Automatic load frequency control of two area Power system using Optimal Control System technique with Pole Placement

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Abstract:
This research paper presents decentralized control scheme for ALFC in a two area Power System by appreciating the performance of the methods in a single area power system. A number of modern control techniques are adopted to implement a reliable stabilizing controller. A serious attempt has been undertaken aiming at investigating the load frequency control problem in a power system consisting of two power generation unit and multiple variable load units. The robustness and reliability of the various control schemes is examined through simulations. The study has been designed for a two area interconnected power system. Using variable values for the proportional and integral gains in the controller unit, the dynamic performance of the system is improved. The used scheme is known as Automatic generation control. In which ,an interconnected system consisting of several pools, the role of the AGC is to divide the load among the system, stations and generators so as to achieve maximum economy and reasonably uniform frequency. Optimal Control System technique is applied in the control system design that is executed by minimizing the performance index of the system variables. In this paper , discuss the design of the optimal controllers for the linear systems with quadratic performance index, which is also referred to as the linear quadratic regulator. The objective of the optimal regulator design is to determine a control law $u*(x,t)$,which can transfer the system from its initial state to the final state by minimizing the performance index. The performance index that is widely used is the quadratic performance index and is based on the minimum energy criterion. MATLAB codes are developed for OCS with Pole placement technique , the results of which are used to study the system step response. All these are through in Simulink based background.

Index terms : **ALFC,AGC,MATLAB,OCS,Pole placement technique.**

1.INTRODUCTION:
The successful operation of interconnected power systems requires the matching of total generation with total load demand and associated system losses. With time, the operating point of a power system changes, and hence, these systems may experience deviations in nominal system frequency and scheduled power exchanges to other areas, which may yield undesirable effects. In actual power system operations, the load is changing continuously and randomly. The ability of the generation side to track the changing load is limited due to physical / technical consideration, causing imbalance between the actual and the scheduled generation quantities. This action leads to a frequency variation. The difference between the actual and the synchronous frequency causes mal operation of sophisticated equipments like power converters by producing harmonics.

1.1 Electric Power Regulation
Power systems consist of control areas representing a coherent group of generators i.e. generators which swing in unison characterized by equal frequency deviations. In addition to their own generations and to eliminate mismatch between generation and demand these control areas are interconnected through tie-lines for providing contractual exchange of power under normal operating conditions. One of the control problems in power

system operation is to maintain the frequency and power interchange between the areas at their rated values. Automatic generation control is to provide control signals to regulate the real power output of various electric generators within a prescribed area in response to changes in system frequency and tie-line loading so as to maintain the scheduled system frequency and established interchange with other areas.

1.2 Load-frequency control (LFC)

For large scale electric power systems with interconnected areas, Load Frequency Control (LFC) is important to keep the system frequency and the inter-area tie power as near to the scheduled values as possible. The input mechanical power to the generators is used to control the frequency of output electrical power and to maintain the power exchange between the areas as scheduled. A well designed and operated power system must cope with changes in the load and with system disturbances, and it should provide acceptable high level of power quality while maintaining both voltage and frequency within tolerable limits. Load frequency control is basic control mechanism in the power system operation. Whenever there is variation in load demand on a generating unit, there is a momentarily an occurrence of unbalance between real-power input and output. This difference is being supplied by the stored energy of the rotating parts of the unit. Load Frequency Control (LFC) is being used for several years as part of the Automatic Generation Control (AGC) scheme in electric power systems. One of the objectives of AGC is to maintain the system frequency at nominal value (50 Hz). [2].

1.3 Automatic generation control (AGC)

Automatic generation control (AGC) is defined as, the regulation of power output of controllable generators within a prescribed area in response to change in system frequency, tie-line loading, or a relation of these to each other, so as to maintain the schedules system frequency and / or the established interchange with other areas within predetermined limits. The two basic inter-area regulating responsibilities are as follows:- [3].

(i) When system frequency is on schedule, each area is expected automatically to adjust its generation to maintain its net transfer with other areas on schedule, thereby absorbing its own load variations. As long, all areas do so; scheduled system frequencies as well as net interchange schedules for all area are maintained.

(ii) When system frequency is off-schedule, because one or more areas are not fulfilling their regulating responsibilities, other areas are expected automatically to shift their respective net transfer schedules proportionally to the system frequency deviation and in direction to assist the deficient areas and hence restore system frequency.

The extent of each area's shift of net interchange schedule is programmed by its frequency bias setting. Therefore, a control strategy is needed that not only maintains constancy of frequency and desired tie-power flow but also achieves zero steady state error and inadvertent interchange. Numbers of control strategies have been employed in the design of load frequency controllers in order to achieve better dynamic performance.

1.4. Control Strategy

The objective of the control strategy in a power system is to generate and deliver power in an interconnected system as economically and reliably as possible while maintaining the frequency and voltage within permissible limits. The power system control has a hierarchical structure. The control system consists of a number of nested control loops that control different quantities in the system. In general, the control loops on lower system levels, e.g. locally in a generator, are characterized by smaller time constants than the control loops active on a higher system level. For example, the automatic voltage regulator (AVR), which regulates the voltage of the generator terminals, responds typically in a time scale of a second or less. While, the secondary voltage control (SVC), which determines the reference values of the voltage controlling devices among which the generators, operates in a time scale of tens of seconds or minutes. That means these two control loops are virtually de-coupled. As another example, AVR (which controls the reactive power and voltage magnitude) and LFC (which controls the real power and frequency) loops can considered. The excitation system time constant is much smaller than the

prime mover time constant and its transient decay much faster, which does not affect the LFC dynamic. Thus, the cross-coupling between the LFC loop and the AVR loop is negligible. This is also generally true for the other control loops. As a result, a number of de-coupled control loops operating in power system in different time scales for protection, voltage control, turbine control, tie-line power and frequency control. Although the overall control system is complex, in most cases it is possible to study the different control loops individually due to the de-coupling. Depending on the loop nature, the required model, important variables, uncertainties, objectives, and possibly control strategy will be different.[1]

1.5 Time Scales of the Power System Controllers

The protection devices are in the first level. To protect the systems and other important devices they must be fast as possible. The second level is mainly related to power system stabilizers (PSS) and reactive power controllers such as AVRs, flexible ac transmission systems (FACTS), energy storages, and HVDC systems. At the highest level, the tie-line power and frequency controllers are in place.[2].

This paper is organized as follows. In Section II, Literature Review, is presented. The proposed Two ares system , in Section III. In section IV ,Pole placement technique .A short overview of OCS is presented in Section V. Results are provided and discussed in Section VI and conclusions are given in Section VII.

2. LITERATURE REVIEW:

2.1 Need of Load Frequency Control

The active and reactive power demands are never steady and they continuously changes with the rising or falling trend of load demand. There is a change in frequency with the change in load which causes problems such as:

1. Most AC motors run at speeds that are directly related to frequency. The speed and induced electro motive force (e.m.f) may vary because of the change of frequency of the power circuit.
2. When operating at frequencies below 49.5 Hz; some types of steam turbines, certain rotor states undergo excessive vibration.
3. The change in frequency can cause mal operation of power converters by producing harmonics.
4. For power stations running in parallel it is necessary that frequency of the network must remain constant for synchronization of generators.

