

## Module 3 : Frequency Control in a Power System

### Lecture 14 : Frequency Control

#### Objectives

In this lecture you will learn the following

- How can frequency be controlled? What is a speed governor?
- How do parameters of a governor affect generated power?

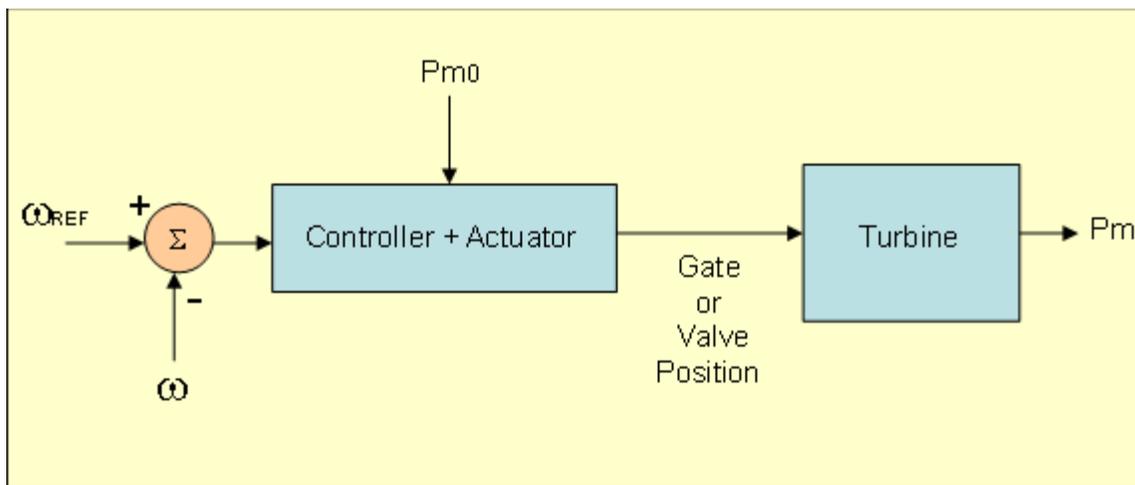
#### Speed Governor

We saw in a previous example that frequency deviation can be quite substantial -- more than 3 Hz -- for 10% change in load. In fact this deviation is considered unacceptably large (at this frequency, the generators will trip due to over-speeding).

Therefore, depending on the frequency dependence of load (which is quite weak) to bring about load generation balance is not a good operating practice.

Therefore it is important to introduce frequency dependence of generated power. This is done by a speed control mechanism known as **speed governing**.

Speed dependence can be introduced by having a feedback control system as shown in the figure below.



#### Speed Governor (Contd..)

The above schematic is **oversimplified**, especially in the case of thermal/nuclear reactors, which have a more complicated control structure involving a boiler and reactor. These additional controllers regulate other parameters like steam pressure by control of fuel, air and feed water. Therefore, strictly speaking, output power for steam turbines is not a function of control valve position alone. However, we shall use this simplified model to illustrate the concepts of speed control.

The exact nature of generator power - frequency steady state relationship can be "set" by the

controller parameters and  $P_{m0}$  - the initial setting.

Typically, **in steady state**, the generated output power (in per -unit) is related to change of speed by the following relationship:

$$P_m = P_{m0} - k_G \left( \frac{f - f_{REF}}{f_0} \right) = P_{m0} - k_G \left( \frac{\omega - \omega_{REF}}{\omega_0} \right)$$

$f_0$  is the rated frequency in Hz.

$\omega$  represents the angular (electrical) speed in rad/s.

$\left( \frac{f - f_{REF}}{f_0} \right)$  and  $\left( \frac{\omega - \omega_{REF}}{\omega_0} \right)$  are equivalent and will be used interchangeably in what follows.

Note that  $\omega_0$  and  $\omega_{REF}$  need not be equal.

### Speed Governor (Con td..)

$k_G$  is the per unit change in power for per unit change in frequency.

If the base value of power is taken to be the generator rated active power, then the reciprocal of  $k_G$  is also known as the "droop".

$P_{m0}$  is the output when  $f - f_{REF} = 0$ .

$k_G$ ,  $P_{m0}$  and  $f_{REF}$  (equivalently  $\omega_{REF}$ ) can be set by system / plant operators.

Normally  $k_G$  is "set" after proper co-ordination among various generators.

It is not usually "tinkered with" during operation. However,  $P_{m0}$  and  $f_{REF}$  are adjusted by system operators or by slow acting automatic controllers to make changes in generated power.

The following questions naturally come to one's mind:

What is the effect of the droop on generator load sharing?

We try to understand this using an [example](#).

## Recap

In this lecture you have learnt the following

- Speed governor is a mechanism to introduce frequency dependence of generated power. This is required to prevent unacceptable deviation in frequency when load changes.

- The droop setting of speed governors allows us to impose a certain sharing of excess load amongst generators.

Congratulations, you have finished Lecture 14. To view the next lecture select it from the left hand side menu of the page.