Power System Security

Major Concerns of Power System Design and Operation

- Reliability
- Power System Security
- Power System Stability

- Reliability of a power system is related to Minimizing loss of load probability i.e. LOLP (failure rate of components and the systems)
- Security means we should design and operate our power system such that our system must be secure.

Power System Security

- Security is related to the robustness of the system to maintain in the normal state even if some contingency takes place.
- Contingency are nothing but outages
  - outages of generating stations
  - outages of power plants.
- Normally two types of contingencies are in the power system.
  - branch outage
  - power outage
- Power outage means the outage of generators, outage of compensating devices, outage of some SVC static compensators. It maybe real power outage or reactive power outage
- In the branch outage, normally the outage of transmission lines, outage of transformers comes under this category.

Reliability & Security of Power System

- The security is related to this robustness of the system to maintain the normal state.
- Normal state means our operating limits of power system i.e.
  - line flow limits
  - voltages limits
  - enerators limits
  - tap limits

  if all are well within limit, we can say our power system is secure.

if right now our system is operating in this well secured manner, it means it is in normal state and there is no violation of the power system states

But if there is any contingency which is going to come into the near feature, what will be the state of our power system if we are planning in such a fashion that the effect of that contingency will not lead to a power system in abnormal condition, then we can say our power system is secured one.

However, the reliability is related to the probability of outage of equipment

Power System Stability

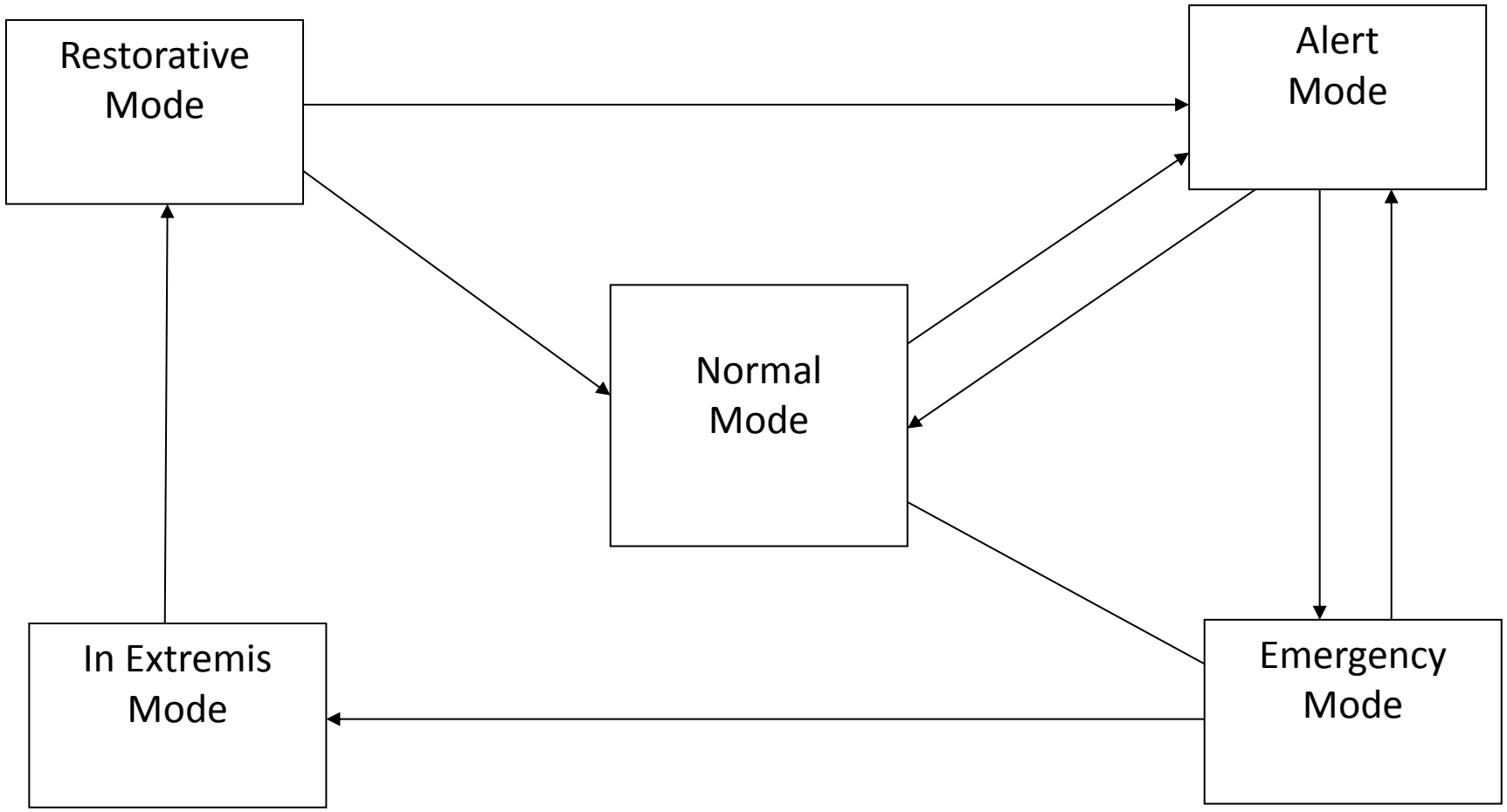
- Another concern for the power system design and operation is stability.
- The stability is one of the big concerns in AC power system.
- It is ability of a system to maintain in synchronous under the disturbance or to ensure the steady state post disturbances operations
- It means we have to operate our power system
  - secure
  - reliable
  - stable
- Several equipments, several generators are connected in the AC power system.
- They must operate in the same frequency
- We cannot have the different frequency as they are operating synchronously.

