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Comparative Study of Different Methods of Transient Stability Assessment

Sonali Raj[1], Preeti Jain[2]

[1]Scholar, Electrical Department, Jabalpur Engineering College, Jabalpur, 482011, India
[2]Asst. Professor, Electrical Department, Jabalpur Engineering College, Jabalpur, 482011, India

Abstract: **This review paper present the comparative study between the various methods of transient stability assessment and also investigate the various technique used to study transient response of power system.**

Keywords: **Transient Stability Assessment, secure system operation.**

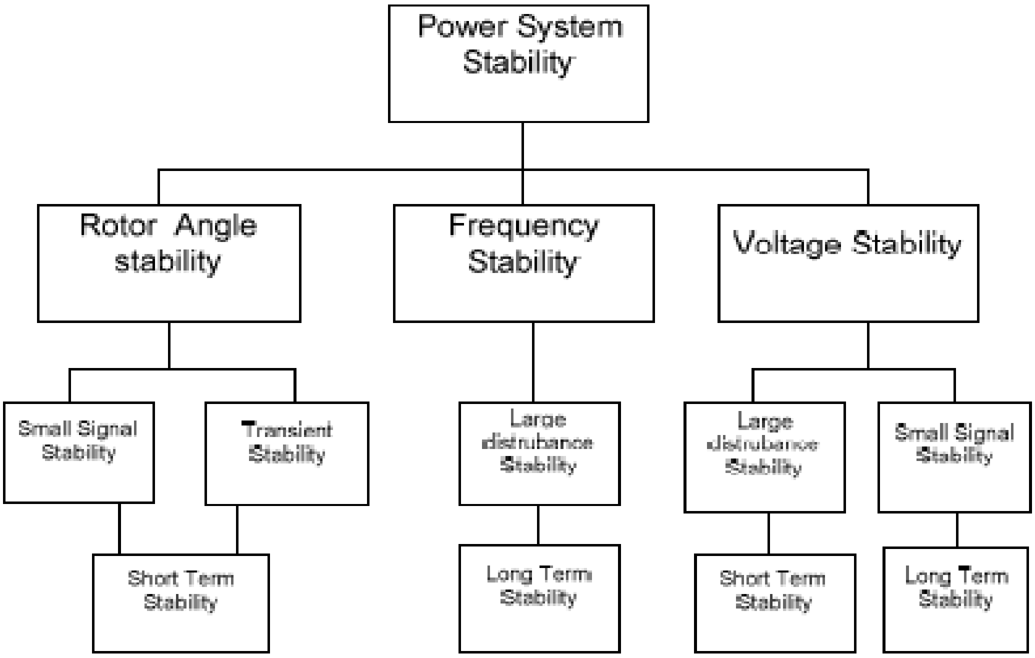
1. INTRODUCTION

Electric power system stability analysis has been recognized as an important and challenging problem for secure system operation. When large disturbances occur in interconnected power system, the security of these power systems has to be examined. Power system security depends on detailed stability studies of system to check and ensure security. In order to determine the stability status of the power system for each contingency of any disturbance occurs in power system, many stability studies are defined [1]. Power system stability analysis may involve the calculation of Critical Clearing time (CCT) for a given fault which is defined as the maximum allowable value of the clearing time for which the system remains to be stable. The power system shall remain stable if the fault is cleared within this time. However, if the fault is cleared after the CCT, the power system is most likely to become unstable. Thus, CCT estimation is an important task in the transient stability analysis for a given contingency. In this paper for the Transient Stability Analysis, 5 Bus system is considered. Critical clearing time (CCT) in a way measures the power systems Transient stability. It denotes the secure and safe time margin for clearing the contingency, usually three-phase ground-fault. The larger the value of CCT, the power system has ample time to clear the contingency. CCT depends on generator inertias, line impedances, grid topology, and power systems operating conditions, fault type and location. For a single machine infinite bus power system, CCT calculation is straightforward. While for the case of multi machine power systems, CCT is always obtained by repeating time-domain simulations, and hence the evaluation of CCT can only be done off-line. The Load Flow study and Transient Stability study is discussed and performed for 5 Bus test system simulated on Mi- power

