand is increasing continuously and the biggest challenge is to provide good quality of power to the consumer under changing load conditions. For satisfactory operation, the frequency of power system should be kept near constant value. Continuous change in frequency by variation of load is a big challenge for generating unit to compensate it as quickly as possible. Many techniques have been proposed to obtained constant value of frequency and to overcome any deviations. The load-frequency control (LFC) is used to restore the balance between load and generation by means of speed control. The main goal of LFC is to minimize the transient deviations and steady state error to zero in advance. PID is a conventional controller that can be used for LFC to get faster and better results. If conventional Controller and power system stabilizer (PSS) are used together then more effective result can be achieved rather than their individual use for LFC. This paper presents a comparison of Multi-area LFC with and without conventional controller and conventional controller in the presence of power system stabilizer (PSS) using MATLAB/SIMULINK software package. Reduction in settling time, overshoot and frequency deviation was successfully achieved by Using PID controlled Power system Stabilizer (PSS).***

***Keywords: Load Frequency Control (LFC), Conventional PID Controller, Power system stabilizer (PSS).***

## I. INTRODUCTION

Nowadays, power systems with several industrial and commercial loads and generators need to operate at 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. 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 is affected .Frequency transients must be eliminated as soon as possible. [1] The generators in a control area always vary their speed together (speed up or slow down) for maintaining the frequency and the relative power angles to the predefined values with tolerance limit in both static and dynamic conditions. Frequency should remain nearly constant for satisfactory operation of power system. Frequency deviations can directly impact on a power system operation, system reliability and efficiency. [2-4]

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**Muddasar Ali**, PG. Scholar, Department of Electrical Engineering, Army Public College of Management & Sciences (APCOMS), Rawalpindi (UET) Taxila, Pakistan.

**Prof. Dr. M. Ejaz Hassan,** Associate Professor & Head, Department of Electrical Engineering, Army Public College of Management & Sciences (APCOMS), Rawalpindi (UET) Taxila, Pakistan.

Large frequency deviations can damage equipments, degrade load performance, overload can ultimately lead to a system collapse. Variation in frequency adversely affects the operation and speed control of induction and synchronous motors. As the peak demands do not have any certain time, they may occur at any random time of the day in many areas, for a large power system the ratio between load peak and load average is smaller as compared to smaller systems. Therefore it is obvious that all interconnected power system areas may benefit from a decreased need of capacity reserved by the scheduled arrangement of interchanging energy [2].Various control strategies have been proposed and investigated by several researchers for LFC design of power systems. Many classical approaches have been used to provide supplementary control which will drag the frequency to normal operating value within very short time. This extensive research is due to fact that LFC constitutes an important function of power system operation where the main objective is to keeping the frequency fluctuations with in pre-specifies limits. In this paper PID controlled power system stabilizer (PSS) has been designed and its performance comparison is carried out with conventional PID Controller in terms of settling time, overshoot and frequency deviations. [5-7]

## II. BRIEF LITERATURE SURVEY

Pradipkumar Prajapati has presented the various Conventional controllers for Multi area load frequency Control in the power system. A comparison was made between PID controller and PI controller in terms of performance aspect in Multi areas power systems. Simulation results showed that the PID controller outperformed the PI controller in terms of less frequency deviation and settling time. [1]. Gajendra Singh Thakur used PI controller and Ziegler-Nichols PID Tuning controller 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. PID controller with simple approach can provide better performance comparing with the conventional PI controller. Simulation results show that the superior performance of the system using Z-N Tuned PID control. [2] Mohinder Pal used PI controller for load frequency Control in the power system. It is seen that Integral Controller results a stable frequency. With the proper choice of control parameters frequency deviations can be effectively controlled. Due to disturbances in the power system frequency deviates So Integral Controller is used to overcome this problem. [3]

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## III. LOAD FREQUENCY CONTROL

Load frequency and excitation control of generator are shown in Fig.1. Generator output power consists of real and reactive Power. Frequency represents the magnitude of real power respectively. Output frequency sensed by frequency sensor and then it is compared with the reference frequency in the comparator. Change in frequency forward to the steam valve controller, this block takes decision either quantity of steam increases or decreases, which depends on the load. If load increases, then steam valve controller gives the signal to increase or decrease the steam or vice-versa. Further, steam valve controller gives a signal to the turbine, either to decrease or increase the speed of turbine for generation of power in the system. [8-11]