Operating Modes of Power System

Power systems are interconnected

- **To improve reliability**
- **To provide quality of power supply to the consumer**
- **To reduce the spinning reserve requirements of individual systems**
- **The operating state of a power system can be divided into following modes**
  - ✓ Normal mode
  - ✓ Alert mode
  - ✓ Emergency mode
  - ✓ Restorative mode
  - ✓ In Extremis mode

State Transition Diagram of a Power System



In the normal mode of operation, the system has to maintain

- scheduled voltages
- frequency
- load flow profile maintaining the schedule tie line power flows.

- The most important aspect in any mode of operation is the matching between load demand and generation.
- The frequency deviation of the system is a direct measure of the mismatch between the total generation and combined load demand.
- It is only when the frequency is maintained at the rated value that the generation balances the load demand.

Modes of Operation

- **Normal Mode** – When the system is in normal state the
  - ✓generation matches the load
  - ✓none of the equipments is overloaded.
  - ✓The system is secure in normal state
  - ✓Some amount of spinning reserve also exists.
- **Alert Mode** – In this mode of operation,
  - ✓the power system is synchronized
  - ✓security level is reduced below the specified limits.
  - ✓The generation and load are matching with
  - ✓none of the equipments getting overloaded.
  - ✓no spinning reserve is available.
  - ✓In this mode, preventive control is provided to restore adequate generating margin, generation shifting, tie line rescheduling, and voltage reduction (if extremely necessary).

Modes of Operation

- **Emergency Mode** – In this mode of operation,
- the power system is synchronized
- the generation matches the load
- some equipment may be overloaded.
- In this mode, immediate control is provided to clear equipment overloads, fault clearing, fast valving dynamic braking, exciter control, load control, capacitor switching and all controls mentioned in Alert state.

- **Restorative Mode** – In this mode of operation,

✓ the power system may or may not be synchronized.

✓ The power engineers are taking necessary corrective actions so that the system is restored back to normal state.

✓ In this mode corrective measures like re-establishing viable system,

✓ generating units restarting and synchronization, load restoration,

✓ re-synchronization of different areas is done.

- In the restorative mode, control action is initiated but the load constraints are not completely satisfied. Under this condition, the system may be in a completely or partially shut down state.

- **In Extremis Mode** – In this mode of operation,
- the power system loses synchronism resulting in tripping of some generators, and overloading of equipments also occurs.
- Some parts of the country (or province) may also face black out if the system is in this mode of operation. Load shedding and all the controls mentioned in emergency state are to be taken.