2.2 Concept of Load Frequency Control

In the steady state operation of power system, the load demand is increased or decreased in the form of Kinetic Energy stored in generator prime mover set, which results the variation of speed and frequency accordingly. Therefore, the control of load frequency is essential to have safe operation of the power system.[7 ,9].
Neglecting resistances

$$P = EV / X . \sin \delta , \tag{1}$$

If δ changes to $\delta + \Delta \delta$ then P changes to $P + \Delta P$

$$P + \Delta P = \frac{E.V}{X} Sin(\delta + \Delta\delta) = \frac{E.V}{X}[Sin\delta\ Cos\Delta\delta +\ Cos\delta\ Sin\Delta\delta] \tag{2}$$

Since $\Delta\delta$ is very small,

$$Cos\Delta\delta \cong 1 \text{ and } Sin\Delta\delta \cong \Delta\delta$$

$$P + \Delta P = \frac{E.V}{X}Sin\delta + \frac{E.V}{X}Cos\delta.\Delta\delta$$

$$\Delta P = \frac{E.V}{X}Cos\delta.\Delta\delta$$

$$or$$

$$\Delta P \propto \Delta\delta$$

Small power changes mainly depends on $\Delta\delta$ or Δf. (3)

Moreover, frequency is also a major stability criterion for large-scale stability in multi area power systems. To provide the stability, a constant frequency is required which depends on active power balance. If any change occurs in active power demand/ generation in power systems,frequency cannot be hold as its rated value. Hence, oscillations increase in both power and frequency. Thus, the system is subjected to a serious instability problem. To improve the stability of the power networks, it is necessary to design load frequency control (LFC) systems that control the power generation and active power at tie lines of interconnected system. In interconnected power networks with two or more areas, the generation within each area has to be controlled to maintain the scheduled power interchange. Load frequency control scheme has two main control loops. These are primary control and secondary control loops. This action has been realized by using a turbine-governor system in the plant.

2.3 Conventional LFC Structure

The LFC model given in Fig. 1. uses three simple (first order) transfer functions for modeling the turbine, generator and power system (load and rotating mass). The effects of local load changes and interface with other areas are properly considered as two input signals. Each control area monitors its own tie-line power flow and frequency at the area control center. The area control error (ACE) which is a linear combination of tie-line and frequency errors is computed and allocated to the controller K(s). Finally, the resulted control action signal or a percentage of it is applied to the turbine-governor unit. The operation objectives of the LFC are summarized to maintain system frequency close to nominal value, to control the tie-line interchange schedules, and to divide the load between generator units. Commonly, a simple integral or proportional-integral control law is used as controller K(s) to perform LFC task. A multi-area power system is comprised of areas that are interconnected by high-voltage transmission lines or tie-lines. The trend of frequency measured in each control area is an indicator of the trend of mismatch power in the interconnection and not in the control area alone. Therefore, following a load disturbance within a control area or an occurred mismatch power on tie-lines, the frequency of that control area experiences a transient change. The feedback mechanism comes into play and generates the appropriate signal to the turbine for tracking the load variation and compensates the mismatch power.
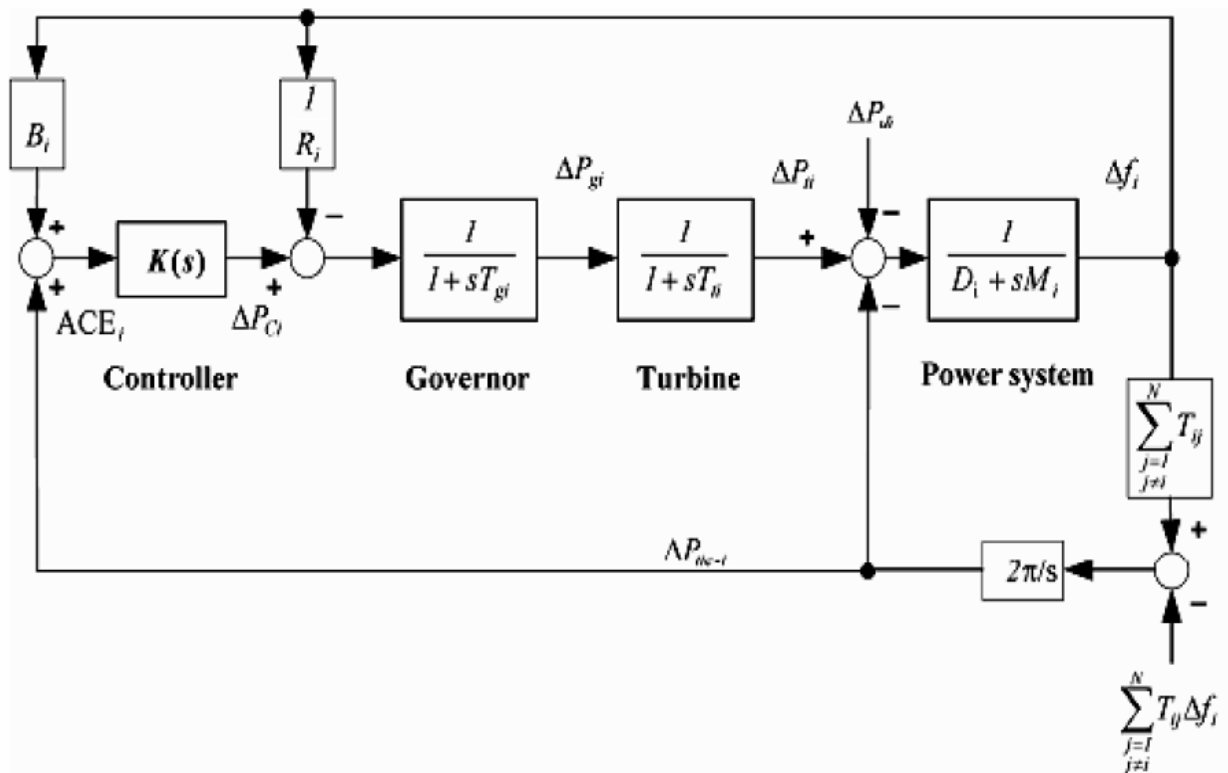
Fig. 1.A control area equipped with LFC

Depending on the type of generating units, and constraints on their range and rate of response to the LFC signals, the actual response time (for example for a steam unit) takes a few to several tens of seconds. In LFC practice, rapidly varying components of system signals are almost unobservable due to filters involved in the process. That is why further reduction in the response time of LFC is neither possible nor desired. Practically, the design and performance of an LFC system highly dependent on how generation units respond to control signal. Such control strategies are useful as they are able to maintain a sufficient level of reserved control range and a sufficient level of control rate. In light of this fact, although the present dissertation uses some academic examples (and data) in which the assumed parameters (and in result, dynamics of the simplified models) are not completely matched to real ones, and gives the impression that the output of the models can be changed quickly, however the proposed control strategies are flexible enough to set a desired level of performance to cover the practical constraint on the control action signals. Since the 1970s, the described LFC scheme in Fig. 1. is widely used by researchers for the LFC analysis and synthesis. [6].

The performance of the automatic generation control depends upon how various power generating units respond to these signals. The speed of their response is limited by natural time lags of the various turbine dynamics and the power system itself. In other words the design of automatic generation controller depends upon various energy source dynamics involved in the AGC of the area. But in real situations each control area may have large number of various sources of power generation such as hydro, thermal, gas, nuclear etc. The various generations are connected by a stiff network that is why the frequency deviations are assumed to be equal in an area. The load over a day varies which is evident from a daily load curve. Therefore the contributions of generations from various sources in an area are adjusted to meet the load variations. The performance of the Automatic Generation Control may also vary in respect to the changes in the share of different type of power generations to the total generation of the area. In order to obtain the optimum realistic AGC performance, the automatic generation controller parameters have to be optimized for various nominal loading conditions. In practice, it is not necessary that all types of power generating units having speed governors may take part in the area AGC activity. Due to the lower power production cost a typical generation in an area may be contributing to its maximum by running at its rated load capacity while others may not be. In such case the typical generation is regulated by the speed governor alone but its dynamics will also play a role

in the selection of the automatic generation controller parameters for other generations in the area. Large scale power systems are normally composed of control areas or regions representing coherent group of generators.[8].