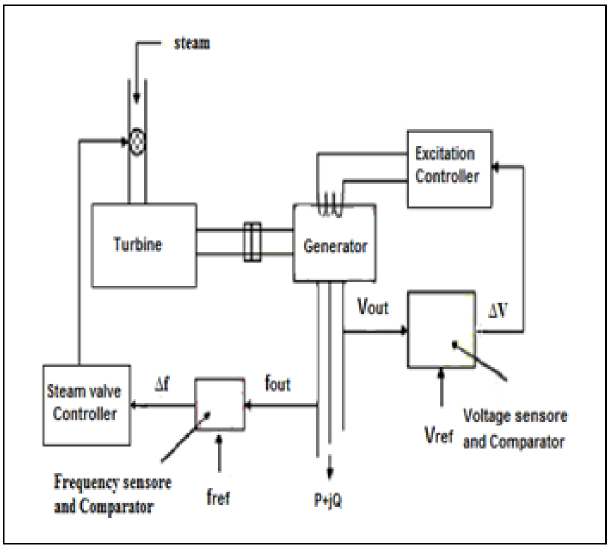

**Figure 1: Block Diagram of Load Frequency and Excitation Control of Generator [6]**

In large electrical power system, nominal frequency depends significantly on the balance of produced and consumed active power. When active power imbalance occurs in any part of the system, it results in changes in the frequency of the entire system. Figure 2 shows the relationship between system frequency and load which is inversely proportional. Possible increase in the load reduces the nominal frequency of the system.[12-16]

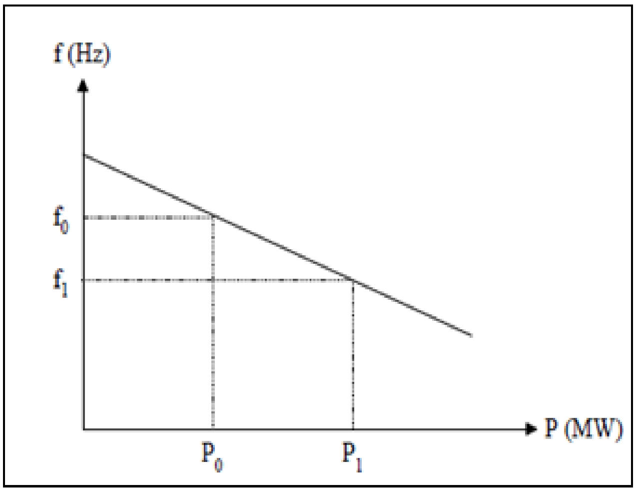

**Figure 2: Variation of Load-Frequency Characteristic [8]**

## IV. PID CONTROLLER

PID controller is employed for better frequency response, system dynamic reaction and to diminish or remove the steady state error of the system. The steady-state error and rise time is reduced with increased in the proportional gain. Due to a large value of proportional gain, an enormous overshoot and excessive oscillations will occur in the system. The system nature by one can be increased with the assist of integral controller. This kind of result can be attained by inserting a pole at the origin and which will degrade the steady-state error. Due to this, the transient response will reduce. A finite zero to the open-loop plant transfer function adding by a derivative controller, which increases the speed response, but it also increases steady-state error. The PID control scheme is named after its three correcting terms, whose sum constitutes the manipulated variable (MV). The proportional, integral, and derivative terms are summed to calculate the output of the PID controller.[17-19]

### A. Proportional Term

The proportional term produces an output value that is proportional to the current error value. The proportional response can be adjusted by multiplying the error by a constant KP, called the proportional gain constant. The proportional term is given in equation (1),

$$\mathbf{Pout = KP\ e(t)} \qquad \text{….(1)}$$

### B. Integral Term

The integral term accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a pure proportional controller. However, since the integral term responds to accumulated errors from the past, it can cause the present value to overshoot the set point value. The Integral term is given in equation (2),

$$\mathbf{Io = Ki \int e\,(t)\,dt} \qquad \text{…. (2)}$$

### C. Derivative Term

The derivative of the process error is calculated by determining the slope of the error over the time and multiplying this rate of change by the derivative gain Kd. The magnitude of the contribution of the derivative term to the overall control action is termed the derivative gain, Kd. The derivative term is given by equation (3).

