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Operating States of Power System and State Transition Diagram

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Abstract: The classification of power system operating states plays an important role in power system control and operation. Determining the state of power system is crucial and requirements for the real time decision making in power system security assessment demand low dimensionally and low computational time. In this paper I have tried to explain all the operating states of power system along with the state transition diagram which comprises of five different states. The main purpose of both of these that is operating states and the state transition diagram is for the power system security. The power system needs to be secured. We need to protect it from the black out or any internal or external damage. The operation of power system is a set to be normal only when the flow of power and bus voltages are within the limits even though there is a change in the load or at the generation side. From this we can say that the security of the power system is an important aspect with respect to the continuation of its operation.

Keywords: Preventive state, Restorative state, Emergency state, Normal State, Alert State and Extreme State.

I. INTRODUCTION

The power system is a network which consists generation, distribution and transmission system. It uses the form of energy (like coal and diesel) and converts it into electrical energy. The power system includes the devices connected to the system like the synchronous generator, motor, transformer, circuit breaker, conductor, etc.[1] The power plant, transformer, transmission line, substations, distribution line, and distribution transformer are the six main components of the power system. The power plant generates the power which is step-up or step-down through the transformer for transmission. The transmission line transfers the power to the various substations. Through substation, the power is transferred to the distribution transformer which step-down the power to the appropriate value which is suitable for the consumers.[5]

II. OPERATING STATES OF POWER SYSTEM

Mainly there are three states of power system. All the system are bidirectional it means that if any state has the problem, it automatically goes to another state and once it is recovered it goes back to normal state.

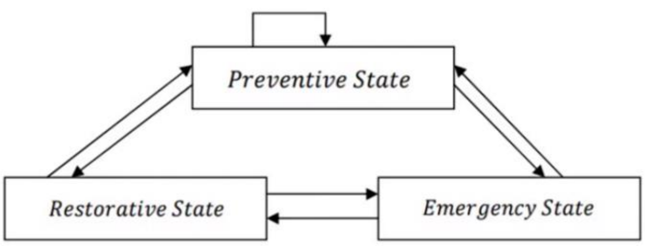

Fig 1– Flow chart of different operating states [2]

There are three major operating states of power system
1. Preventive state or normal state
2. Emergency State
3. Restorative state

(A) Preventive State or Normal State

In the normal operating state, the system is said to be secure and all constrains like voltages at nodes, real and active power generation, real and active power flows are satisfied.

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The aim of power system is to keep the operating state of power system to lie in normal state. Even though this is a stable operating state, any slight disturbance will take it to the abnormal state. The system should also continue to operate 'normally' even in the case of credible contingencies. The operator should 'foresee' such contingencies (disturbance) and take primitive control actions (as economically as possible) such that the system integrity and quality of power supply is maintained.[3]

(B) Emergency State

The power balanced between generation and load is still satisfied. However, either overvoltage or voltage violations happens in emergency state. If suitable control action is taken, the state can still be restored to normal state or at least alert state. In the event of disturbance, like generator outage or line outage, the operating conditions changes and the variables like node voltages and powers (real and reactive); real and reactive power flows violate the operating limits or constrains.

The abnormal state or insecure state is further classified into the following states:

a. Alert
b. Emergency
c. In-extremis (or islanding).

The control objective in the emergency state is to relieve system stress by appropriate actions. Economic considerations become secondary at this stage.[3]

(C) Restorative State

The power system disturbance, based on its nature, can lead the power system to a blackout or brownout state. In the blackout state, the entire load is separated from the generators, through either the tripping of generators or the transmission lines. No load is supplied. In the brownout state, partial load is supplied through the transmission network. The blackout state is more severe than brownout state and required several stages for restoring in back to normal operating state. The control objective in this state is to steer the system to a normal state again by taking appropriate actions.[4]

III. STATE TRANSITION DIAGRAM

There are five main blocks in state transition diagram

a) Normal State
b) Alert State
c) Emergency State
d) Extreme State
e) Restorative State

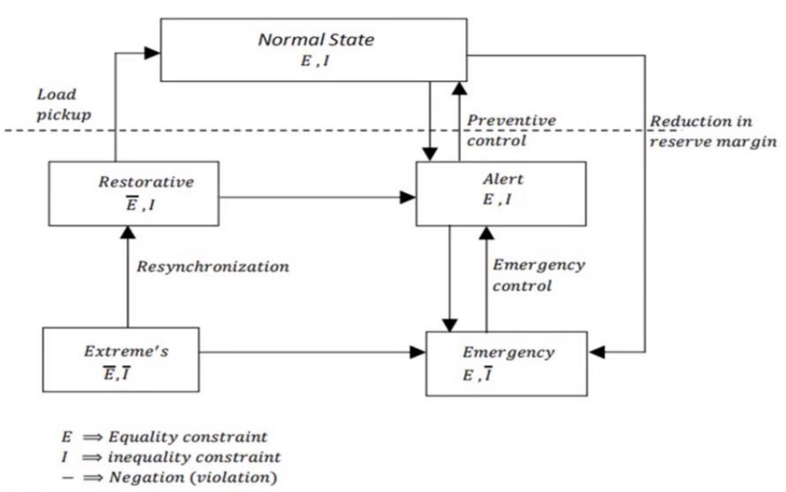

Fig 2- State Transition Diagram [2]

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There is a reserve margin which is shown by dotted line.

E stands for equality constraint and I stand for inequality constraint. Equality constraint are related to active power flow and reactive power flow. Inequality constraint are monitoring the limits on the various factors such as voltage, frequency and current. Bar is the navigation that violates the limits.

For normal operation conditions the E and I constraint are within the limits. If it goes beyond the dotted line then the system goes to alert state. If the preventive action is not taken then the system goes into emergency state, in which inequality constraint limits are violated, if proper emergency control is taken then the system goes back to alert state and then the normal state. In case of extreme condition, the equality and inequality constraint both are violated.

Operation of state transition Diagram

Power system operation can be described by three sets of generic equation: one differential, and two algebraic.

Of the two sets of algebraic equations, one comprises the equality constraints (E), which is the balance between generation and load demand.

The other set consists of inequality constraints (I) which ensure that the various components in the system and the states (e.g., voltage and current) remain within safe and acceptable limits.

If the generation falls below the certain threshold, load increases beyond some limit, or a potentially dangerous disturbance becomes imminent, the system is said to enter the alert state.

Though the equality and inequality constraints are still maintained, preventive control should be brought into action to steer the system out of the alert state.[7]

If preventive control fails, or the disturbance is reversed, the system may enter into emergency state, though the demand is still met by the generation, one or more components or state violate the prescribed operation limits. Emergency control actions should immediately be brought into action to bring the system back to the normal state.

If the emergency control actions also fail, the system may enter extremis state which is characterized by disintegration of the entire system into smaller islands, or a complete system blackout.

It may take anywhere between few seconds to few minutes for a system to enter an extremis state from a normal state.

The restoration process is however is very slow. It may take several hours or even days to bring the system back to normal.[8]

IV. CONCLUSION

Since, the power system security is very important for the power system so the operating states of power system and state transition diagram plays a very important role in the security. The three types of operating states of power system are discussed above and also the detailed study of state transition diagram is also discussed in which we see that there are finite number of possible states and those interaction with the outside world.

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