A Review on AGC of Interconnected Power System using Integral Controller

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Abstract— The focus on power quality problems has recently become one of the important issues in power system due to fast industrialization and extensive use of nonlinear loads with varying distortion at ac mains. Poor power factor and voltage drop at the load terminals along with other power quality problems such as harmonics, unbalanced loads have considerable effect on the other connected consumer loads. Harmonics currents produce voltage distortion at PCC (Point of Common Coupling), resonance with source impedance and excessive power losses in supply lines. There are various control algorithms in time and frequency domain for extraction of harmonics components from distorted signals. The facts devices such as STATCOM (Static Compensator) has taken a considerable lead for harmonics suppression, load balancing and reactive power compensation in PFC (Power Factor Correction) as well as ZVR (Zero Voltage Regulation) modes at PCC. The algorithm to find the optimal location of STATCOM based on particle swarm optimization (PSO) has been developed. The effect of this device on line flows and bus voltage profile has been studied by Newton-Rapshon method placing STATCOM at random location and placing them optimally with optimal ratings dictated by PSO. The effectiveness of developed algorithm has been tested on IEEE 14 bus and IEEE 30 bus systems using MATLAB 7.1.0 software. The results obtained are quite encouraging and will be useful in electrical restructuring.

Key words: Hospital Bed Management, Hospital Capacity Planning, Decision Support Systems, Decision Support Models

I. INTRODUCTION

When load in the system increases turbine speed drops before the governor can adjust the input. As the change in the value of speed decreases the error signal becomes smaller and the positions of governor valve get close to the required position, to maintain constant speed. However the constant speed will not be the set point and there will be an offset, to overcome this problem an integrator is added, which will automatically adjust the generation to restore the frequency to its nominal value. This scheme is called automatic generation control (AGC).

The role of AGC is to divide the loads among the system, station and generator to achieve maximum economy and accurate control of the scheduled interchanges of tie-line power while maintaining a reasonability uniform frequency. Modern power system network consists of a number of utilities interconnected together and power is exchanged between utilities over tie lines by which they are connected. Automatic generation control (AGC) plays a very important role in power system as its main role is to maintain the system frequency and tie line flow at their scheduled values during normal period. Automatic generation control with primary speed control action, a change in system load will Result in a steady state frequency deviation, depending upon governor droop characteristics and frequency sensitivity of the load.

All generating units on speed governing will contribute to overall change in gyration, irrespective of the location of the load change. Restoration of the system frequency to nominal value requires supplementary control action which adjusts the load reference set point. Therefore the primary objectives of the automatic generation control are to regulate frequency to the nominal value and to maintain the interchange power between control areas at the scheduled values by adjusting the output of selected generators. This function is commonly referred to as load frequency control. A secondary objective is to distribute the required change in generation among the units to minimize the operating costs.

Modern power system network consists of a number of utilities interconnected together and power is exchanged between utilities overtime-lines by which they are connected. Automatic generation control (AGC) plays a very important role in power system its main role is to maintain the system frequency and tie line flow at their scheduled values during normal period. During large transient disturbance and emergencies AGC is by passed and other emergency control takes over. The synchronization of different system to interconnected system depends upon (1) voltage magnitude (2) frequency and (3) phase sequence. Any wide deviation from the nominal value of frequency or voltage will lead the system to total collapse. Hence AGC has gained importance with the growth of interconnected systems and with rise in size of interconnected system automation of the control system have aroused.

Under normal conditions with each area able to carry out its control obligations, steady state corrective action of AGC is confined to the area where the deficit or excess of generation occurs. Inter area power transfers are maintained at scheduled levels and system frequency is held constant. Under abnormal conditions, one or more areas may be able to correct for the generation-load mismatch due to insufficient generation reserve on AGC. In such an event, other areas assist by permitting the inter areas power transfers to deviate from scheduled values and by allowing system frequency to depart from its pre disturbance value. Each area participates in frequency regulation in proportion to its available regulating capacity relative to that of overall system.

In modern large interconnected systems, manual regulation is not feasible and therefore automatic generation and voltage regulation equipment is installed on each generator. Figure gives the schematic diagram of load frequency and excitation voltage regulators of a turbo-generator. The controllers are set for a particular operating condition and they take care of small changes in load

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demand without frequency and voltage exceeding the prescribed limits.

