Automatic Generation Control in Power System Network

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Abstract- **To improve the operation of generation system the way that found is automatic generation control. Automatic Generation control(AGC) is a process that controls the limits of the frequency and voltage variations. Generation system stability can be achieved by controlling the frequency and the voltage regulation. The load frequency control plays an important role in an interconnected power system. The AGC control units are divided into three: automatic generation control unit, transitional unit and planning unit. Appropriate controller must be designed to keep the system frequency within permissible limits.**

1. INTRODUCTION

In an power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different generation plant, in response to changes in the load. Since a power grid requires that generation and load closely balance moment by moment, frequent adjustments to the output of generators are necessary. The balance can be judged by measuring the system frequency; if it is increasing, more power is being generated than used, which causes all the machines in the system to accelerate. If the system frequency is decreasing, more load is on the system than the instantaneous generation can provide, which causes all generators to slow down.

Before the use of automatic generation control, one generating unit in a system would be designated as the regulating unit and would be manually adjusted to control the balance between generation and load to maintain system frequency at the desired value. The remaining units would be controlled with speed droop to share the load in proportion to their ratings. With automatic systems, many units in a system can participate in regulation, reducing wear on a single unit's controls and improving overall system efficiency, stability, and economy.

Where the grid has tie interconnections to adjacent control areas, automatic generation control helps maintain the power interchanges over the tie lines at the scheduled levels. With computer-based control systems and multiple inputs, an automatic generation control system can take into account such matters as the most economical units to adjust, the coordination of thermal, hydroelectric, and other generation types, and even constraints related to the stability of the system and capacity of interconnections to other power

2. AUTOMATIC GENERATION CONTROL

The load sharing in a multi-generator power system can be achieved using droop characteristics of governors. The sharing according to droop is irrespective of load location.

However if non-zero governor droops are used (which is necessary for appropriate sharing), a steady state frequency error will remain which needs to be corrected. Moreover, since all the governors respond to the load change irrespective of load location, there may be undesirable exchange of power between different areas of the grid. This is manifested as a change in the flows of lines interconnecting these areas.

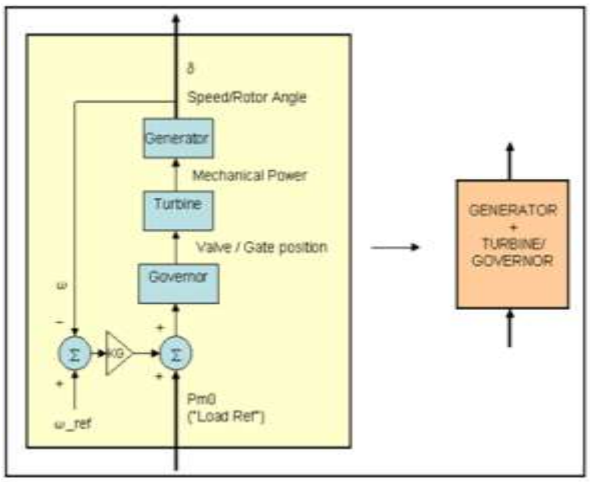
To ensure that frequency steady state error is corrected and generators in a particular area take on the burden of their own load, the load reference (Pm0) of governors is adjusted slowly. This control is also called "secondary control". This correction may be done over several minutes as opposed to 5-10 seconds for initial or "primary" control action of governors.

Thus, while primary control (governor action) ensures that a large and sudden frequency fall or rise is prevented, secondary control or Automatic Generation Control ensures that frequency is brought back to the nominal value and inter-area power flow is regulated. Any change of reference value will lead to a change in sharing among the generators. Thus by slowly changing the reference of speed governors we can over-ride the sharing which is imposed by the droop characteristics.

