Module 2 : Equipment and Stability Constraints in System Operation

Lecture 4 : Introduction

Objectives

In this lecture you will learn the following

- What are the nature of constraints faced in power system operation ?
- What are the various types of equipment constraints ?

Power System Operating Constraints

Can you use the 50 Hz power supply at your home to drive a 100 kW load? Obviously, the answer is no!

The reason is that the power supply in your house is not *designed* to handle such power. If you tried to connect a motor of that rating, you would find that the fuse (or miniature circuit breaker) will trip and disconnect the power supply. If it did not do so, the wiring would be damaged.

In a similar fashion, a power system is designed to handle several load demand scenarios. This design is done much in advance (planning stages) based on the expected demand, while keeping some reserve "margins" for situations in which one or more equipment is out of service. A planner will not *over-design* (i.e., have unreasonably large margins) since it will cost a lot of money.

However during operation, it is not possible to requisition or install equipment at short notice. Therefore, an operator is forced to ensure that the system is operated within the existing design constraints.

Nature of constraints

There are two types of constraints which limit the capability of a power system:

a) Equipment Constraints: An equipment must be operated within the specified ratings otherwise it may result in damage. Examples of such ratings are the maximum current handling capability of a conductor, the maximum voltage across an insulator before it breaks down etc. Equipment like generators may have a relatively large number of constraints. An equipment which is designed to have a larger capability is also costlier (e.g. a higher current ability will require one to use thicker conductors). Therefore, system and equipment designers do not over-design an equipment. Under abnormal or unforeseen situations, an equipment may get overloaded. If the overloading exceeds limits, the equipment is tripped out by protection systems.

b) Stability Constraints: A power system may not be able to cater to power flows beyond a certain point due to stability constraints. An unstable system is a one which cannot withstand disturbances, i.e., it may not settle to an equilibrium *although a post-disturbance equilibrium condition may exist*. This is due to the basic physical characteristics which define the behavior under transient conditions. Improvement of stability may require system reinforcement (like adding new transmission lines) and/or improving/augmenting existing automatic controllers. Inability to come to an equilibrium may *eventually* lead to equipment constraints being violated too. This will cause operation of protection systems.

Loss of equipment due to stability or equipment constraints may take the system into an emergency or in-extremis state wherein interconnected operation may become unviable.

Therefore, it is important to characterize the capability of the system to handle load power demands and power flows in a transmission network without violation of the above constraints.

Equipment Constraints

There are two major equipment constraints:

1) Thermal: Excessive heat produced by current carrying conductors results in unacceptable sags in transmission lines and degradation of insulation in other equipment. Depending on the thermal time constants (note that the temperature does not jump instantaneously), an equipment may have larger short time thermal ratings.

2) Dielectric: Over-voltages result in large electric fields causing dielectric breakdown. Dielectric breakdown may also occur due to aging or degradation of insulation due to thermal limit violations. Typically +/- 10% variation in the rated voltage is often permissible.

For mechanical equipment, parameters like steam pressure and temperature (which may restrict for instance, the rate of ramping the mechanical power in steam plants) have to be monitored to prevent overheating. Vibration of turbine blades also needs to be monitored especially during off-nominal frequency operation.

We shall now consider equipment constraints of 2 major power system components:

(1) Generators
(2) Transmission lines

While it is understood that every equipment has certain limits, we shall restrict our discussion to these two components in this course.

Recap

- In this lecture you have learnt the following
- A power system has to operate within its capability
- There are two types of constraints : equipment and stability
- Electrical equipment constraints are mainly those related to dielectric and thermal limits.