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Load Frequency Control for 3 Area Interconnected Power Systems

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Abstract: Nowadays bulk power system is consisted of multiple interconnected controllable areas. In Interconnected power system, small disturbance occurs in load at any areas that causes the fluctuation of frequency at each and every area. Also fluctuate the power flow between the different areas. So, the main objectives of LFC are to maintain the frequency to its nominal value and scheduled the power exchange between the areas. LFC scheme contain the appropriate control system for an interconnect power system, which have the capability to bring the frequency of each area and tie line power back to its specified nominal value. For this consider three hydro thermal area.

Keywords: load frequency control (LFC) scheme, Automatic generation control (AGC), battery energy storage (BES), AC/DC link .Generation rate constraint.

I. INTRODUCTION

Nowadays most of power systems are interconnected with their neighboring areas. In a multi-area power system, every area has a various types of uncertainties and disturbances arising from complexity of the system, system modelling errors and changes in power system topology due to faults and switching. In interconnected multi area power system as a power load demand varies randomly, in the case of any small sudden systems are divided into various areas.In an interconnected multi-area power system, as a power load demand varies randomly, in the case of any small sudden load change in any of the areas, both area frequency and tie-line power flow interchange also vary. The main goals of Load Frequency Control (LFC) are,

- Hold the frequency constant ($\Delta f = 0$) against any load change. Each area must contribute to absorb any load change such that frequency does not deviate.
- Each area must maintain the tie-line power flow to its pre-specified value.

Unbalance between supply and load causes the fluctuation of the system frequency, which can degrade the power system performance and makes his control more difficult. LFC has been one of the important control challenges in electric power system stability and control. Automatic generation control plays the major role to maintain system frequency at or very close to a specified nominal value and to sustain the scheduled exchange of power.Load Frequency Control is important to hold the system frequency and the inter-area tie -line power flow as near with neighbouring control areas at the scheduled values. In order to satisfy the LFC objectives, a control error signal named the area control error (*ACE*) is measured. This signal is a linear combination of net interchange and frequency deviation and represents the real power unbalance between supply and load of power.

The area control error (*ACE*) is given by:

$$ACE = \Delta P_{tieij} + \beta_i \Delta f_i$$

Automatic generation control (AGC):

Load frequency control has a control feature in the speed governing linkage mechanism. AGC (automatic generation control), which have a speed governing linkage mechanism. In this mechanism if the generator speed is suddenly falls or exceeds to its nominal pre- specified value then the speed governor sense the speed of generator and it will adjust the steam/water which is given to the turbine. Because ultimately the electromagnetic torque which produced by the turbine is regulated then the generator speed and output power become regulate to its normal value.The main aim of load frequency control is to minimize the transient variations in these variables and also to make sure that their steady state errors is zero.

Battery energy storage (BES):

The Battery energy storage is one the alternative is used to improve the performance of AGC during peak load period and it can provide fast active power compensation. BES also provides a reliability of supply during peak load period. Also additional benefit such as spinning reserve and black start capabilities.

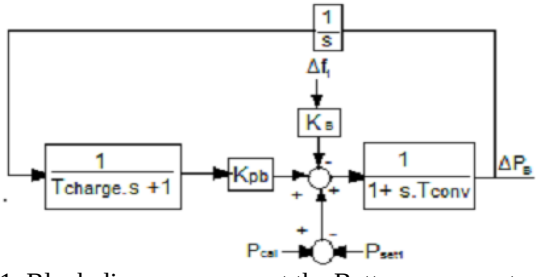

Fig.1. Block diagram represent the Battery energy storage

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Where,
K_B - represents the feedback gain of the frequency fluctuation in the power grid.
Pcal-Pset - represents the compensated power, which is caused by ramp limitations of generators.

AC/DC tie line:
The main function of tie line is to exchange the power between the connect area.The control areas are interconnected via AC tie-lines. Tie-lines are useful for exchange of power from one area to the other according to the contract made among them. This also provides support during fault condition and thus helps in clearing of th e fault. So, the tie-lines are economically and technically feasible for operation of the power system. But the AC tie-lines have some disadvantage particularly in long distance transmission of power. The presence of large power oscillations lead to frequent tripping of circuits and increase in fault level current. This also leads to transmission of disturbance from one system to the otherThere by deteriorating the dynamic performance of the power system. This introduces the High Voltage DC (HVDC) transmission system which transmits bulk power over long distance. This system has the advantage of fast controllability of power in HVDC line through converter control. This also eliminates the transient stability problem which is associated in AC transmission system and it has some other economic advantages too. Thus, DC link is in parallel with the AC link to improve the system performance.

Generation Rate constraint (GRC):
In general, there exists a minimum and maximum limit on the rate of change in the generating power (ΔP_G). Figure 3.16 shows, due to adiabatic expansion, sudden power decrease would draw out excessive steam from boiler system to cause steam condensation. The steam valve of high pressure turbine acts as a control valve associated with LFC.

