Module 7 : Power System Structures

Lecture 35 : Concluding Notes

Objectives

In this lecture you will learn the following

- A summary of what we learnt in the entire course

- What are future challenges and trends in power system operation and control ?

We have come to the concluding part of this course. We started out in this course by reviewing the basic power system structure, operational objectives and the ways to achieve them.

We re-iterate the basic objectives here in a concise sentence

A power system should supply *quality* power, on demand, to a consumer *economically* and with minimal ecological impact.

Quality power implies that a consumer is given a supply with a practically constant voltage magnitude and frequency. The supply is also reliable, which means that barring a very large (and rare) disturbance or a sequence of disturbances, "the lights are always on".

The power system operation is controlled by a mix of automatic feedback and manual control actions. Real time operation of a power system is monitored by a "system operator" who has several "schedulable" quantities at his disposal. These quantities are scheduled to maximize economic benefit for a consumer and also to ensure security.

So is there any thing more to be "done" ? Yes. Although we have learnt all about operational and control objectives, there is scope to improve the way a system is operated. With concerns about ecological impact, it has become difficult (and expensive) to build new transmission lines and add generation. As a result, the focus is to utilize our resources even more optimally, while still satisfying all constraints. With changes in power system structure ("de-regulation") from a vertically integrated utility structure to a market based one, there is a greater need for flexibility to accomodate "power transactions" and also ensure fair access of common resources (such as the transmission network) for all players.

These challenges can be tackled with newer technologies -- we will discuss some of these soon -- and by better analytical techniques.

Some New Technologies

Often new ideas which have been proposed either recently or long before become viable economically due to advances in materials and manufacturing techniques. Amongst the recent technologies which are likely to impact power system *operation and control* are:

a) **Wide Area Measurement Systems (WAMS):** We introduced Wide Area Measurement Systems in Module 6. This communication technology can allow for fast control. Most automatic controllers in a power system use locally measured feedback systems for control, e.g., Automatic Voltage Regulators and Governors. In fact, AGC, which uses feedback signal from the tie -lines to control generation, is the **only** control which uses non-local measurements. AGC itself is a slow control (it acts over several minutes) and therefore the communication requirements are quite modest. It is expected that fast wide area measurements may allow for superior emergency control schemes which need to be executed in a very short time.

b) **Power Electronics :** Although HVDC has been around for a fairly long time, new converter topologies using voltage source converters offer a promise of increased flexibility in control. These converters use devices (like Gate Turn-off Thyristors) which can be turned off by a gate signal (unlike thyristors). This implies that there is an extra degree of freedom in their control. Voltage source converters as well as variable impedance controllers based on thyristors, like TCSC, which we learnt in Module 4, are now commercially available.

Can you do a survey of recent literature on both these technologies ?

Needless to add, there are and will be several other technologies which can revolutionalize the way power systems are operated. However, along with new technologies, there is a need to develop appropriate analytical tools to *apply* these technologies optimally.

Analysis Tools

A major challenge in future power system operation and control is the development of appropriate analytical tools to apply the new technologies and also take into account power system restructuring. The challenge is to also utilize the existing resources optimally.

Some of the problems that require good analytical tools (to aid a system operator) are as follows:

a) To determine whether or not the system is operating in a secure condition.

b) What are the optimal preventive control actions if one is insecure?

c) With the advent of WAMS, how does one use it to do emergency control ? How to design emergency control logic/schemes like islanding, generation tripping etc.?

d) How does one use the extra transient margins of existing controllers in the system including HVDC and other power electronics based controllers for improving transient behaviour?

e) What is the optimal sequencing of restorative actions to minimize restoration time ?

f) What is the fair method of allocation and pricing of common resources such as a transmission system capacity in the deregulated power system structure ?

g) What are the optimal operating strategies for individual entities in a deregulated environment ?

Although computational power has increased over the years, most of the above problems are difficult to solve due to the large size of power systems.

Power Systems Operation and Control- The future

It is unlikely that for the coming few decades, the interconnected grid structure of a power system will change significantly. It is possible that a large number of smaller generators - using gas, solar energy, wind energy - will get added on at lower voltage levels (distributed generation) depending on the availability of technologies which will make building and operating smaller generators more economical.

Power system operation and control will become more complex, although it will be aided by technologies like power electronics, computers and communications. Utilization of existing resources more optimally would imply that operating conservatively with large security margins will be a thing of the past. This also means that system operation will have to rely more on automation than on operator experience and intuition.

There are exciting times ahead !

Recap

In this lecture you have learnt the following

- A summary of what we learnt in the entire course

- What are future challenges and trends in power system operation and control ?

Congratulations, you have finished Lecture 36, Module7 and the course !

I hope you have enjoyed it!