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# Load frequency analysis and its schematic control

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**Abstract -** *In case of an interconnected power system, any small sudden load change in any of the areas causes the fluctuation of the frequencies of each and every area and also there is fluctuation of power in tie line. The main goals of Load Frequency control (LFC) are, to maintain the real frequency and the desired power output (megawatt) in the interconnected power system and to control the change in tie line power between control areas. So, a LFC scheme basically incorporates a appropriate control system for an interconnected power system, which is heaving the capability to bring the frequencies of each area and the tie line powers back to original set point values or very nearer to set point values effectively after the load change. This is achieved by the use of conventional controllers. But the conventional controllers are heaving some demerits like; they are very slow in operation, they do not care about the inherent nonlinearities of different power system component, it is very hard to decide the gain of the integrator setting according to changes in the operating point. Advance control system has a lot of advantage over conventional integral controller. They are much faster than integral controllers and also they give better stability response than integral controllers. In this proposed research work advanced control technique (optimal controller, optimal compensator) and IMCPID control technique has been applied for LFC of two area power systems. The optimal controllers and compensators are capable of working without full state feedback and at the presence of process and measurement noise. The IMC-PID controller is capable of giving better response and is applicable under different nonlinearities.*

## 1.INTRODUCTION

### *Load Frequency Control Problem*

The power systems means, it is the interconnection of more than one control areas through tie lines. The generators in a control area always vary their speed together (speed up or slow down) for maintenance of frequency and the relative power angles to the predefined values in both static and dynamic conditions. If there is any sudden load change occurs in a control area of an interconnected power system then there will be frequency deviation as well as tie line power deviation.

The two main objective of Load Frequency Control (LFC) are

1. To maintain the real frequency and the desired power output (megawatt) in the interconnected power system.
2. To control the change in tie line power between control areas. If there is a small change in load power in a single area power system operating at set value of frequency then it creates mismatch in power both for generation and demand. This mismatch problem is initially solved by kinetic energy extraction from the system, as a result declining of system frequency occurs. As the frequency gradually decreases, power consumed by the old load also decreases. In case of large power systems the equilibrium can be obtained by them at a single point when the newly added load is distracted by reducing the power consumed by the old load and power related to kinetic energy removed from the system. Definitely at a cost of frequency reduction we are getting this equilibrium .The system creates some control action to maintain this equilibrium and no governor action is required for this. The reduction in frequency under such condition is very large. However, governor is introduced into action and generator output is increased for larger mismatch. Now here the equilibrium point is obtained when the newly added load is distracted by reducing the power consumed by the old load and the increased generation by the governor action. Thus, there is a reduction in amount of kinetic energy which is extracted from the system to a large extent, but not totally. So the frequency decline still exists for this category of equilibrium. Whereas for this case it is much smaller than the previous one mentioned above. This type of equilibrium is generally obtained within 10 to 12 seconds just after the load addition. And this governor action is called primary control. Science after the introduction of governors action the system frequency is still different its predefined value, by another different control strategies it is needed the frequency to bring back to its predefined value. Conventionally Integral Controllers are used for this purpose. This control is

called a secondary control (which is operating after the primary control operation) which brings the system frequency to its predefined value or close to it. Whereas, integral controllers are generally slow in operation. In a two area interconnected power system, where the two areas are connected through tie lines, the control area are supplied by each area and the power flow is allowed by the tie lines among the areas. Whereas, the output frequencies of all the areas are affected due to a small change in load in any of the areas so as the tie line power flow are affected. So the transient situation information's of all other areas are needed by the control system of each area to restore the pre defined values of tie line powers and area frequency. Each output frequency finds the information about its own area and the tie line power deviation finds the information about the other areas

**1.1 Interconnected Power Systems:**

According to practical point of view, the load frequency control problem of interconnected power system is much more important than the isolated (single area) power systems. Whereas the theory and knowledge of a isolated power system is equally important for understanding the overall view of interconnected power system. Generally now days all power systems are tied with their neighbouring areas and the Load Frequency Control Problem become a joint undertaking. Some basic operating principle of an interconnected power system is written below:

1. The loads should strive to be carried by their own control areas under normal operating conditions, except the scheduled portion of the loads of other members, as mutually agreed upon.
2. Each area must have to agree upon adopting, regulating, control strategies and equipment which are beneficial for both normal and abnormal conditions.

**Advantages of Interconnection:**

**1. Effect of size:** This one is one of the most important advantages for the whole interconnected power system. When a load block is added, at the initial time, the required energy is temporarily borrowed from the system kinetic energy. Generally the availability of energy is more for larger systems. So there is comparatively less static frequency drop.
Whereas, for a single area power system the frequency drop may be a bit higher for same amount in load change.

**2. Need of reduced reserve capacity:** 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.

**Major Drawbacks of Conventional Integral Controller:**

The drawbacks can be summarised as

1. They are very slow in operation.
2. There is some inherent nonlinearity of different power system components, which the integral controller does not care. Governor dead band effects, generation rate constraints (GRCs) and the use of reheat type turbines in thermal systems are some of the examples of inherent nonlinearities.
3. While there is continuously load changes occur during daily cycle, this changes the operating point accordingly. It is generally known as the inherent characteristic of power system. For good results the gain of the integrator should has to be changed repeatedly according to the change in operating point. Again it should also be ensure that, the value of the gain compromises the best between fast transient recovery and low overshoot in case of dynamic response. Practically to achieve this is very difficult. So basically an integral controller is known as a fixed type of controller. It is optimal in one condition but at another operating point it is unsuitable. Therefore, the control rule applied should be suitable with the dynamics of power system. So an advance controller would be suitable for controlling the system.