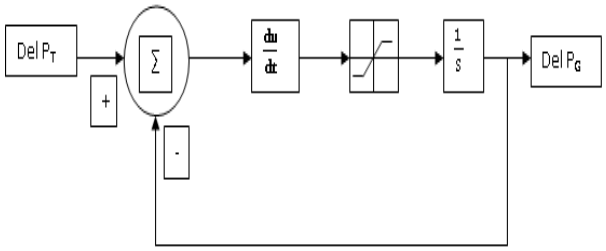


Fig.2. Block diagram represent the generation rate constraint

Three area interconnected power system:
Three interconnected area considered in this paper are:
Area-1 is reheat thermal plant Areaa-2 is also reheat thermal plant and Area-3 is hydro plant. All these three areas are interconnected with tie line.in hydro area the electrical governor is used.

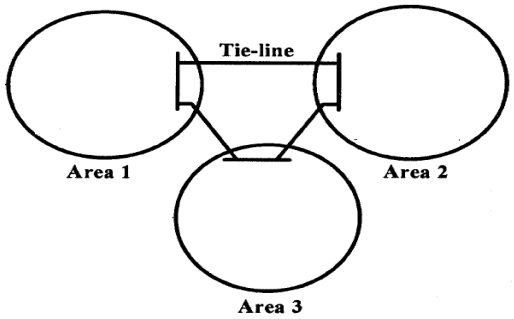
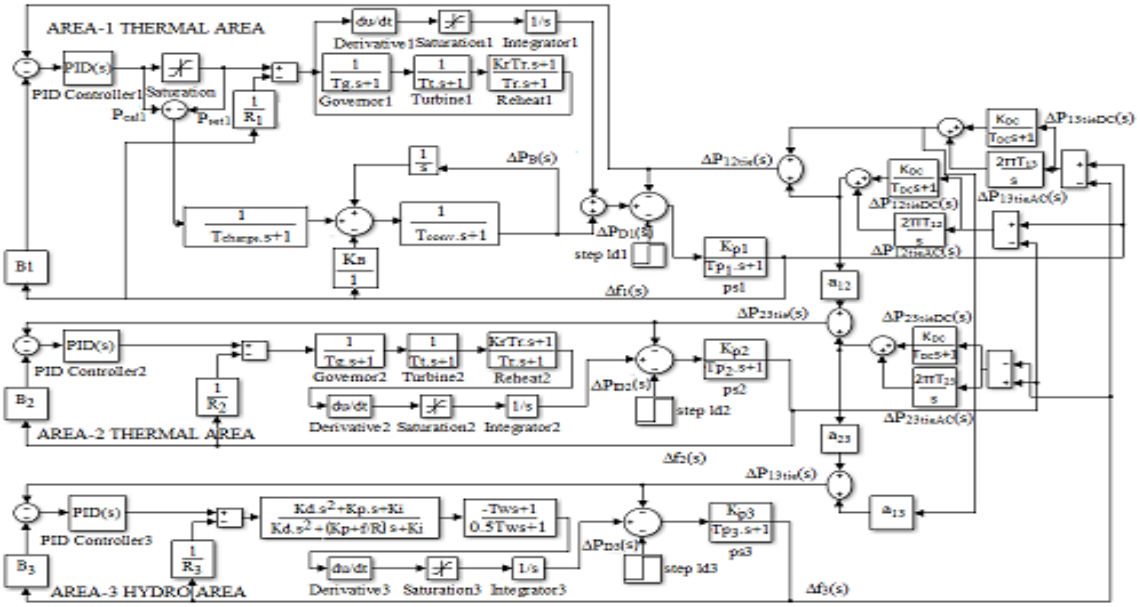


Fig.3 Three area interconnected power system

The complete block diagram of LFC in three area: In this system three area interconnected system is used. Conventional controller is also used to control the frequency at nominal value.



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II. CONCLUSION

The outcomes from the literature review are, the automatic generation control is used for regulate thefrequency at nominal. And the AC tie line is use parallel with DC tie line. Because it improved the system parameter. And the disadvantages of AC tie line is overcome by using DC tie line. Also in LFC battery energy storage is used. Because it is one of the alternative to provide the spinningreserve. In battery energy storage the electrical power is stored. Also the LFC with generation rate constraint is used. Because the In general, there exists a minimum and maximum limit on the rate of change in the generating power (ΔPG). Due to adiabatic expansion, sudden power decrease would draw out excessive steam from boiler system to cause steam condensation. The steam valve of high pressure turbine acts as a control valve associated with LFC. Conventional controller is also used for scheduled the power and frequency.

But the disadvantages of conventional controller is its operation is become slow due to gain decided by the trial and error method is very hard and it required more time and less accurate result. For proper tuning of conventional controller is done by using Ziegler Nichols and artificial intelligent technique. It is less time consuming and give the better result compared to tuned with trial and error method using LFC.

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