2.4 LFC problem in Single Area Power System

Basically, single area power system consists of a governor, a turbine, and a generator with feedback of regulation constant. System also includes step load change input to the generator. This work mainly, related with the controller unit of a single area power system. The load frequency control strategies have been suggested based on the conventional linear Control theory. These controllers may be unsuitable in some operating conditions due to the complexity of the power systems such as nonlinear load characteristics and variable operating points. To some authors, variable structure control maintains stability of system frequency. However, this method needs some information for system states, which are very difficult to know completely. Also, the growing needs of complex and huge modern power systems require optimal and flexible operation of them. The dynamic and static properties of the system must be well known to design an efficient controller.

Under normal operating condition controller are set for small changes in load demand without voltage and frequency exceeding the pre specified limits. If the operating condition changes by any cause, the controller must be reset either manually or automatically. The objective of load frequency controller is to exert the control off frequency and at the same time real power exchange via outgoing transmission line.
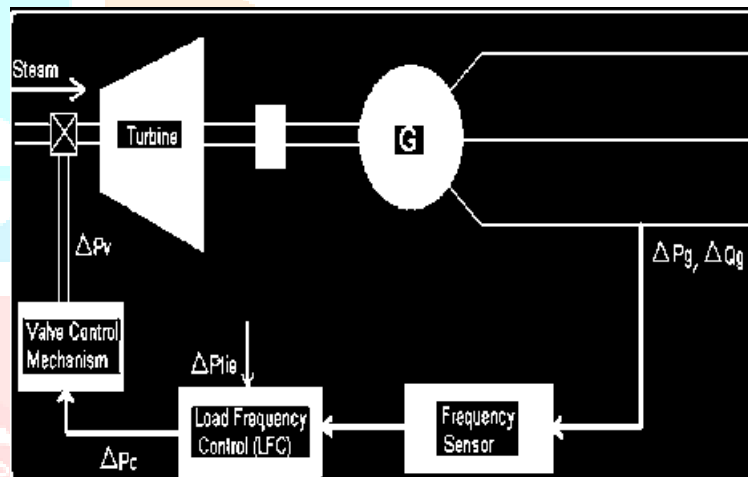

Fig.2. Block diagram Load frequency control in single area power system

The frequency is sensed by frequency sensor. The change in frequency and tie line real power can be measured by change in rotor angle δ. The load frequency controller amplify and transform error signal, i.e., (Δf_i and ΔP_{tie}) in to real power command signal ΔP_{ci} which is sent to the prime mover via governor (that control the valve mechanism). To call for an increment or decrement in torque the prime mover balances the output of governor which will compensate the value of error signal that is Δf_i and ΔP_{tie}. The process continues till deviation in form of Δf_i and ΔP_{tie} as well as the specified tolerance.

The LFC problem in power systems has a long history. In a power system, LFC as an ancillary service acquires an important and fundamental role to maintain the electrical system reliability at an adequate level. It has gained the importance with the change of power system structure and the growth of size and complexity of interconnected systems. The well-known conventional LFC structure for a given control area and a multi area power system (includes N area) is shown in Fig. 1.

2.5 Concept of Two Area Control

An extended power system can be divided into a number of load frequency control areas interconnected by means of tie lines. Without loss of generality two- area case connected by tie-line is considered. The control objectives are as follows:

(1) Each control area as for as possible should supply its own load demand and power transfer through tie line should be on mutual agreement.

(2) Both control areas should controllable to the frequency control.

A two area system consists of two single area systems connected through a power line called tie-line. Each area feeds its user pool, and the tie line allows electric power to flow between the areas, because both areas as well as the power flow on the tie-line. For the same reason, the control system of each area needs information about the transient situation in both areas to bring the local frequency back to its steady state value. Information about the local area is found in the tie line power fluctuations. Therefore, the tie-line power is sensed, and the resulting tie-line power signal is fed back into both areas. It is conveniently assumed that each control area can be represented by an equivalent turbine, generator and governor system. Symbol used with suffix 1 refer to area 1 and those with suffix 2 refer to area 2. A complete diagram is given in Fig. 3.

In an isolated control area case the incremental power (ΔP_G - ΔP_D) accounted for by the rate of increase of stored kinetic energy and increase in area load caused by increase in frequency. Since a tie line transports power in or out of an area, this fact must be accounted for in the incremental power balance equation of each
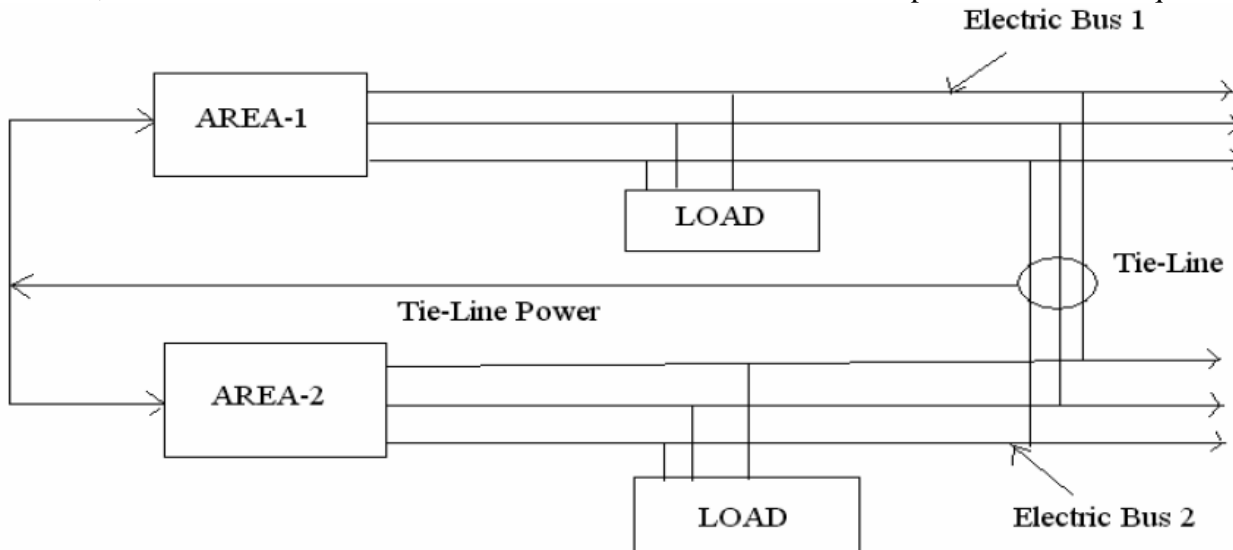
area.

Fig.3. Conventional Two Area System: Basic Block Diagram

3.TWO-AREA SYSTEM :

A control area is characterized by the same frequency throughout. This tantamount to saying that the area network is "rigid" or "strong". In the single-area case we could thus represent the frequency deviation by the single variable Δf. In the present case we assume each area individually "strong". Having interconnected them with a "weak" tie-line therefore leads us to the assumption that the frequency deviations in the two areas can be represented by two variables Δf_1 and Δf_2 respectively. [9].