2. POWER SYSTEMSTABILITY

Power system stability defined as that property of a power system that enables it to remain in a state of operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance. Stability phenomenon is a single problem associated with various forms of instabilities affected on power system due to the high dimensionality and complexity of power system constructions and behaviours. For properly understood of stability, the classification is essential for significant power system stability analysis. Stability classified based on the nature of resulting system instability (voltage instability, frequency instability…), the size of the disturbance (small disturbance, large disturbance) and timeframe of stability (short term, long term). In the other hand, stability broadly classified as steady state stability and dynamic stability. Steady state stability is the ability of the system to transit from one operating point to another under the condition of small load changes. Whereas Dynamic stability is the stability which deals with continuous small disturbances occurring in the system broadly it is small signal stability. A System is said to be dynamically stable, if the oscillations do not acquire certain amplitude and die out quickly. Dynamic stability is concerned with small disturbances lasting for a long time. Low frequency oscillations are observed when large power systems are interconnected by relatively weak tie lines. These oscillations may sustain and grow to cause system separation if no adequate damping is available.

According to IEEE/CIGRE Power system stability is broadly classified as



3. LITERATURE SURVEY

The following literature review describes the important result regarding the transient of power systems;

Research paper[1] In order to determine the stability of the power system as a response to a certain disturbance, the extended equal area criterion (EEAC) method described in [10] decomposes the multi-machine system into a set of critical machine(s) and a set of the 'remaining' generators. In order to form an OMIB system, the machines in the two groups are aggregated and then transformed into two equivalent machines.\Some basic assumptions for EEAC are : (i) The disturbed system separation depends upon the angular deviation b/w the following two equivalent clusters: the critical machine group(cmg) and the remaining machine group (rmg), (ii) The partial centre of angles (PCOA) of the critical machine group.

In research paper[2] Transient stability entails the evaluation of a power system's ability to withstand large disturbances, and to survive transition to a normal operating condition. These disturbances can be faults such as: a short circuit on a transmission line ,loss of a generator, loss of a load, gain of load or loss of a portion of transmission network [2].Large number of simulations is carried out regularly during planning stages.

In research paper[3]A salient feature of the report is a systematic classification of power system stability, and the identification of different categories of stability behavior. Linkages between power system reliability, security, and stability are also established and discussed. The report also includes a rigorous treatment of definitions and concepts of stability from mathematics and control theory.

In research paper[4] To establish theoretical connect the effects of various parameters on the transient stability studies of a power system is presented and discussed. The parameters investigated were the Fault Clearing Time, fault location, different load levels, generator damping coefficient and generator armature resistances. A numerical integration method is used to compute CCTs, and IEEE 30-bus test system is required. According to the simulation results, some preliminary conclusions and comments can be summarized as follows: Under three-phase short-circuit fault, the rapid clearing of the fault promotes power system stability; The fault that is nearer to the generating station must be cleared rapidly than the fault on the line distant from the generation station ;More then allowed level of load increasing a power generation

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increased, voltage at all buses dropped and Critical Clearing Time decreased. The damping coefficient prevents the growth of oscillations and improves the power system Critical Clearing Time; Generator armature resistances have an effect on results of the transient stability analysis, for this reason the transient stability analysis of power system can be accurately represented by including the armature resistances of the synchronous machines.

4. TRANSIENT STABILITY ASSESTMENT

Transient stability is the ability of the power system to maintain synchronism when subjected to a severe transient disturbance such as the occurrence of a fault, the sudden outage of a line or the sudden application or removal of loads [2][4].The resulting system response involves large excursions of generator rotor angles and is influenced by the nonlinear power-angle relationship. Following such sudden disturbances in the power system, rotor angular differences, rotor speeds, and power transfer undergo fast changes whose magnitudes are dependent upon the severity of disturbances. For a large disturbance, changes in angular differences may be so large as to cause the machine to fall out of step. This type of instability is known as Transient Instability. Transient stability is a fast phenomenon, usually occurring within one second for a generator close to the cause of disturbance. The objective of the transient stability study is to ascertain whether the load angle returns to a steady value following the clearance of the disturbance.