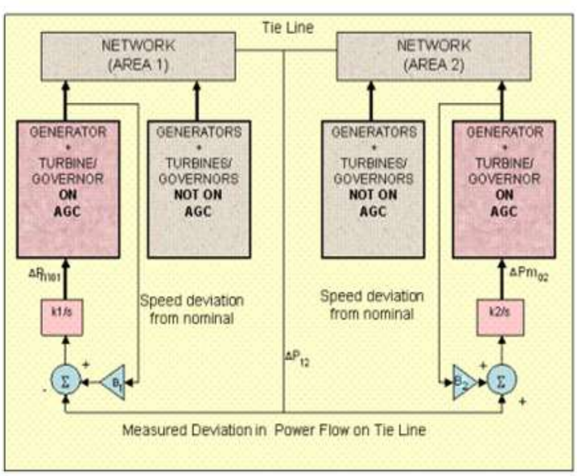
It is not feasible to independently change more than one governor reference in one area, otherwise there is no unique value of reference change for different governors. Thus if more than one governors in an area are "on AGC", then their actions have to be in a pre-decided proportion and not independent of one another.

The AGC concept is illustrated by the following schematic,

Each generator which has a governor can be represented as follows. Note that the value of the load reference Pm0 is adjusted by AGC.



The following figure shows how a generator in each area in a 2 area system receives feedback from a tie line (P12). The feedback is combined with the speed deviation signal in a certain proportion (decided by the constant B). It is then fed to an integral controller, the output of which changes Pm0.



An integral controller acts on this error to change the load reference of both governors. Since an integral controller drives its input to zero in steady state (why?), it follows that in steady state:

$$B_1\left(\frac{\omega_{REF}-\omega_1}{\omega_0}\right)-\Delta P_{12}=0$$

$$B_2\left(\frac{\omega_{REF}-\omega_2}{\omega_0}\right)-\Delta P_{21}=0$$

$\Delta P_{21} = -\Delta P_{12}$ (losses are assumed to be small), $\omega_1 = \omega_2$ in steady state and typically $\omega_{REF} = \omega_0$

Then it follows that if B_1 and B_2 are > zero,

$$\omega_1 = \omega_2 = \omega_0$$

and

$$\Delta P_{12} = 0$$

Which means that in steady state, both frequency deviation and tie line power flow deviation are made to go to zero by the AGC.

While any value of the weighting factors which are non-zero gives the same result in steady state, they are chosen such that the transient response is good

3. FREQUENCY DEVIATIONS AND ASSOCIATED CONTROLS

The primary, secondary and emergency controls are classified based on the magnitude of frequency deviations. These are shown Fig. 2. For a typical power system operating at 50 Hz nominal frequency, the ranges of frequency deviations and type of control actions are described in Table-1. The accepted standard value of frequency in Hz is also shown by Table-1.

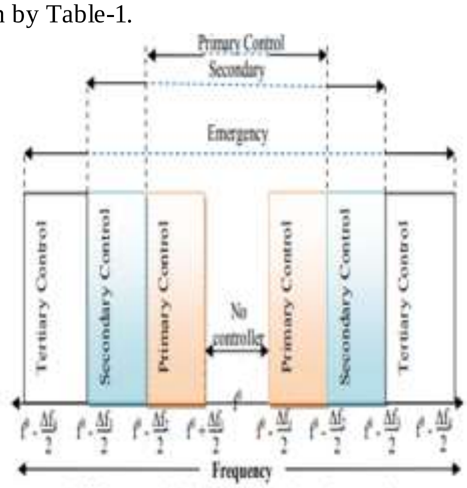


Fig. 2. Frequency deviations and associated operating controls

Table 2 Frequency Deviations and Associated Operating Controls

Sr. No.	Range of frequency (F)	Range of frequency at 50 Hz	Types of operation	Types of Control
1	$f^0 - \frac{\Delta f_1}{2}$ to $f^0 + \frac{\Delta f_1}{2}$	50.05 to 49.95	Normal	No controller is required
2	$f^0 - \frac{\Delta f_2}{2}$ to $f^0 + \frac{\Delta f_2}{2}$	50.20 to 50. 05 and 49.8 to 49.95	Normal operation	Primary control
3	$f^0 - \frac{\Delta f_3}{2}$ to $f^0 + \frac{\Delta f_3}{2}$	50.20 to 51.00 and 49.80 to 49.00	Off-normal operation	Secondary control (AGC)
4	$f^0 - \frac{\Delta f_4}{2}$ to $f^0 + \frac{\Delta f_4}{2}$	above 51.00 and below 49.00	Emergency operation	Emergency control

The nominal frequency f0 and frequency deviations Δf1, Δf2, Δf3 and Δf4 show frequency variation range corresponding to the different operating conditions based on the accepted frequency operating standards. However the natural governor response known as the primary control, the supplementary control (AGC), or secondary control, and emergency control may all be required to maintain successful operation of the power system. The detailed functional block diagram representing primary control loop, supplementary control loop and emergency control loop are shown in Fig. 3.