3.1 Modeling the tie-line and block diagram for two-area system
In normal operation the power flows in the tie-line connecting the areas 1 and 2 is given by

$$P^0{}_{12} = \frac{|V_1^0||V_2^0|}{X} \sin(\delta_1^0 - \delta_2^0)$$

(4)

where δ_1^0 and δ_2^0 are the angles of end voltages V1 and V2 respectively. The order of the subscripts indicates that the tie-line power is defined in direction 1 to 2. Knowing $dy/dx = \Delta y/\Delta x$, for small deviations in angles $\delta 1$ and $\delta 2$ the tie-line power changes by an amount

$$\Delta P_{12} \approx \frac{|V_1^0||V_2^0|}{X} \cos(\delta_1^0 - \delta_2^0)(\Delta\delta_1 - \Delta\delta_2)$$

(5)

We now define the "synchronizing coefficient" of a line as

$$T^0 = \frac{|V_1^0||V_2^0|}{X} \cos(\delta_1^0 - \delta_2^0) \quad MW / rad.$$

(6)

Then the tie-line power deviation is $\Delta P_{12} = T^0 (\Delta\delta_1 - \Delta\delta_2)$ MW (7)

We like to have ΔP_{12} in terms of frequency deviations Δf_1 and Δf_2. We know

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\frac{d\delta}{dt}; \quad i.e. \ d\delta = 2\Pi f \, dt \quad Thus \ \delta = 2\pi \int_0^t f \, dt$$

(8)

And hence

$$\Delta\delta = 2\pi \int^t \Delta f \, dt$$

(9)

Expressing tie-line power in terms of Δf_1 and Δf_2 we get

$$\Delta P_{12} = 2\pi T^0 \left(\int^t \Delta f_1 \, dt - \int^t \Delta f_2 \, dt \right)$$

(10)

$$\Delta P_{12} = 2\pi T_0 \left(\int^t \Delta f_1 \, dt - \int^t \Delta f_2 \, dt \right)$$

(11)

Taking Laplace transformation of the above eq. we get

$$\Delta P_{12}(s) = \frac{2\pi T_0}{s} [\Delta f_1(s) - \Delta f_2(s)]$$

(12)

Representing this equation in terms of block diagram symbols yields the diagram in Fig.4.
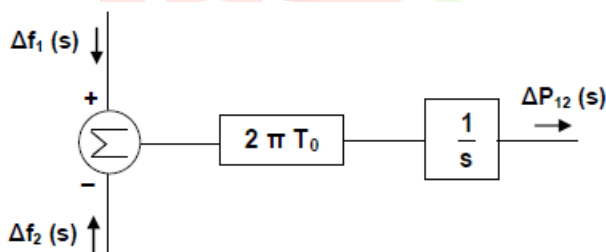

Fig.4. Representation of Tie-lone power flow

Tie-line power ΔP_{12} shall be treated as load in area 1. Similar to power balance eq.

$$\Delta f(s) = G_p(s) [\Delta P_T(s) - \Delta P_D(s)]$$

(13)

can be written as

$$\Delta f_1(s) = G_{p1}(s) [\Delta P_{T1}(s) - \Delta P_{D1}(s) - \Delta P_{12}(s)]$$

(14)

3.2 Tie-line bias control for two-area system:

The persistent static frequency error is intolerable. Also, a persistent static error in tie-line power flow would mean that one area would have to support the other on a steady state basis. To circumvent this, some form of reset integral control must be added to the two-area system. The control strategy of "tie-line bias control" is based upon the principle that all operating pool members must contribute their share to frequency control in

addition to taking care of their own net interchange. This means that for two-area system, at steady state, both Δf_0 and $\Delta P_{12\,0}$ must be zero. To achieve these objectives, the Area Control Error (ACE) for each area consists of a linear combination of frequency and tie-line error. Thus

$$ACE_1 = \Delta P_{12} + B_1 \Delta f_1 \tag{15}$$
$$ACE_2 = \Delta P_{21} + B_2 \Delta f_2 \tag{16}$$

The speed changer commands will thus be of the form

$$\Delta P_{ref\,1} = -K_{I1} \int (\Delta P_{12} + B_1 \Delta f_1)\, dt \tag{17}$$

$$\Delta P_{ref\,2} = -K_{I2} \int (\Delta P_{21} + B_2 \Delta f_2)\, dt \tag{18}$$

The constants K_{I1} and K_{I2} are integrator gains and the constants B_1 and B_2 are the frequency bias parameters. The minus sign must be included to ensure that, if there is positive frequency deviation or tie-line power deviation, then each area should decrease its generation.

4.Pole Placement Technique:

Modern Control design is especially based on the multivariable state vector system. In this design algorithm we make use of the state variable parameters that can be obtained from the system. For the systems where all the state variables are not available a state estimator is designed.

Various Methodologies to implement the Feedback control:

The control is achieved by feedback the state variables through a regulator with constant gains. Consider the system in the state variable form:

$$X(t) = Ax(t) + Bu(t) \quad\text{------------------------------equation (19)}$$

$$Y(t) = Cx(t) \quad\text{--------------------------------------equation (20)}$$

The pole placement design allows all the roots of the system characteristic equation to be placed in desired location, which eventually results in a regulator with constant gain vector K.
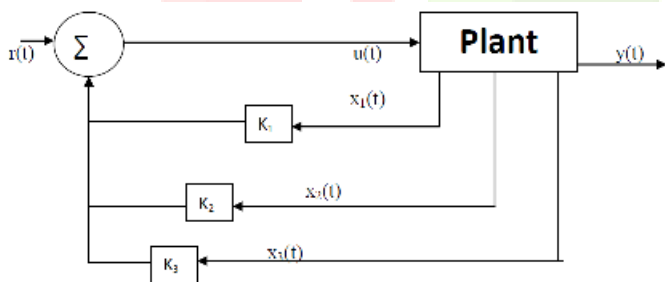

Figure 5:Control Design via Pole Placement.

The block diagram with the following state feedback control

$$U(t) = -Kx(t) \quad\text{-------------equation (21)}$$

where K is a $1 \times n$ vector of constant feedback gains. The control system input r(t) is assumed to be zero. The purpose of the method is to reduce all the values of the state variables to be zero when the states have been

perturbed. Substituting equation 21 in equation 19 the compensated system state variable representation becomes

X(t)= (A- BK) X(t)= AfX(t)------equation (22)

The compensated system characteristic equation is

|sI- A + BK| =0 ----------   equation (23)

The function [K,Af] = place pol(A,B,C,p) is developed for the pole placement design. The matrices A,B,C are the system matrices and p is row matrix containing the desired closed-loop poles. The function returns the gain matrix K and the closed-loop matrix Af. For a multi input system K= place (A,B,p), which uses a more reliable algorithm.

5.Optimal Control System:

It is a technique applied in the control system design that is executed by minimizing the performance index of the system variables. In this section we discuss the design of the optimal controllers for the linear systems with quadratic performance index, which is also referred to as the linear quadratic regulator. The objective of the optimal regulator design is to determine a control law **u*(x,t)** which can transfer the system from its initial state to the final state by minimizing the performance index. The performance index that is widely used is the quadratic performance index and is based on the minimum energy criterion.

Consider the plant as discussed :

X(t)=Ax(t) + Bu(t)

The problem is to find the vector **K** of the control law

U(t)= -K(t)*x(t)

Which minimizes the value of the quadratic performance index **J** of the form:

$$J= \int_{t0}^{tf} (x'Qx + u'Ru)dt$$

$$(24)$$

Where Q is a positive semi definite matrix and **R** is real symmetric matrix. **Q** is a positive definite matrix if all its principal minors are non-negative. The choice of the elements of **Q** and **R** allows the relative weighting of three individual state variables and individual control inputs.

