Power System Stability

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Power System Stability Overview

- Power system is defined as a network of one or more generating units, loads and power transmission lines including the associated equipments connected to it.
- The stability of a power system is its ability to develop restoring forces equal to or greater than the disturbing forces to maintain the state of equilibrium.
- Power system stability problem gets more pronounced in case of interconnection of large power networks.

Power System Stability

A Proposed Definition

Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact.

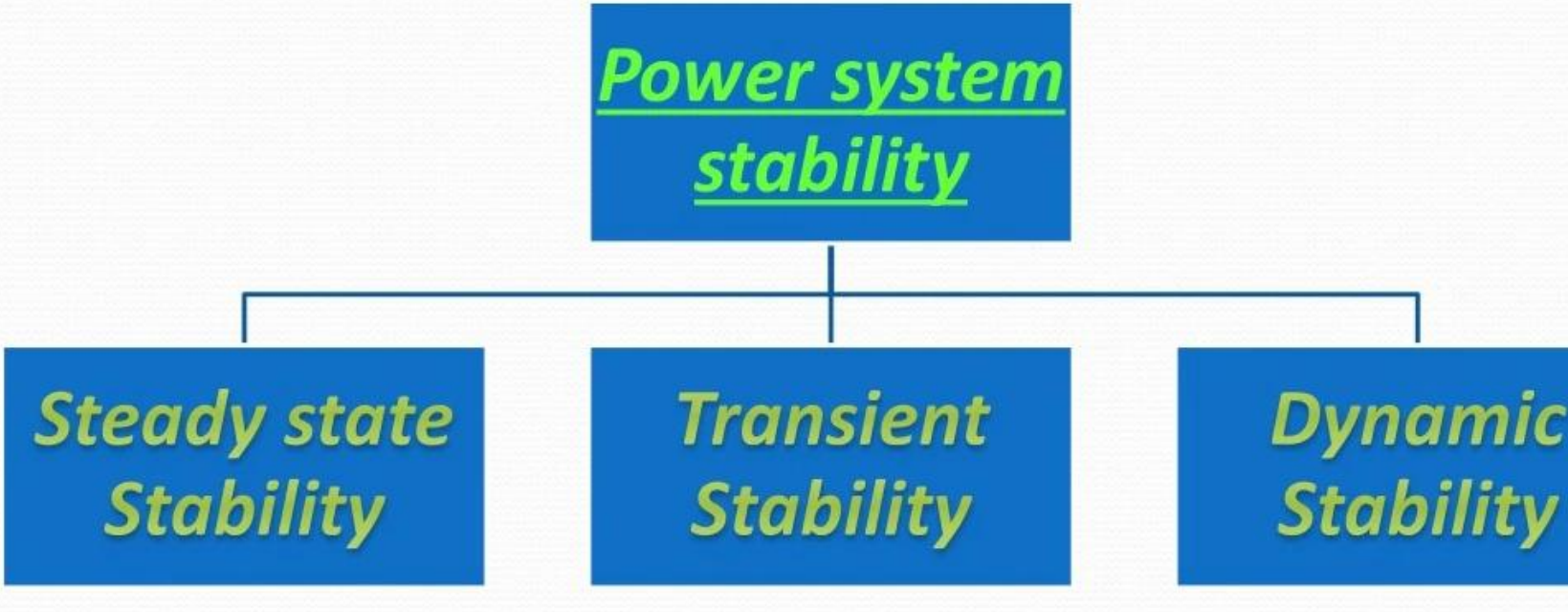
Need of Stability Classification

- Stability analysis is easier. Also it leads to proper and effective understanding of different power system instabilities.
- Key factors that leads to instability can be easily identified.
- Methods can be devised for improving power system stability.

Classification of stability

Classification is based on the following considerations:

- physical nature of the resulting instability
- size of the disturbance considered
- processes, and the time span involved



Steady state Stability

- Ability to regain normal and stable operation after being subjected to gradual or slow change in the load.
- Concerned with upper loading of machine before losing synchronism.
- Load is assume to be applied at a rate which is slow.
- System is Analysis by the set of linear equation.
- Action of Voltage regulators and turbine governers are not included.