$$\mathbf{Do= Kd\ d/dt\ [e\,(t)]} \qquad \text{…. (3)}$$

Derivative action predicts system behavior and thus improves settling time and stability of the system. In the early history of automatic process control the PID controller was implemented as a mechanical device. These mechanical controllers used a lever; spring and a mass were often energized by compressed air. After development of mechanical controller electronic analog controllers can be made from a solid-state amplifier to from a capacitor and a resistor. Electronic analog PID control loops were often found within more complex electronic systems. Nowadays, electronic controllers have largely been replaced by digital controllers implemented with microcontrollers or FPGAs. The PID controller equation can be given by equation (4),

$$G_{pid}(s) = K_P + \frac{K_I}{s} + sK_D \quad \text{... (4)}$$

## V. POWER SYSTEM STABILIZER (PSS)

The basic function of a Power System Stabilizer (PSS) is to add damping to the generator rotor oscillations by controlling its excitation using auxiliary stabilizing signals. To provide damping, the stabilizer must produce a component of electrical torque in phase with the rotor speed deviations [20].

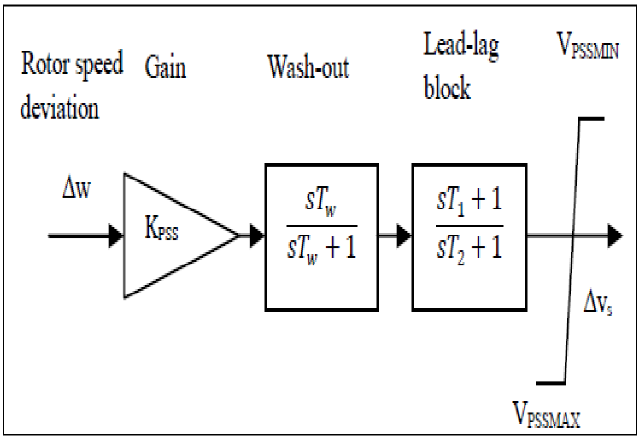

**Figure 3: Block Diagram of Power System Stabilizer [8]**

It basically consists of following blocks,

1. Washout filter.
2. Stabilizer gain.
3. Lead-lag compensator.
4. Limiter.

Tw is washout filter time constant which is taken as 10sec, KPSS is stabilizer gain; T1 and T2 are lead-lag compensator time constants. Washout circuit is provided to eliminate steady-state bias in the output of PSS which will modify the generator terminal voltage. The PSS should respond only to low frequency oscillations and not to the dc offsets in the signal. So, washout filter acts as a high pass filter whose time constant is selected in such a way that it allows only oscillation frequencies in the range of 0.1 to 2Hz.[21-23]

## VI. SIMULATION AND RESULTS

A comparison of Multi-area LFC with and without PID controller and PID controller in the presence of power system stabilizer (PSS) has been observed. The comparison is made in terms of performance with respect to frequency deviation, settling time and overshoot as shown in Table 1.The parameters of the numerical example which is solved using Simulink/Matlab as shown in Table 2.In addition, the solution of an example consists of three scenarios: the first one contains no controller, the second scenario used PID controller, and the final scenario used PID controlled PSS.

### A. First SENARIO

In the first scenario, Matlab block diagram of LFC is constructed using Simulink and solved without using any controller. Figure 4 and Figure 5 show the Simulink block diagram of LFC and the frequency deviation respectively.