To obtain the solution we make use of the method of Langrange multipliers using an n vector of the unconstrained equation

[x,λ,u,t]= [x'Qx + u'Ru] + λ'[Ax + Bu – x']----------------------(25)

The optimal values determined are found by equating the partial derivative to zero.

$$\frac{\partial L}{\partial \lambda} = AX^* + Bu^* - x'^* = 0 \Rightarrow x'^* = AX^* + Bu^*$$

$$(26)$$

$$\frac{\partial L}{\partial u} = 2Ru^* + \lambda^* B = 0 \Rightarrow u^* = -\frac{1}{2}R^{-1}\lambda'B$$

$$(27)$$

$$\frac{\partial L}{\partial x} = 2x'^* + \lambda' + \lambda'A = 0 \Rightarrow \lambda' = -2Qx^* - A'\lambda$$

$$(28)$$

Assuming that there exists a symmetric , time varying positive definite matrix **p(t)** satisfying

λ = 2p(t)x*   (29)

Substituting (29) in (27) we get

U * (t)=   - R $_{-1}$ B'p(t)x*   (30)

Obtaining the derivative of (29) we get

$$\lambda = 2(p\dot{x}^* + \dot{p}x^*)$$ (31)

Finally we equate (28) and (31)

$$p(t) = -p(t)A - A'p(t) - Q + p(t)BR^{-1}B'p(t)$$ (32)

Compensators are generally used to satisfy all the desired specifications in a system. But in most of the cases the system needs to fulfill some more specifications that are difficult to attain in case of a compensated system. As an alternative to this we mainly use Optimal Control system. The trial and error system for the compensated design system makes it cumbersome for the designers to attain the specifications. This trial and error procedure works well for the system with a single input and a single output. But for a multi-input-multi-output system the trial and error method is done away and replaced with Optimal Control design method where the trial and error uncertainties are eliminated in parameter optimization method. It consists of a single performance index specially the integral square performance index. The minimization of the performance index is done using the Lyapunov stability theorem in order to yield better system performance for a fixed system configuration. The values of Q and R has to carefully selected and if the responses are unsuitable then the some other values of Q and R has to be selected. K is automatically generated and the closed loop responses are found.[7,8].

6.RESULTS:

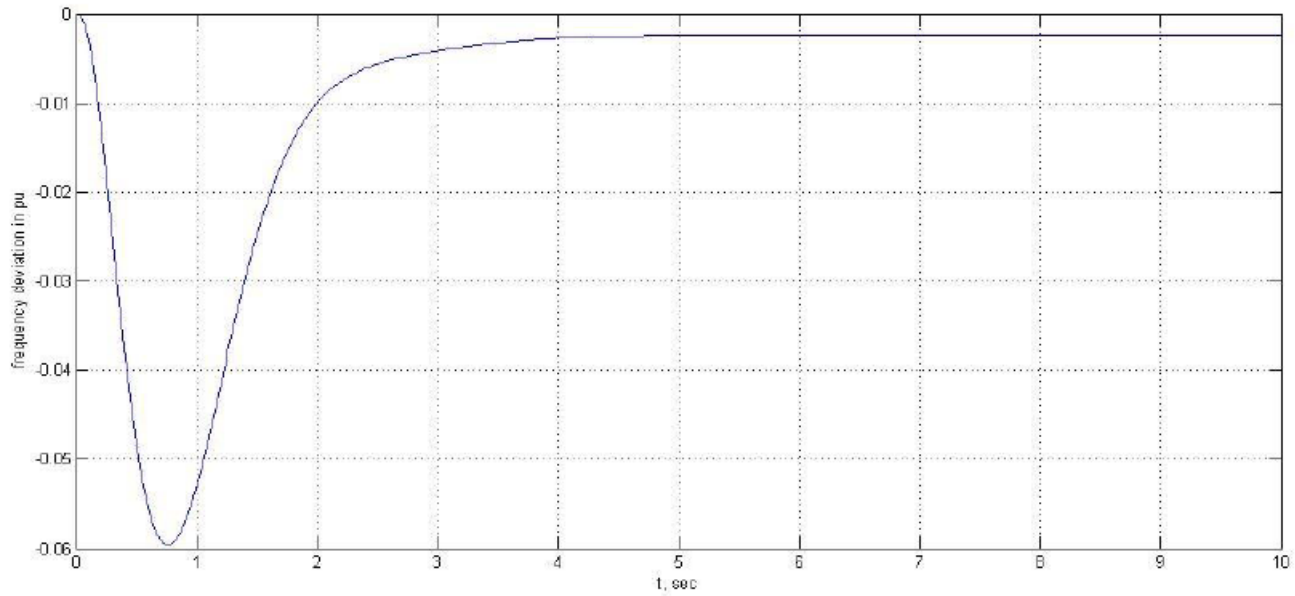Optimal Control Design of two area power System 6.1. Simulation results when 2nd area input is changed.