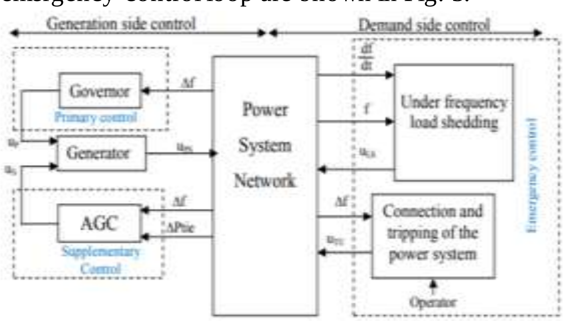


Fig. 3. Frequency control loops

The typical dynamic responses of power system to a generating power plant trip event, with the responses of primary, supplementary and emergency control are plotted in Fig. 4.

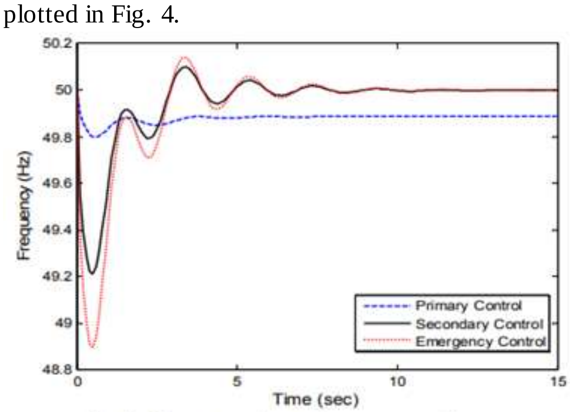


Fig. 4 Primary, secondary and emergency control

Needless to say that for satisfactory operation of a power system, the frequency should remain as near as nominal system frequency. Under normal operation of power system, the small frequency deviations can be controlled by the primary control loop. Depending on the type of generation, the real power delivered by a generator is controlled by the mechanical power output of a prime mover such as a steam turbine, gas turbine, hydro turbine, or diesel engine. As shown in Fig. 3, a synchronous generator is equipped with a primary frequency control loop. The speed governor senses the change in frequency (Δf) via the primary control loop. In fact, primary control performs a local automatic control that delivers reserve power in opposition to any deviation in nominal frequency. The speed changer in speed governing system provides an incremental change (up) in steady state power output setting for the turbine. The speed governor on each generating unit provides the primary speed control function, and all generating units contribute to the overall change in generation, irrespective of the location of the load deviations, using their speed governing. However, primary control action is not normally found adequate to restore the system frequency, particularly in an interconnected power system, and the supplementary control loop is required to handle the situation.

4. AGC MAJOR FUNCTION

Load Frequency Control: AGC matches power generation with system load while maintaining the desired frequency

Economic Dispatch: AGC calculates the economic base points for the units.

Reverse Monitoring: AGC takes into account the required reserve that is necessary to provide a measure of electrical security in the network based on MW reserves that are available.

Performance monitoring: AGC provides measurements of its performance based on nerc operating standards.

5. CONCLUSION

AGC is control scheme which ensures that frequency deviation from the nominal value is brought to zero, and the power flows between different areas in an interconnected system are regulated.

While governors act relatively fast to arrest frequency decline, AGC is slow acting. While governors can be present on almost all generators in a system, AGC is present only in selected units.

Tertiary control involves adjusting generator powers due to economic reasons. This is the slowest generator power control action.

An overview of structure of modern power systems is discussed comprehensively with due attention on the requirement of proper type of interconnections for effectively delivering the electrical power to the loads/ consumers located at very far away from generating stations. The AGC problem in an interconnected power system and its various aspects are also identified. The duties and functions of AGC schemes are also highlighted so that AGC schemes can be designed and implemented effectively.

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