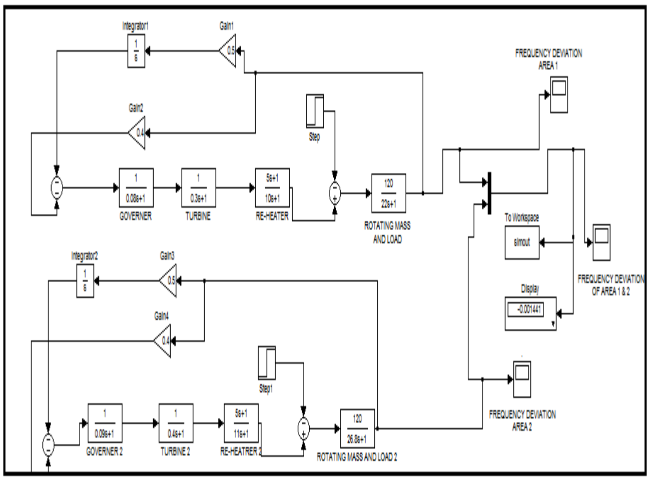

**Figure 4: Simulink Model of Two Area LFC Without Controller**

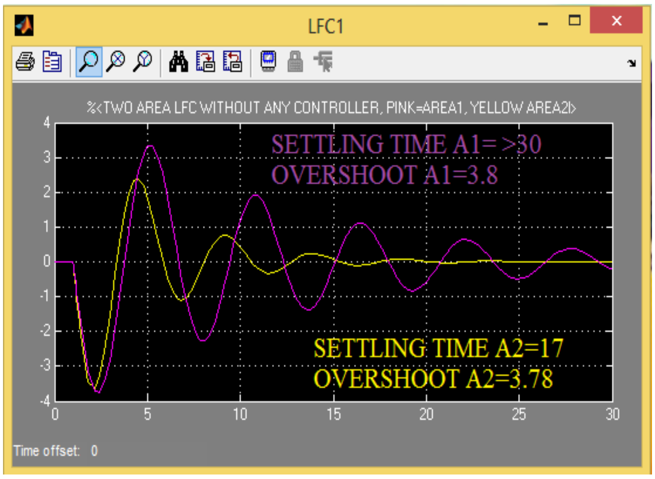

**Figure 5: Frequency Deviation of First Scenario of Two Area LFC without Controller**

### B. Second SENARIO

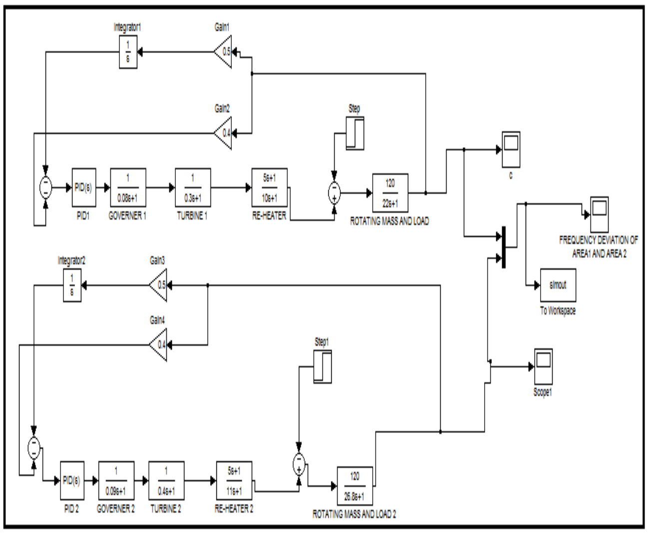

**Figure 6: Simulink Model of Two Area LFC with PID-Controller**

In the second scenario, a Matlab block diagram of LFC is constructed using Simulink in which PID controller is designed to reduced the frequency deviations, overshoot and settling time of the load frequency control (LFC) as shown in figure 6 & 7.

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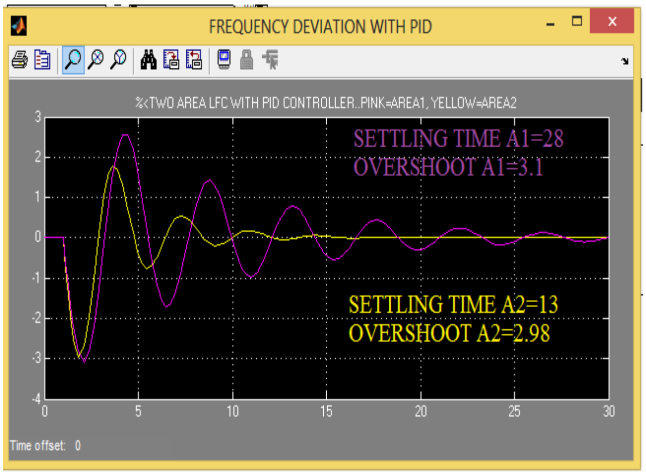

**Figure 7: Frequency Deviation of Second Scenario of Two Area LFC with PID Controller**

### C. Third SENARIO

In the third scenario PID controlled Power system stabilizer (PSS) is designed to improve the output response and reduced the frequency deviations, overshoot and settling time of the load frequency control (LFC) as shown in figure 8 & 9.