For North America, the standard values for the frequency and voltage are 60 Hertz and 120 Volts respectively. However, the users of the electric power change the loads randomly and momentarily. It will be impossible to maintain the balances of both the active and reactive powers without control. As a result of the imbalance, the frequency and voltage levels will be varying with the change of the loads. Thus a control system is essential to cancel the effects of the random load changes and to keep the frequency and voltage at the standard values. Although the active power and reactive power have combined effects on the frequency and voltage, the control problem of the frequency and voltage can be decoupled. The frequency is highly dependent on the active power while the voltage is highly dependent on the reactive power. Thus the control issue in power systems can be decoupled into two independent problems. One is about the active power and frequency control while the other is about the reactive power and voltage control.

The active power and frequency control is referred to as load frequency control (LFC). The foremost task of LFC is to keep the frequency constant against the randomly varying active power loads, which are also referred to as unknown external disturbance. Another task of the LFC is to regulate the tie-line power exchange error.

Therefore, the requirement of the LFC is to be robust against the uncertainties of the system model and the variations of system parameters in reality. In summary, the LFC has two major assignments, which are to maintain the standard value of frequency and to keep the tie-line power exchange under schedule in the presences of any load changes [1]. In addition, the LFC has to be robust against unknown external disturbances and system model and parameter uncertainties. The high-order interconnected power system could also increase the complexity of the controller design of the LFC.

II. Historical Development of AGC

Investigations in the field of automatic generation control of interconnected power system have been reported over the past few decades. These investigation deals with how to select a frequency bias, selection of controller parameters and selection of speed regulator parameter of speed governor. The following are summaries of some related work in this area, which gives a comprehensive review of the literature.

previous investigates the improvement of transient stability of a two-area power system, using UPFC (Unified Power Flow Controller) which is an effective FACTS (Flexible AC Transmission System) device capable of controlling the active and reactive power flows in a transmission line by controlling appropriately its series and shunt parameters. Simulations are carried out in Matlab/Simulink environment for the two-area power system model with UPFC to analyze the effects of UPFC on transient stability performance of the system. The performance of UPFC is compared with other FACTS devices such as Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series Capacitor (TCSC), and Static Var Compensator (SVC) respectively. The simulation results demonstrate the effectiveness and robustness of the proposed UPFC on transient stability improvement of the system [2].

A. Generator Controllers (P-F and Q-V Controllers)

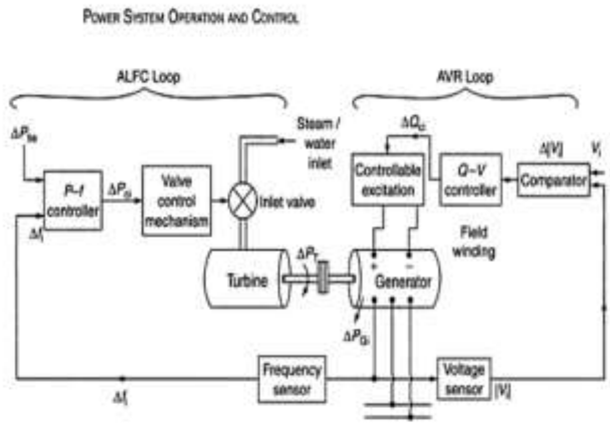

Fig. 1: P-f controller and Q-V controller

In the design the Load-Frequency Control (LFC) system for improving power system dynamic performance over a wide range of operating conditions based on model predictive control MPC technique. The two control schemes namely Fuzzy logic control and proposed model predictive control are designed. Both the two controllers employ the local frequency deviation signal as input signal. The dynamic model of two-area power system under study is established. To validate the effectiveness of the proposed MPC controller, two-area power system is simulated over a wide range of operating conditions. Further, comparative studies between the fuzzy logic controller (FLC) and the proposed MPC load frequency control are evaluated [3].

In the development of a realistic automatic generation control (AGC) model for a two area reheats thermal power system under an open market environment. The analysis is carried out by considering dual rate sampling.

The effect of various load following contracts on the performance of the controller in a deregulated environment has been investigated [5].

The traditional automatic generation control (AGC) of two-area system is modified to take into account the effect of bilateral contracts on the dynamics. The concept of distribution companies (DISCO) participation matrix to simulate these bilateral contracts is introduced and reflected in the two-area block diagram. Trajectory sensitivities are used to obtain optimal parameters of the system using a gradient Newton algorithm [6].

In a robust approach to real-time detection of faults in the load-frequency control loop of interconnected power systems, the detection of faults takes place under different operating conditions, in the presence of modelling uncertainties, unknown changes in the load demand, and other external disturbances, such as plant and sensor noise. Although the approach is applicable to N-area systems, a two-area interconnected power system example is considered for simplicity [7].