Transient Stability

- Ability to regain normal and stable operation after being subjected to sudden & large changes in the load.
- Losses-generator excitation, transmission, switching operations and faults.
- Linearization of system equation is not permitted.
- Studied on the basis of swing.
- Action of Voltage regulators and turbine governer are not included.

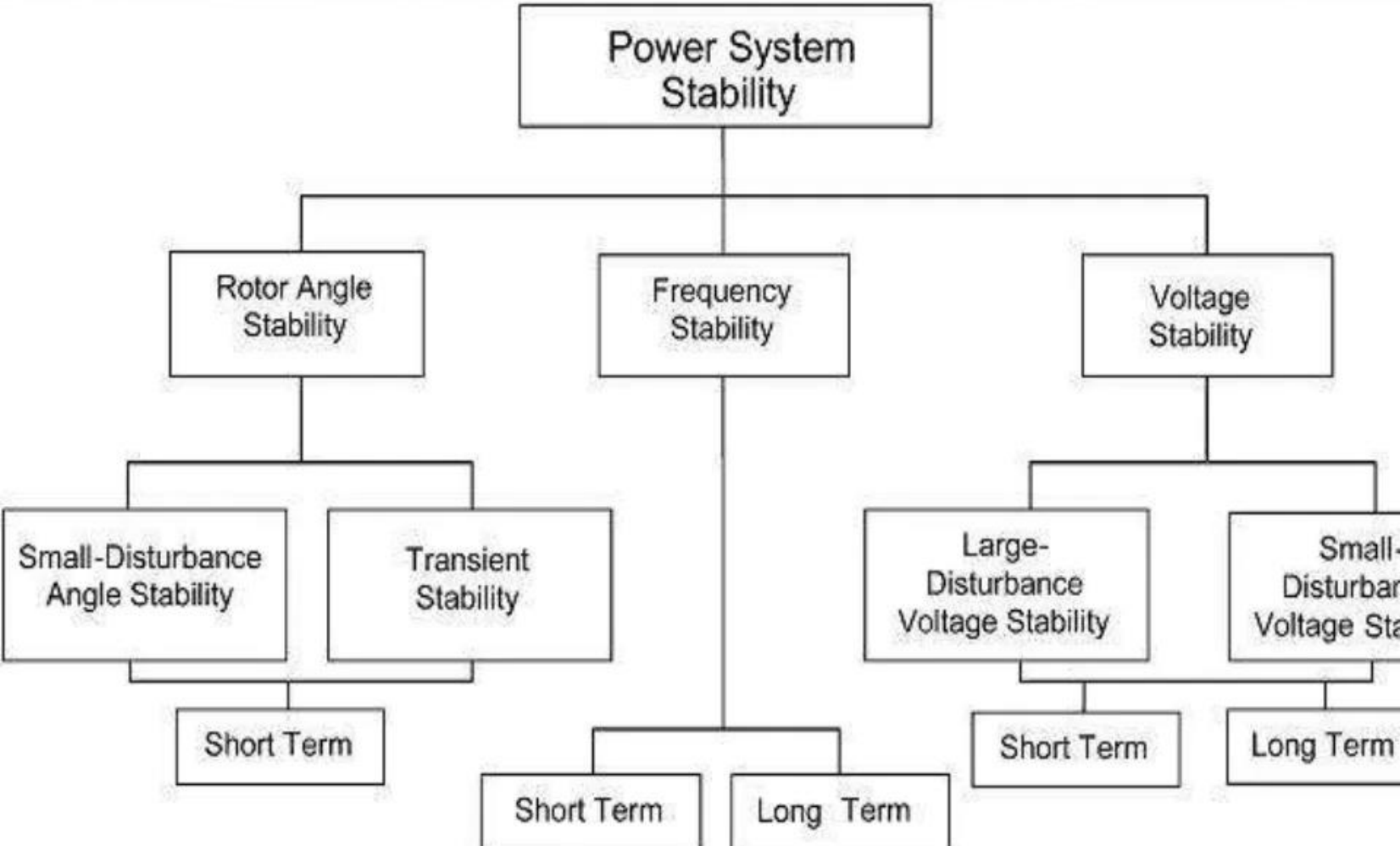
Dynamic Stability

- Same as steady state stability
- Included action of turbine governers and voltage regulators.
- Study time is 4-10 sec