**Need of Advance Control Technique:**

Implementation of advanced control technique provides great help in LFC of power systems. Now days there are more complex power systems and required operation in less structured and uncertain environment. Similarly innovative and improved control is required for economic, secure and stable operation. Advance control techniques are having the ability to provide high adaption for changing conditions. They are having the ability for making quick decisions. Optimal control pole placement, Linear Quadratic Regulator, Linear Quadratic Gaussian), Robust Control, sliding mode control, Internal Model Control are some examples of advanced control techniques. LQR, LQG, IMC has been used here for LFC of power system.

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### 1.2 DESIGN OF OPTIMAL REGULATOR AND OPTIMAL COMPENSATOR

An optimal regulator (LQR) and an optimal observer (kalman filter) are designed separately for Load Frequency Control (LFC)of a two area power system. At first the Linear Quadratic Regulator is designed which is the cause of minimization of the quadratic objective function. Than an optimal observer (Kalman filter) is introduced for LFC with presence of noise (process and measurement noise) considered as white noises. The
combination of optimal regulator with the optimal observer forms a Optimal compensator
which is called as Linear Quadratic Gaussian (LQG).

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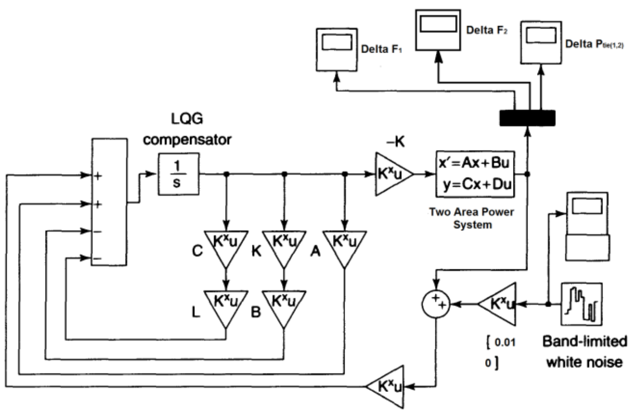


Fig. : Simulink diagram of LQG operating on LFC of two area power system

The above figure represents the simulink diagram of a linear Quadratic compensator operating on the load frequency control of a two area power system. it defines the state equation and the control law of linear quadratic regulator where the control law u=-Kx0 (t) is based on the estimated state x0 (t) and measured output y(t.) it will be seen that after the simulation, the LQG derives the same output as like the outputs of LQR. Means both the application of LQG and LQR are same but LQG is applicable at those places where process and measurement noise are taken in to account.

So finally we concluded that in this chapter a LQR is designed on the basis of present input and measured output. Then an optimal observer (Kalman filter) is designed which estimates the state vector at the presence of process and measurement noise considered as white Gaussian noise. And finally LQG is designed for LFC of a two area power system which creates an control input

### RESULTS AND DISCUSSION

In this study here, first a optimal control law is generated for the power system stability, then the states are estimated by kalman filter at the presence process and measurement noises taken as white Gaussian noise. Then combining those both a optimal compensator is designed which recovers the responses of optimal regulator at the presence of noise. So, the operation of optimal compensator is equal to the operation of optimal regulator but it can work noise environment. After that an IMC-PID controller is designed for LFC of power system and its results are compared with conventional integral Load Frequency Controller for a two area power system.

**Results of LQR for LFC of Two Area Power System:**

Dynamic responses of deviation in frequency for both the areas ($\Delta f_1$ , $\Delta f_2$ ) and the power deviation in tie line ( $\Delta P_{tie(1,\ 2)}$ ) for a power system heaving two control areas with thermal non-reheat turbines. The change in load powers which are the input disturbances are taken as, $d_1$ = 0.01 pu , $d_2$ = 0.00 pu Model of a two area interconnected power system has been developed with different area characteristics for optimal and conventional control strategies. The control equations and the state equations have successfully been derived in continuous time for a two area power system. The model developed here has also been examined for the stability before and after the application of state feedback control. Optimal control technique has a huge application over control engineering. An optimal regulator called Linear Quadratic Regulator (LQR) has been applied for Load Frequency Control (LFC) of a two area power system. A control law is generated on the basis of measured output and present states for infinite period of time. A State space model was developed by the help of state equations for the application of LQR. So by the application of state feedback controller the stability of area frequency and tie line power was obtained which is been proved as one of the effective controller in this proposed work.It is well known to everyone, that the optimal regulator (LQR) is not sufficient for full state feedback and also is not applicable at noisy environments. So an powerful observer, which is applicable for MIMO systems called Kalman filter is designed for the Load Frequency Control of a two area power system, at the presence of process and measurement noise. This observer minimizes the covariance of estimation error. The process and measurement noises in this type of observer are considered as white Gaussian noise. In this case all the states are estimate on the basis of present input and measured output for finite period of time.such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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**BIOGRAPHY**

Mr Vikash Rathee persuing m.tech from the RIEM,rohtak in deparment of power electronics. He worked on the topic of frequency analysis working with his guide Mr. devender goyat a assistant professor ,in this research topic he analysis the no of data on the machine .