Figure 6: Frequency deviation Δf1
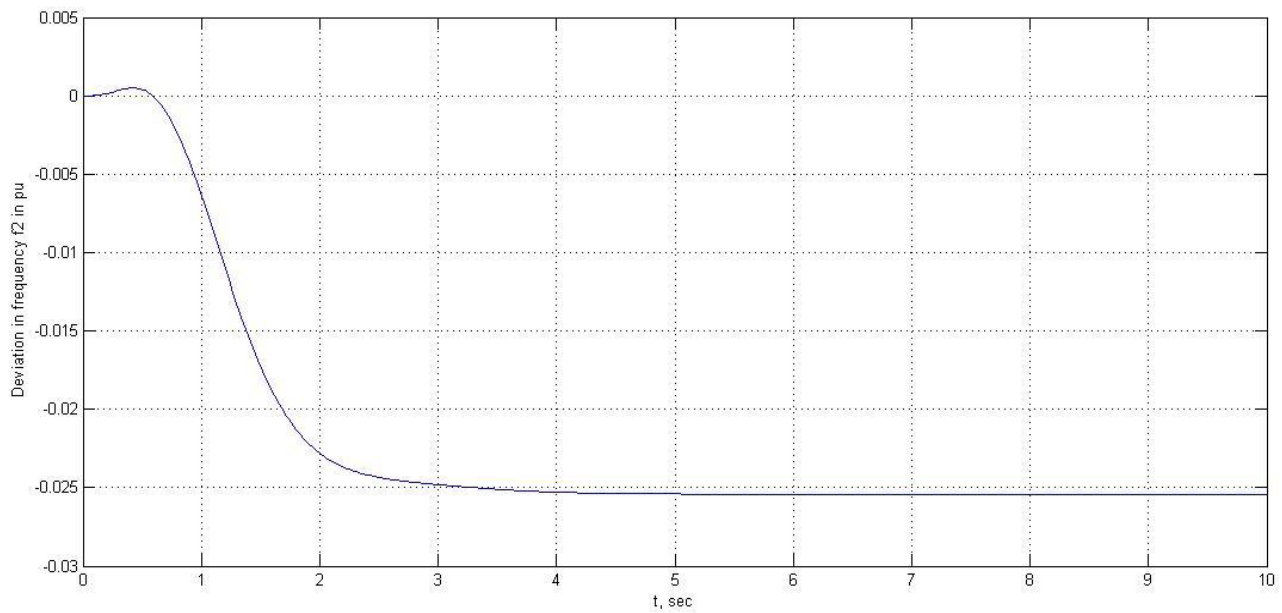

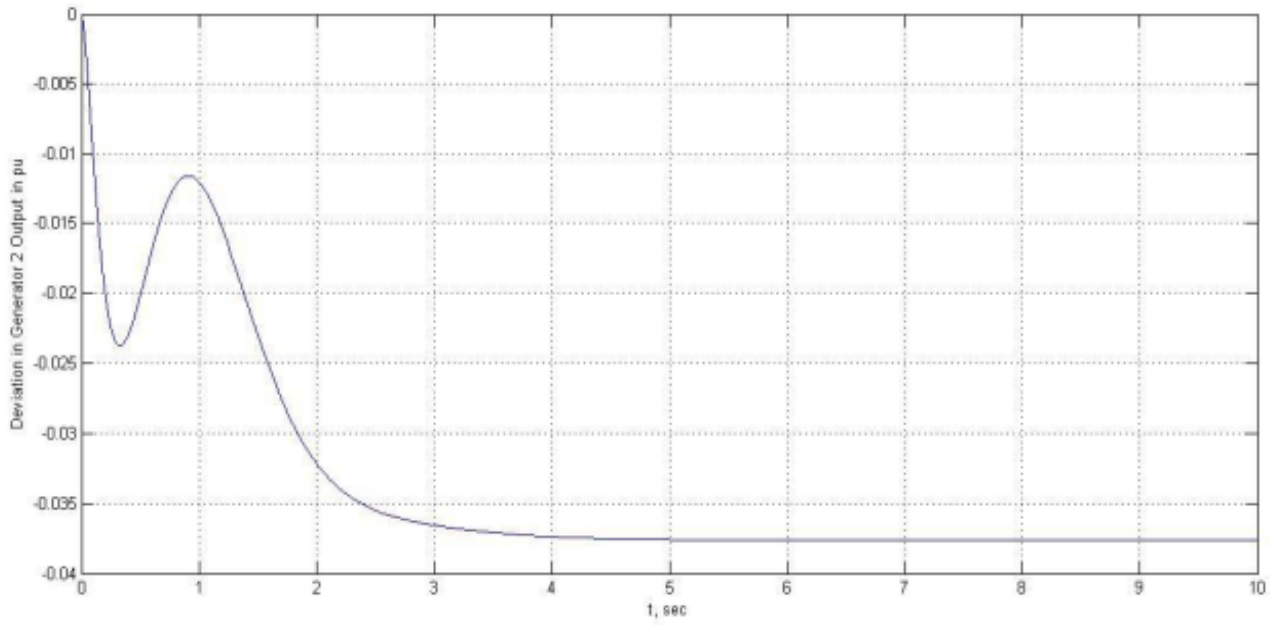Figure 7: Frequency deviation Δf2
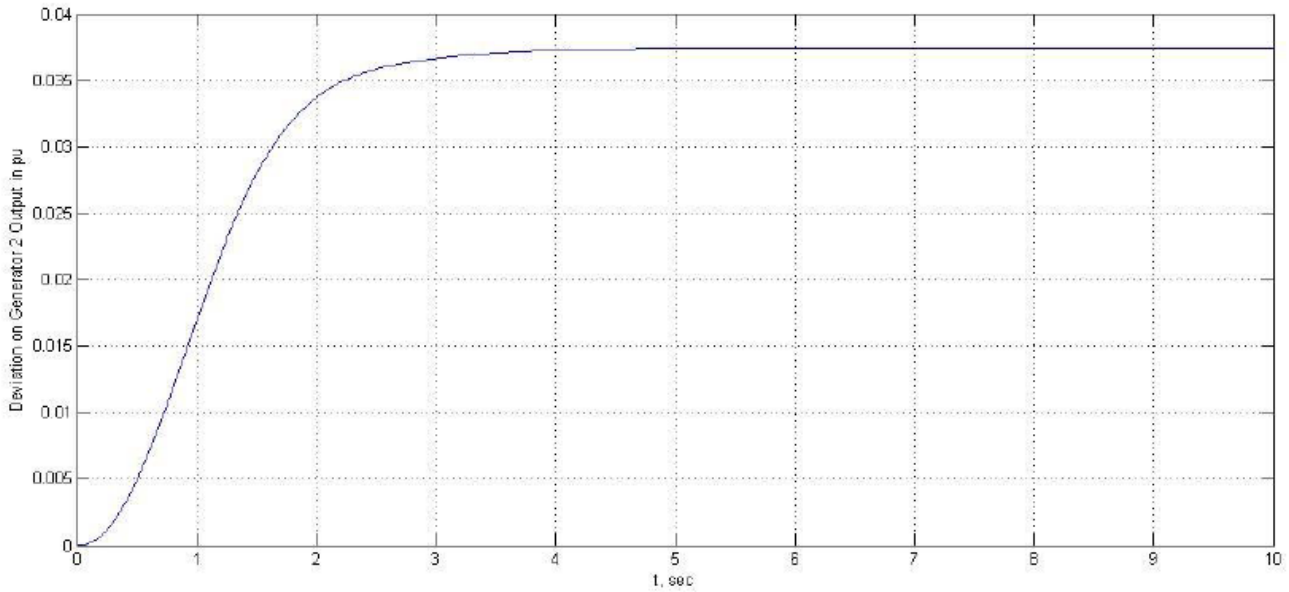
Figure 8: Deviation in Generator 2 Output Pg2.

Figure 9: Deviation in Generator 1 Output Pg1.