Power System Stability Classificatio

- **Rotor angle stability.**
  - Small disturbance angle stability.
  - Transient stability.
- **Voltage stability.**
  - Small disturbance voltage stability.
  - Large disturbance voltage stability.
- **Frequency stability.**
  - Short term frequency stability.
  - Long term frequency stability.

Stability Classification at a Glanc



Rotor Angle Stability

- Rotor angle stability refers to the ability of synchronous machines of an interconnected power system to remain in synchronism after being subjected to a disturbance.

- Rotor angle instability occurs due to angular swings of some generators leading to their loss of synchronism with other generators.

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- Depends on the ability to maintain/restore equilibrium between electromagnetic torque and mechanical torque of each synchronous machine.

- At equilibrium, Input mechanical torque equals output electromagnetic torque of each generator. In case of any disturbance the above equality doesn't hold leading to acceleration/ deceleration of rotors of machines.

Rotor Angle Stability Classificatio

- Small Disturbance Rotor Angle Stability:

  - It is the ability of the power system to maintain synchronism under **small disturbances**.
  - Disturbances are considered to be sufficiently small such that the linearization of system equations is permissible for purposes of analysis.
  - The time frame of interest in small-disturbance stabi studies is of the order of 10 to 20 seconds following a disturbance.

- Large Disturbance Rotor Angle Stability:

  - It is the ability of the power system to maintain synchronism under a **severe disturbance**, such as a short circuit on a transmission line.
  - Disturbances are large so that the linearization of system equations is **not permissible** for purposes of analysis.
  - The time frame of interest in small-disturbance stability studies is of the order of 3 to 5 seconds following a disturbance.

Voltage Stability

- Voltage stability refers to the ability of a power system to maintain steady voltages at all buses in the system after being subjected to a disturbance from a given initial operating condition.

- A system is voltage instable if for atleast one bus in the system, the voltage magnitude decreases as reactive power injection is increased.

- Voltage instability results in progressive fall or rise of

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- Large scale effect of voltage instability leads to **Voltage collapse.** It is a process by which the sequence of event accompanying voltage instability leads to a blackout or abnormally low voltages in a significant part of the power system.

- The driving force for voltage instability is usually the loads.

- Voltage stability problems is also experienced at terminals of HVDC links connected to weak ac systems.

Voltage Stability Classification

- Small Disturbance Voltage Stability:
  - Small-disturbance voltage stability refers to the system's ability to maintain steady voltages when subjected to small disturbances such as incremental changes in system load.
  - A combination of both linear and non-linear techniques are used for analysis.

- Large Disturbance Voltage Stability:
  - Large-disturbance voltage stability refers to the system's ability to maintain steady voltages following large disturbances such as system faults, loss of generation, or circuit contingencies.
  - The study period of interest may extend from a few seconds to tens of minutes.

Frequency Stability

- Frequency stability refers to the ability of a power system to maintain steady frequency following a severe system upset resulting in a significant imbalance between generation and load.
- Frequency instability leads to tripping of generating units and/or loads.
- Frequency stability may be a short-term phenomenon or a long-term phenomenon.

Rotor Angle Stability vs. Voltage Stability

- Rotor angle stability is basically a generator stability while voltage stability means load stability.

- Rotor angle stability is mainly interlinked to real power transfer whereas voltage stability is mainly related to reactive power transfer.

Conclusion

- Power system is always required normal and stable operation at rated operating condition & it's also required improvement of stability .
- Stability of power system is improved by using shunt & series capacitors, governing system and Facts controllers.
- Reduce transmission losses.
- Power is generated by renewable energy sources and ceate a power park.

Thank You ☺

Questions Please