

Module 6 : Preventive, Emergency and Restorative Control

Lecture 25 : Introduction

Objectives

In this lecture you will learn the following

- Nature of Control Actions in a Power System
- Brief recap on operating states and control actions
- The role of the load dispatch center

Nature of Control Actions in a Power System

What we have learnt so far can be broadly classified as follows:

1. Frequency, voltage and power flow control
2. Real and Reactive power scheduling

Essentially, these are "routine" control actions of a manual controller (i.e., a system/plant operator) or an automatic controller (like a generator terminal voltage regulator).

">These actions ensure a good quality supply (i.e., near-constant voltage and frequency) at a low cost.

">However, an important class of control actions are appropriate when a system is not in a "normal" state. To understand this let us revisit a previous lecture on various operating states of a power system.

Operating states and nature of control actions (revisited)

The state (or condition) of a power system can be judged from the answers to the following questions:

- Is the demanded load being met ?(i.e., is there a real and reactive power balance?)
- Are all equipment within their current and voltage limits?
- Can the system withstand stresses due a possible contingency (leading to a loss of equipment)?

Definition of states and control actions*

System operation in steady state is governed by equations which express:

- (1) Real and Reactive power balance at each node (**Equality Constraints**)

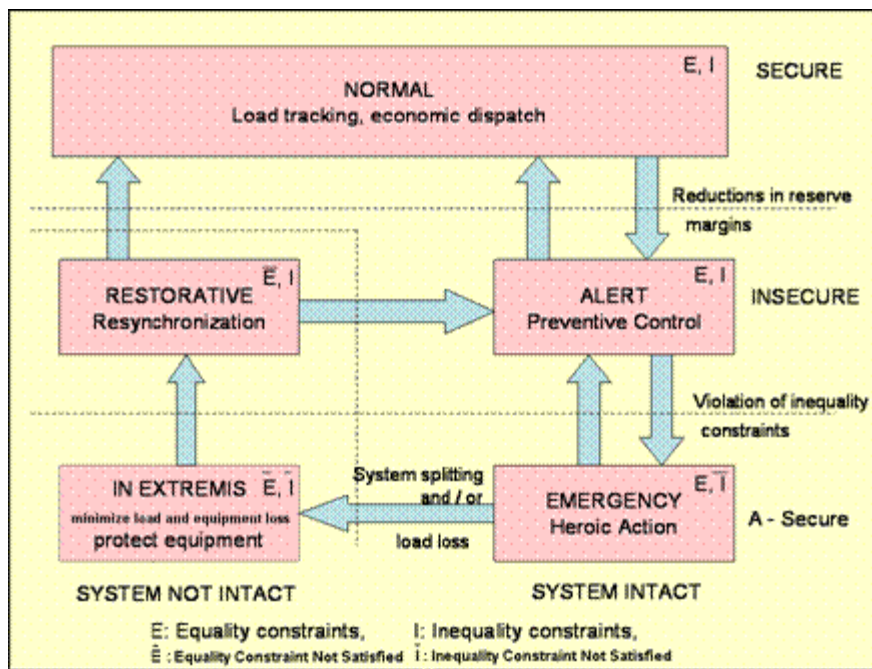
- (2) Limitations of physical equipment, such as currents and voltages must not exceed maximum limits
(**Inequality Constraints**)

Normal (Secure) State	Here all equality (E) and inequality constraints (I) are satisfied. In this state, generation is adequate to supply the existing load demand and no equipment is overloaded. Also in this state, reserve margins (for transmission as well as generation) are sufficient to provide an adequate level of security with respect to the stresses to which the system may be subjected. The latter maybe treated as the satisfaction of security constraints.
Alert (Insecure) State	The difference between this and the previous state is that in this state, the security level is below some threshold of adequacy. This implies that there is a danger of violating some of the inequality (I) constraints when subjected to disturbances (stresses). It can also be said that security constraints are not met. Preventive control enables the transition from an alert state to a secure state.
Emergency State	Due to a severe disturbance, the system can enter emergency state. Here (I) constraints are violated. The system, would still be intact., and emergency control action (heroic measures) could be initiated to restore the system to an alert state. If these measures are not taken in time or are ineffective, and if the initiating disturbance or a subsequent one is severe enough to overstress the system, the system will breakdown and reach "In Extremis" state.

* adapted from Power System Dynamics - Stability and Control, K.R. Padiyar, Interline Publishing Pvt. Ltd., 1996

Definition of states and control actions (cont.)

In Extremis State	Here, both (E) and (I) constraints are violated. the violation of equality constraints implies that parts of the system load are lost. Emergency control action should be directed at avoiding total collapse.
Restorative State	This is a transitional state in which (I) constraints are met from emergency control actions taken but the (E) constraints are yet to be satisfied. From this state, the system can transmit to either the alert or the normal state depending on the circumstances.



viability crisis, resulting from an imbalance between generations, load and transmission whether local or system-

wise, or
stability crisis, resulting from energy accumulated at sufficient level in swings of the system to disrupt its integrity

In Extremis' state corresponds to a system failure characterized by the loss of system integrity involving uncontrolled islandings (fragmentation) of the system and/or uncontrolled loss of large blocks of load.

It is obvious that the objective of the emergency control action should be to avoid transition from emergency state to a failure state (In Extremis).

Load Dispatch Centre

A load dispatch center (or more appropriately, an *Energy Management Centre*) enables a system operator and supporting engineers to monitor a power system in real time and includes facilities to capture the current operating state of the system and instruct a generating plant or any other controllable system components so that a system operates with good quality and security.

The major components of a load dispatch centre are:

- a) Engineers for carrying out scheduling and monitoring
- b) Software programs to carry out monitoring and scheduling functions
- c) Displays for adequate visualization

In a previous lecture in Module 1, we saw that there is a hierarchy of controls in a power system.

A Central Load Dispatch centre is at the top of the hierarchy and oversees the operation of the entire grid using a "Supervisory Control and Data Acquisition" (SCADA) system.

A SCADA system obtains data from various levels in the control hierarchy and displays it in a meaningful way (like a one line mimic diagram on a large LCD screen).



(pictures courtesy from WRLDC, Mumbai)

The data is used to feed an Alarm Management systems which indicates to the monitoring engineers, an abnormality in the system.

The software tools in an Load Dispatch Centre process data obtained from field measurements to identify the topology of the network in real time (using the "on" or "off" data of circuit breakers and isolators). Along with voltage and current measurements, this data is used to estimate the "state" of the system.

Since the number of components need to be monitored are very large, a sophisticated digital

processing of the data is required. If data is simply displayed, then an operator has to use his past experience to co-relate the displayed data and the system state and even take remedial actions.

However, if data is used for automatic estimation of the state and to compute the response of a system to a potential disturbance (contingency analysis), then reliability of the measured data needs to be ensured.

This process is known as "Power System State Estimation" which we shall consider in the next lecture.

Recap

In this lecture you have learnt the following

- Preventive Control, Restorative Control and Emergency Control.
- The role of the Load Dispatch Center and what it comprises of.

Congratulations, you have finished Lecture 25. To view the next lecture select it from the left hand side menu of the page