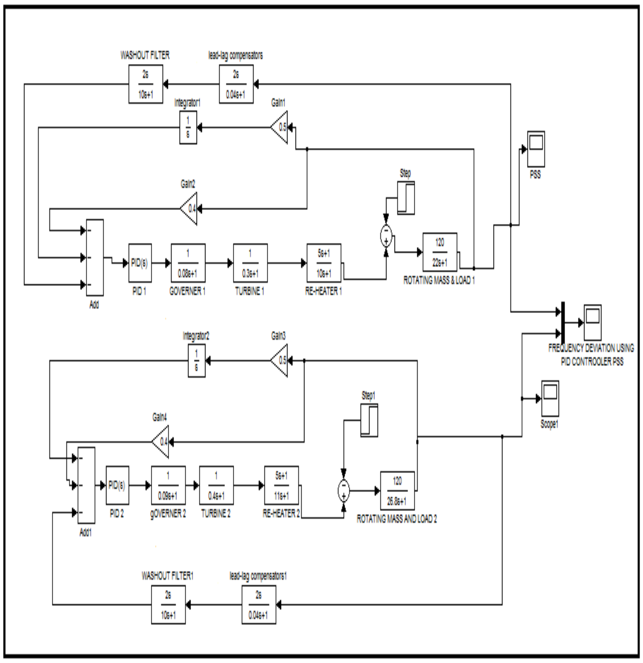

**Figure 8: Simulink Model of Two Area LFC with PID-Controlled PSS**

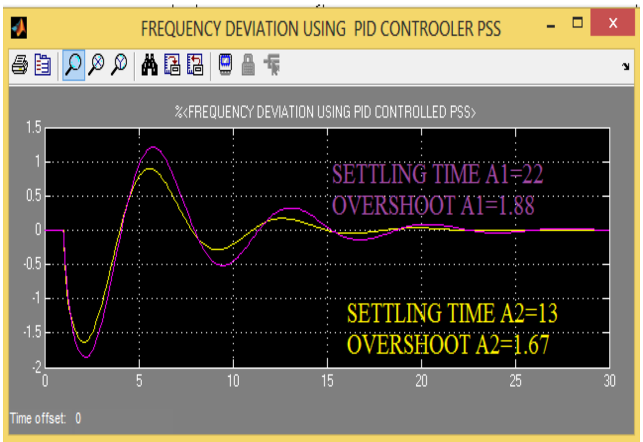

**Figure 9: Frequency Deviation of Third Scenario of Two Area LFC with PID-Controlled PSS**

**Table 1: Comparative Analysis of Different Controllers**

| S # | Parameter | Area | LFC Without Control | LFC with PID Controller | LFC with PID Controlled PSS |
|---|---|---|---|---|---|
| 1 | Settling Time | 1 | >30 | 28 | 23 |
| | | 2 | 17 | 13 | 13 |
| 2 | Overshoot | 1 | 3.8 | 3.1 | 1.88 |
| | | 2 | 3.78 | 2.98 | 1.67 |

Table 1 shows the performance of LFC by various control strategy over settling time and overshoot for two area LFC with the help of comparison.

## VII. CONCLUSION

In this paper, PID controller and PID Controlled Power system Stabilizer (PSS) was proposed to solve the load frequency control (LFC) problem of two area power system. The study about simulation permitted PID controlled PSS gives enhanced performance compare to their individual use. Simulation result shows that PID controlled PSS reduces the frequency deviations of power system and has a better performance than the PID controller, because it reduced the settling time and minimized the overshoot of the system.

## APPENDIX

**Table 2: Two Area Power System Parameters**

| S # | Two Area Power System Parameter |
|---|---|
| 1 | F=50HZ |
| 2 | P=1000MW |
| 3 | Kr1=0.5 |
| 4 | Kr2=0.4 |
| 5 | Tr1=10.0s |
| 6 | Tr2=11.0s |
| 7 | Tg1=0.08s |
| 8 | Tg2=0.09s |
| 9 | Tt1=0.3s |
| 10 | Tt2=0.4s |

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**Muddasar Ali** has obtained BE degree in Electrical Engineering from Air University, Islamabad in 2015.He is Pursuing MS degree in Electrical Engineering at Army Public College of Management & Sciences (APCOMS), Rawalpindi (UET) Taxila, Pakistan under the supervision of Associate Professor Dr.M.Ejaz Hassan. He is currently working on the Controller Selection for better Performances of Load Frequency Control (LFC) in Power Systems.

**Prof. Dr. M. Ejaz Hassan** has obtained PhD degree in Electrical Engineering from UET Peshawar, Pakistan. Currently, he is working as an Associate Professor and Head of Electrical Engineering Department at Army Public College of Management & Sciences (APCOMS) Rawalpindi (UET) Taxila, Pakistan. His research interest includes applications of Modern Control Engineering in Electric Power Systems.

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