In a new PID tuning method for load frequency control of power systems as discussed in this paper, the tuning method is based on the two-degree-of-freedom (TDF) internal model control (IMC) design method and a PID

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approximation procedure. The time-domain performance and robustness of the resulting PID controller is related to two tuning parameters. The method is applicable to power systems with non-reheat, reheat, and hydro turbines, and simulation results show that it can indeed improve the damping of the power systems [8].

The changes in real power affect mainly the system frequency. The integration of fuel cell when coupled with change in load will result into a change in real power. The integration will result into change of frequency of synchronous machines. Possibility of control actions related for PEMFC and/or external disturbances occurring in one sub system may be transmitted, via the interconnection, to neighbouring sub systems, thereby producing undesirable effects. In this paper a LFC scheme is design using DAC. A DAC controller by which maximum utilization of DR output to achieve the control objective more efficiently is designed [16].

A new PID tuning method for load frequency control of power systems is based on the two-degree-of-freedom (TDF) internal model control (IMC) design method and a PID approximation procedure. The time-domain performance and robustness of the resulting PID controller is related to two tuning parameters. The method is applicable to power systems with non-reheat, reheat, and hydro turbines, and simulation results show that it can indeed improve the damping of the power systems [18].

III. Scope of AGC at Present

On the basis of detailed literature review given above the purpose of this thesis work is to develop Simulink for analysis the frequency deviation .Here some of the problem which are faced during the operation of electric power system are discussed below .these problem should be overcome to make the system efficient for the desired work. In this he solution of this problem are also discussed.

There is need for a dynamic model for the analysis of frequency variation in interconnected area power system.

1) Frequency Deviation- Constant frequency is identified as the primary mark of a normal operating system. Because the generator turbine and motors are designed to operate at a precise speed, which depends on frequency .The reason for the frequency deviation is the change in system load.
2) Speed Variation-When load in the system increases turbine speed drops before the governor can adjust the input. As the change in the value of speed decreases the error signal becomes smaller and the positions of governor valve get close to the required position, to maintain constant speed. However the constant speed will not be the set point and there will be an offset, which must overcome for proper operation of power system.
3) Voltage Deviation-Practically all equipment used in or operating of a power system is designed for certain voltage level .If it deviates its performance deviates and life expectancy drops. The voltage deviation is mainly caused by the change in system load.
4) Power flow problem - Power flow analysis is very important in planning stages of new network or addition to existing one. The power flow must be controlled because the transmission link can carry certain amount of power which must be below their stability or thermal limit. Also the generator output which must be closely maintain at predetermined set point changes from hour to hour to assess the demand.
5) Optimal Dispatch-when there is sudden increase in load (1%) in control area then some unit become overloaded to meet the generation demand. The problem is not only due to hourly shifting the power demand but also the entire generating unit must be regularly maintained.

On the basis of problem statements given before this section, following are the objectives of this thesis work:

1) It is proposed to process dynamic modeling of interconnected power system to study the dynamic behavior of interconnected area in power system.
   – To study the dynamic response to the interconnected area with or without integral controller
   – To investigate the stability of the system using transfer function approach in MATLAB/Simulink.
2) To maintain the constant speed and to restore frequency to its nominal value
3) To make constant voltage level, when the load is changing and to reduce wear and tear of machine part,
4) To keep power flow below the stability limit or thermal limit of the transmission link.
5) The optimal management of load among the generating units to achieve max

IV. Advantages of AGC

The automatic generation control has many advantages in power system .It improves the following factors-

A. Economy:

The automatic generation control divides the loads among the system, station and generator to achieve maximum economy. In other words, it distributes the required change in generation among the units to minimize the operating cost. Thus it makes the electrical power system to work properly at low operating cost to improve the economy.

B. Stability

With the automatic system, many units in a system can participate in regulation, reducing wear on single unit's control to improve the overall stability of the system .It reduces the frequency variation and voltage variation to increase the life of machine parts or to make them stable.

C. Efficiency

The automatic generation control helps to maintain the power interchanges over the tie lines at the scheduled levels to reduce the transmission losses. Thus it improves the efficiency of the electric power system. Thus, the automatic generation control not only regulates the frequency variation and voltage variation in the electric power system but it also improves the efficiency, stability and economy of the system.

V. Applications of AGC

The automatic generation control has many application which are given as following-

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- The automatic generation control is applicable in electric power system for adjusting the power output of multiple generators at different power plants, in response to change in the load.
- The automatic generation control is applicable for regulating the frequency and voltage in electric power system for –
  - One area
  - Two area
  - Multiple area

Thus the automatic generation control is applicable in one area, two area and multiple area interconnected power system to maintain the frequency and interchange power between control areas at scheduled value.

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