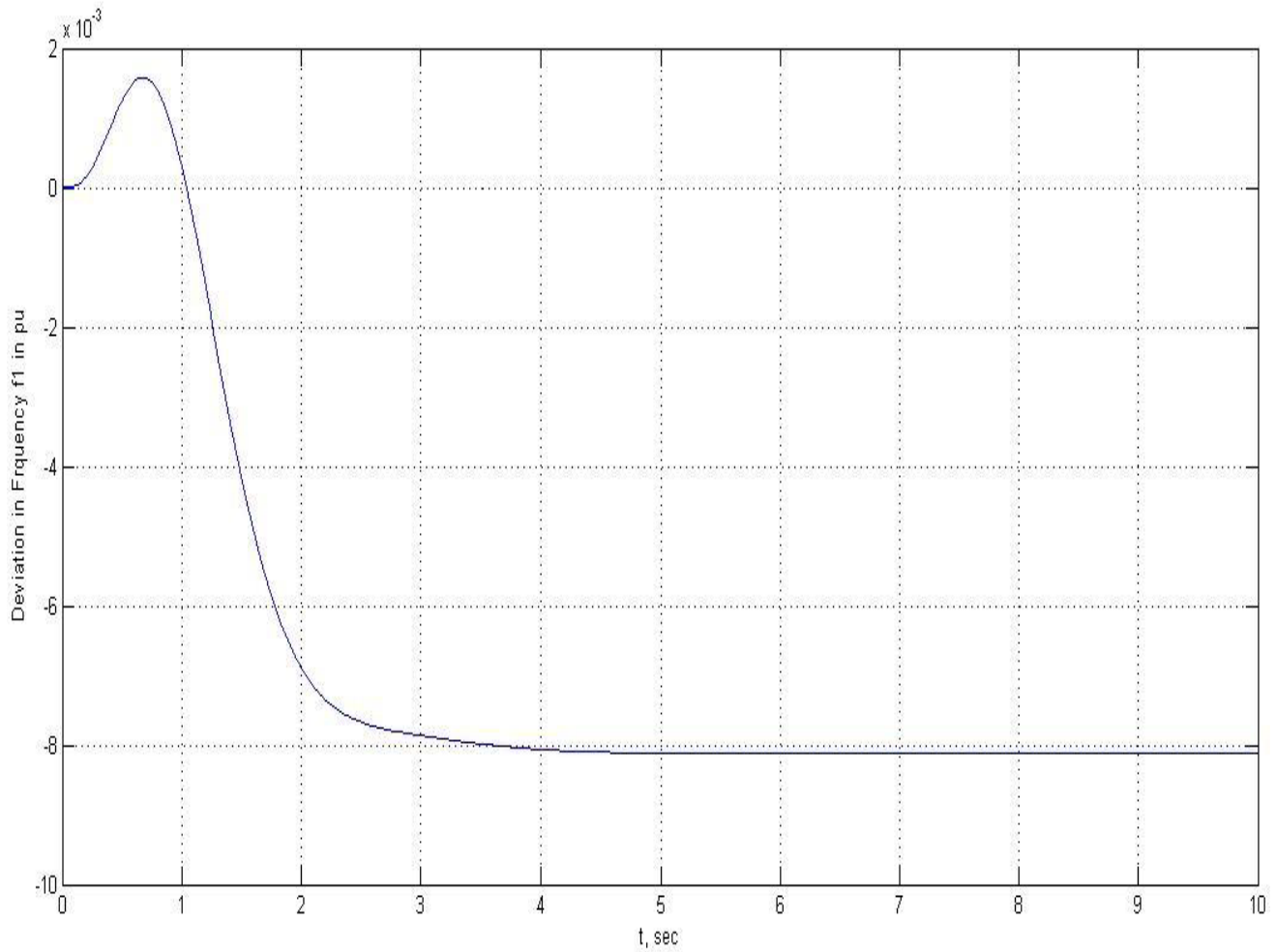6.2. Simulation Results when Input to Area 1 is varied.
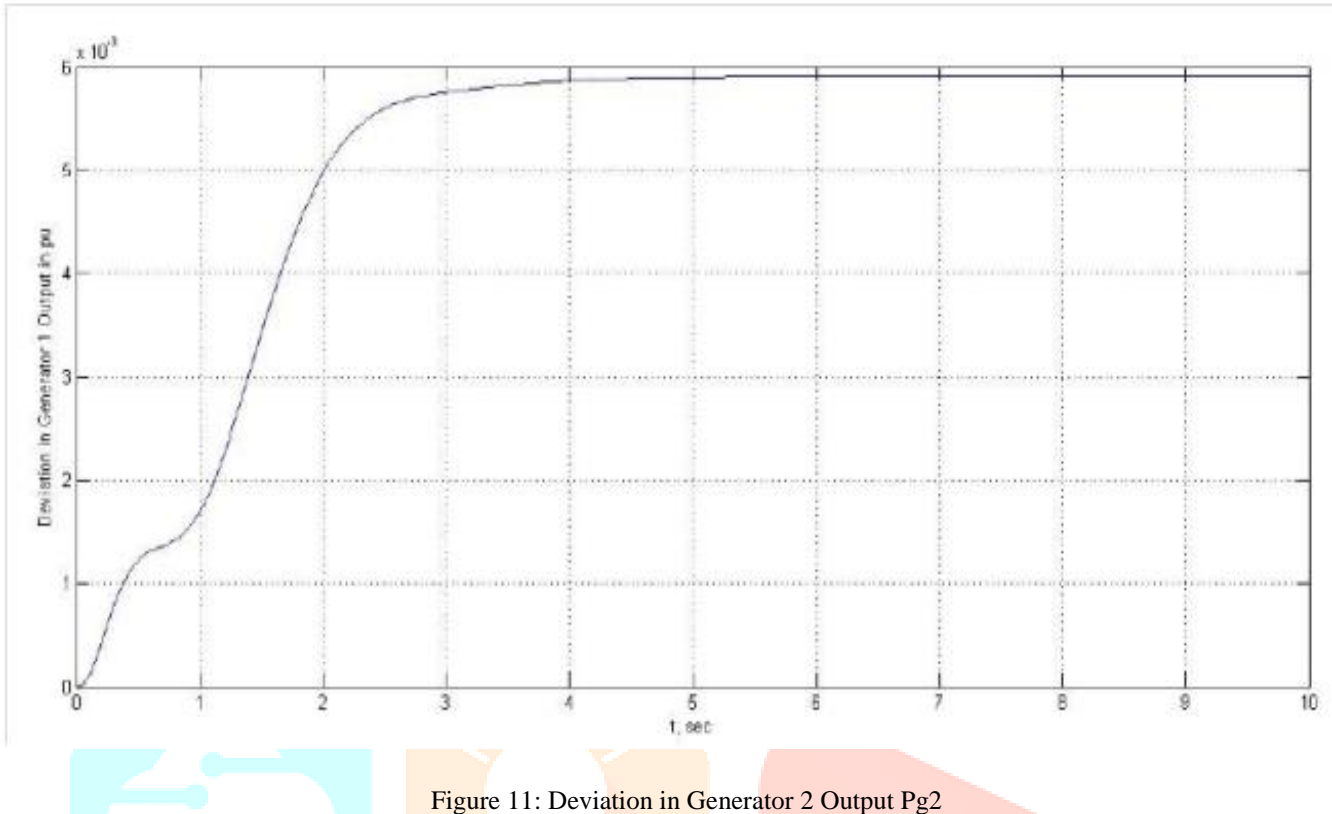

Figure 10: Frequency Deviation Δf1
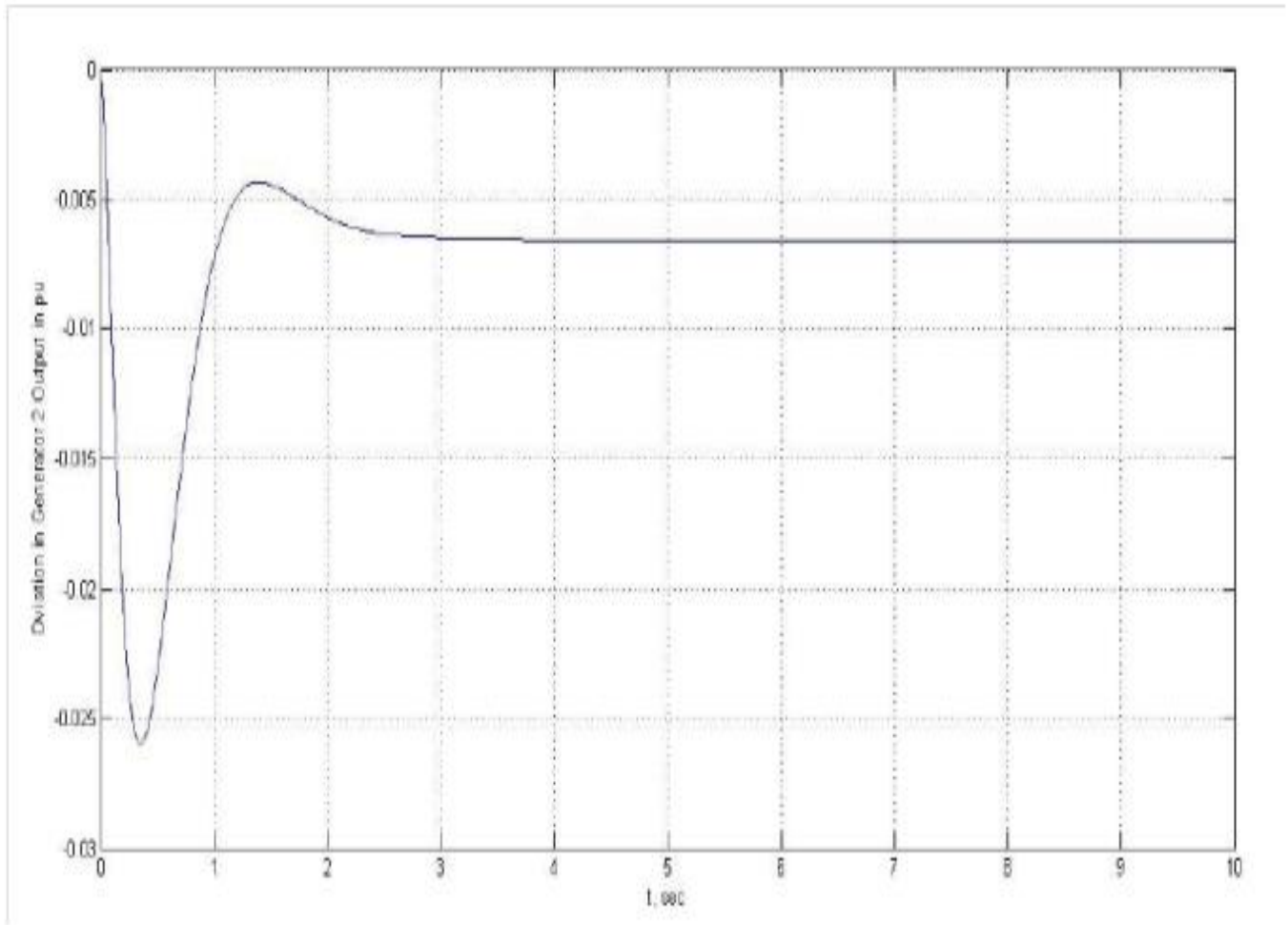
Figure 11: Deviation in Generator 2 Output Pg2
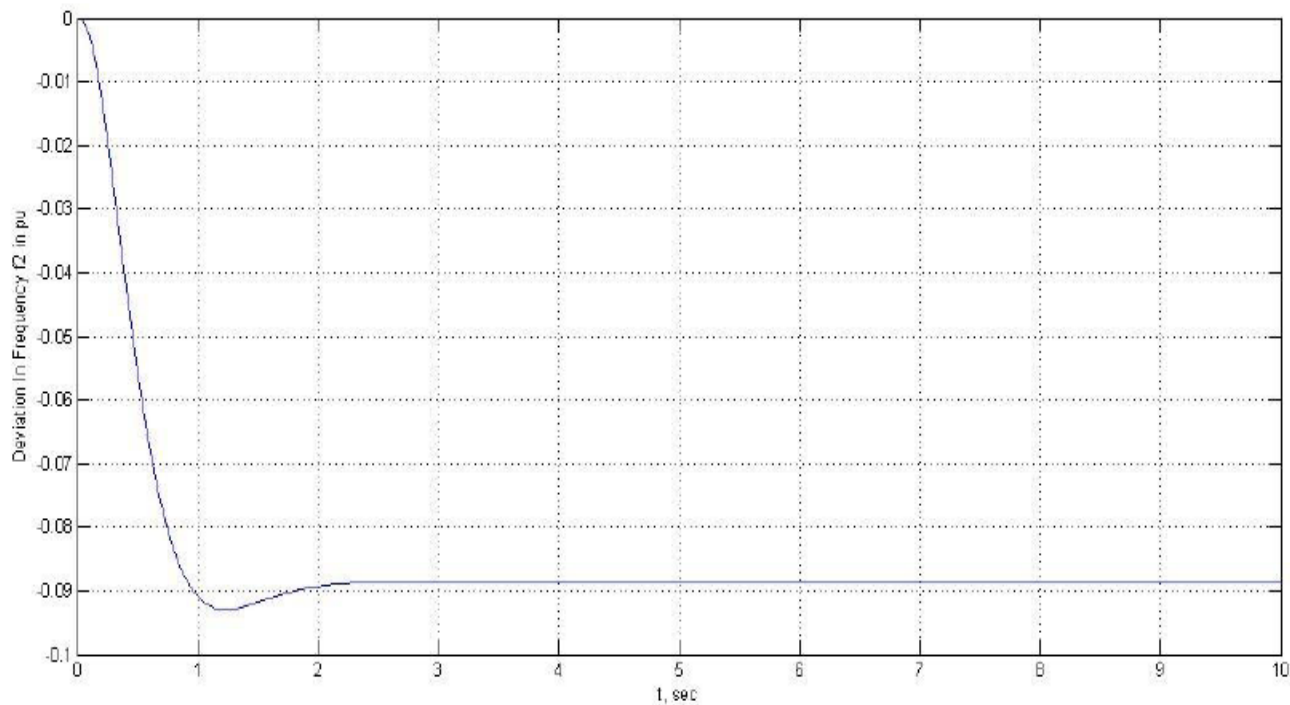

