Necessity of Voltage and Frequency Regulation

Constant frequency

- Constant frequency is to be maintained for the following functions:
- All the AC motors should require constant frequency supply so as to maintain speed constant.
- In continuous process industry, it affects the operation of the process itself.
- For synchronous operation of various units in the power system network, it isnecessary to maintain frequency constant.
- Frequency affects the amount of power transmitted through interconnecting lines.Frequency fluctuations are harmful to electrical appliances.
- Speed of three phase ac motors proportional to the frequency.
    - (N=120f/p)
- The blades of turbines are designed to operate at a particular speed. Frequencyvariation leads to speed variation and results in mechanical vibration

Constant voltage

- Over voltage and under voltage Electric motors will tend to run on over speed when they are fed with higher voltages resulting vibration and mechanical damage.
- Over voltage may cause insulation failure.
- For a specified power rating, lower voltage results in more current and this results inheating problems. (P=VI)
- Kinetic energy= $1/2\ J w^2$
- N=120 f/P

Real Power Vs Frequency And Reactive Power VsVoltage Control Loops

P–f control

The Load Frequency Control (LFC), also known as generation control or P–f control, deals with the control of loading of the generating units for the system at normal frequency. The load in a power system is never constant and the system frequency remains at its nominal value only when there is a match between the active power generation and the active power demand. During the period of load change, the deviation from the nominal frequency, which may be called frequency error (Δf), is an index of mismatch and can be used to send the appropriate command to change the generation by adjusting the LFC system. It is basically controlling the opening of the inlet valves of the prime movers according to the loading condition of thesystem. In the case of a multi-area system, the LFC system also maintains the specified power interchanges between the participating areas. In a smaller system, this control is done manually, but in large systems automatic control devices areused in the loop of the LFC system

Q–V Control

In this control, the terminal voltage of the generator is sensed and converted into proportionate DC signal and then compared to DC reference voltage. The error in between a DC signal and a DC reference voltage, i.e., $\Delta |V|$ is taken as an input to the Q–V controller. A control output ΔQ is applied to the exciter

Generator Controllers (p–f and Q–V Controllers)

The active power P is mainly dependent on the internal angle δ and is independent of the bus voltage magnitude $|V|$. The bus voltage is dependent on machine excitation and hence on reactive power Q and is independent of the machine angle δ. Change in the machine angle δ is caused by a momentary change in the generator speed and hence the frequency. Therefore, the load frequency and excitation voltage controls are non-interactive for small changes and can be modeled and analyzed independently. Figure gives the schematic diagram of load frequency (P–f) and excitation voltage (Q–V) regulators of a turbo- generator. The objective of the MW frequency or the P–f control mechanism is to exert control of frequency and simultaneously exchange of the realpower flows via interconnecting lines. In this control, a frequency sensor senses the change in frequency and gives the signal Δf . The P–f controller senses the change in frequency signal (Δ f) and the increments in tie-line real powers (ΔP), which will indirectly provide information about the incremental state error ($\Delta\delta$). These sensor signals (Δf and ΔP) are amplified, mixed, and transformed into a real-power control signal ΔP . The valve control mechanism takes ΔP as the input signal and provides the output signal, which will change the position of the inlet valve of the prime mover. As a result, there will be a change in the prime mover output and hence a change in real-power generation ΔP . This entire P–f control can be yielded by automatic load frequency control (ALFC) loop.

The objective of the MVAr-voltage or Q–V control mechanism is to exert control of the voltage state |Vi |. A voltage sensor senses the terminal voltage and converts it into an equivalent proportionate DC voltage. This proportionate DC voltage is compared with a reference voltage Viref by means of a comparator. The output obtained from the comparator is error signal Δ|Vi | given as input to Q–V controller, which transforms it to a reactive power signal command ΔQci and is fed to a controllable excitation source. This results in a change in the rotor field current, which in turn modifies the generator terminal voltage. This entire Q–V control can be yielded by an automatic voltage regulator (AVR) loop

<u>Schematic diagram of P–f controller and Q–V controller</u>

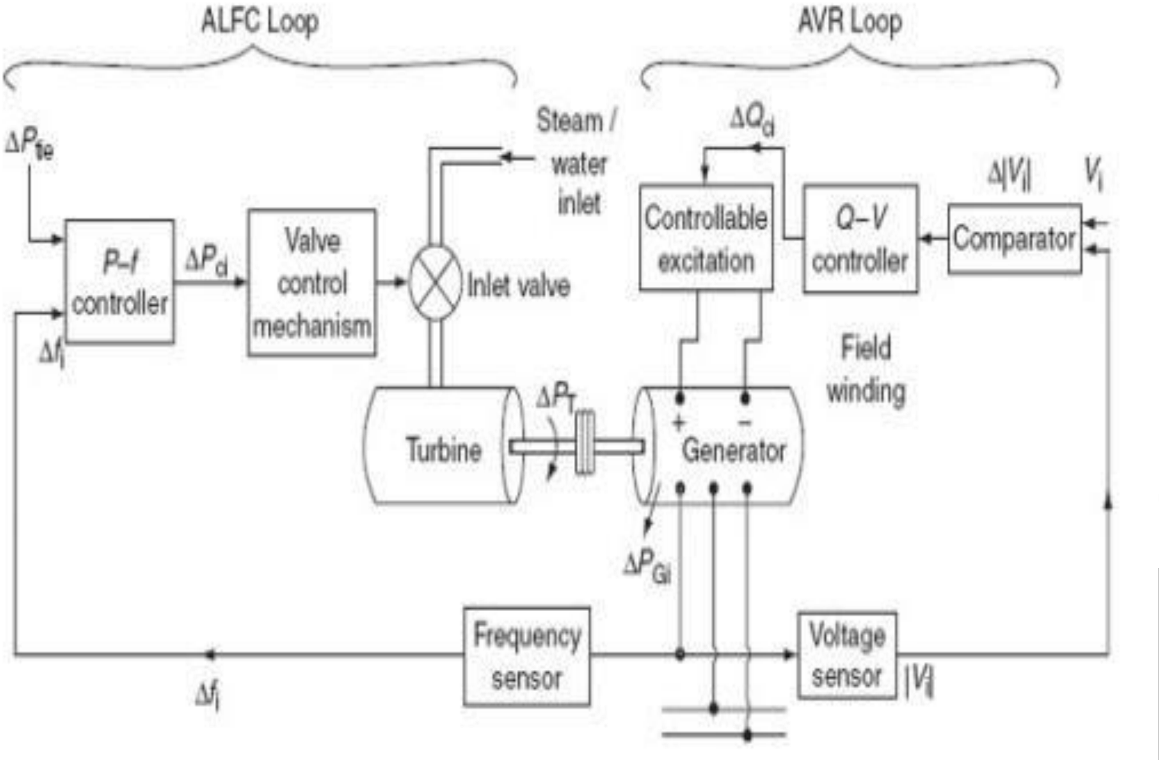

Fig. Schematic diagram of P–f controller and Q–V controller