Figure 12: Deviation in Generator 1 Output Pg1.

Figure 13: Frequency deviation Δf2

Figures 6 ,7 ,8 ,9 denote the variation the frequencies and power generation of the two area power system when there is a variation in the input parameters of area 1. Similarly the Figures 10, 11, 12, 13 denote the variation of the above quantities when a variation in the input to the area 2 occurs, which clearly suggests that a decentralized control of the load frequency is achievable through Optimal Control Technique. Whenever the speed regulation to the area 2 generation is negative the load demand increases with respect to that of area 1, hence the frequency of area 2 deceases and the generation of power by the generator 2 also decreases. In order to meet the load demand the generator 1 has to increase generation and since the load has increased slightly with respect to the generation capacity it follows a slight deviation in the system frequency is ought to occur that is evidently shown in the simulations. [10,11].

Similarly when we look into the system in another way by changing the parameters in the input of generator 1 then the load demand increases with respect to the generation. As a result of which the frequency in the 1st area decreases and the generation capacity also decreases. In order to balance the generation and supply the generator in the second area must generate more power but since the load is slightly more than that of the generation capacity the system frequency decreases slightly, which is verified from the above simulation results.

7.CONCLUSIONS:

The paper presents a case study of designing a controller that can bear desirable results in a two area power system when the input parameters to the system is changed. Two methods of Load Frequency Control was studied taking an isolated power system into consideration. It was seen that the Optimal controller design bore better results and achieved desired reliability under changes in the input parameter. Hence an attempt was made to extend the Optimal Control design to a two area network. The assumptions taken under consideration strictly followed that the system operation was normal throughout and the simulations were obtained without the presence of the integral controllers. Lyapunov stability study revealed that by minimizing the system performance index the optimal controller can be designed that improves the system stability and performance drastically over the pole placement method with extensively depended on trial and error process. In fact there is a huge scope of improvement in this area where the power system study can be extended to a multi-area system that shall ensure stability in closed loop system.

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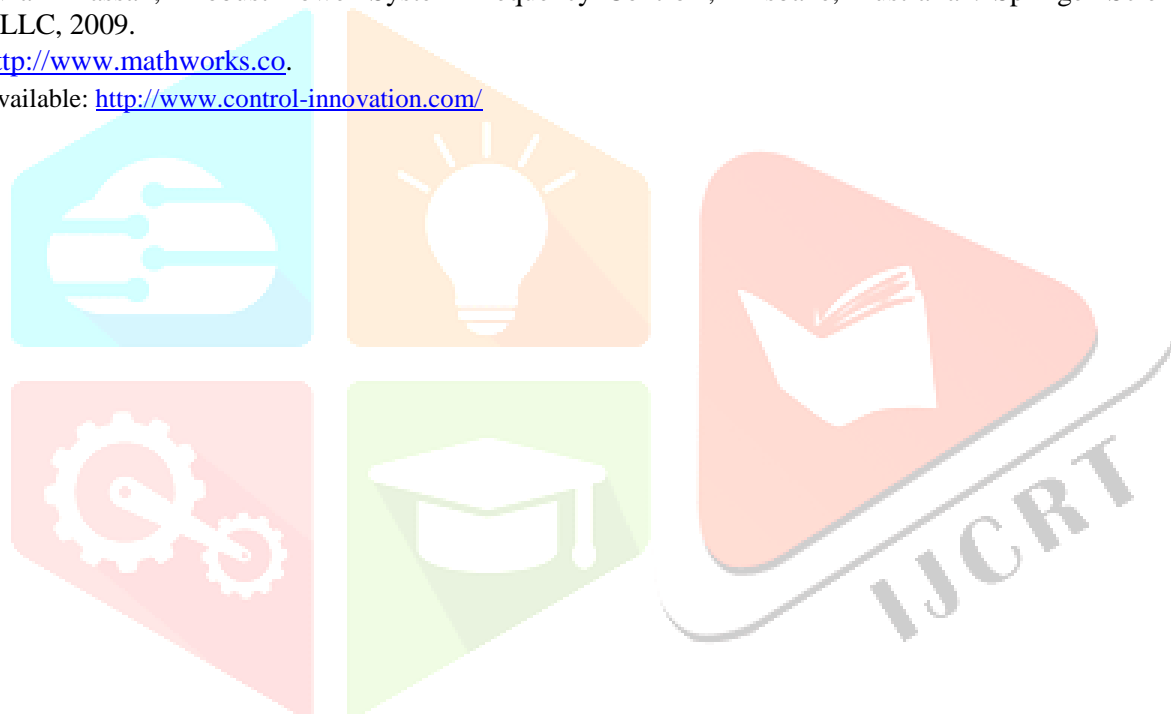
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