Factors influencing transient stability:

i) Generator inertia

ii) Generator loading

iii) Generator output (power transfer) during fault-depends on fault location and fault type

iv) Fault clearing time

v) Post-fault transmission system reactance

vi) Generator reactance

vii) Generator internal voltage magnitude-this depends on field excitation, i.e. the power factor of the power sent at the generator terminals

viii) Infinite bus voltage magnitude.

5. SWING EQUATION

The equation governing the motion of the rotor of synchronous machine is based on elementary principal in dynamics which states that the accelerating torque is the producer of the moment of inertia and angular acceleration

$$M\frac{d^2\delta m}{dt^2} = P_m - P_e = P_a$$

Where P_a is the accelerating power

TRANSIENT STABILITY EVALUATION:

Transient stability analysis is used to investigate the stability of power system under sudden and large disturbances, and plays an important role in maintaining security of power system operation. The transient stability analysis is performed by combining a solution of the algebraic equations describing the network with numerical solution of the differential equations. However, due to the non-linearity of the differential equations, the solving process is tedious and complicated.

Thus, numerical integration methods have been applied to examine a system's stability .In order to reduce the complexity of the transient stability analysis for the considered test systems, the following assumption are accepted [10]: *(i)* Each synchronous machine is represented by a constant voltage source behind the direct axis transient reactance. *(ii)* The governor's action are neglected and the input powers are assumed to remain constant during the entire period of simulation. *(iii)* Using pre-fault bus voltage, al l loads are converted to equivalent admittances to ground and a reassumed to remain constant. *(iv)* The mechanical rotor angle of each machine coincides with the angel of the voltage behind the machine reactance. *(v)* Machines belonging to the same station swing together and are said to be coherent. A group of coherent machines is represented by one machine.

A. Solution steps:

The algorithm for the transient stability studies involves the following steps:

• Reads the line and bus data. It includes the data for lines, transformers and shunt capacitors.

• Form admittance matrix, Ybus.

• Solve the initial load flow.

• Reads generator data.

• Modify Ybus by adding the generator and load admittances.

• Compute the pre-fault admittance matrix Ypre-fault by eliminating all nodes except the internal generator nodes.

• Solve the generator swing equation for the pre-fault period.

• Set t = 1s a three-phase fault occurs at any line in the system, and fault bus voltage equal to zero.

• Compute the new faulted admittance matrix Yfault.

• Solve the swing equation for the fault period.

• Isolate the line witch fault occurred.

• Compute the post-fault system admittance matrix Ypostfault.

• Solve the swing equation for the post fault period.

• Plots the swing curves for all generators.

In this paper, we define the CCT as the small lest from all CCTs values for different generators.

A. Effect of Fault Clearing Time (FCT):

In order to know the effect of Fault Clearing Time (FCT)on transient stability a disturbance in the form of a three phase to ground fault is occurs at t = 1 second at bus 1, cleared by opening the line connecting the nodes 1–2. The rotor angle differences are shown in Figure 2. If the fault is cleared rapidly the angular deviation is less and subsequently the system may become stable. This angular deviation increases if the fault clearing time increases and ultimately if the fault is cleared after Critical Clearing Time (CCT) the system will lose synchronism. In this case the CCT is equal to 166 ms

B. Effect of fault location:

In this sub-section the effects of fault location in transient stability are analyzed. A three-phase fault is located at two

different locations, one closer to the generating stations (at bus1 with opening the line 1–2), in this case the CCT is equal to166 ms (Fig. 1), the other one far from the generating stations(at bus 6 with opening the line 4–6).

Fig. 3 shows the angular positions of the machines in the system for a fault on line 4–6. It is found that the CCT is equal to 620 ms

C. Effect of load increasing:

The man objective of this sub-section is to know the impact of load increasing on the power system Critical Clearing Time. For this reason, active load at all buses in the IEEE 30-bussystem are increased from base case by 10%, 20%, 30%, and40%. Real example of this case is electrical peak load of energy consumption. It is observed that more than allowed level of load increasing, power generation increased and voltage at all buses dropped.

D. Effect of damping coefficient:

The machine damping coefficient D represents the natural damping of the system. In this sub-section, the effect of this coefficient on the transient stability evaluation has beeninvestigated.Fig.6 and Fig.7 show the rotor angle differences with and without of damping coefficient for a short circuit at 1, the FCT in this case is set at 100 ms .From figures it can be seen that under the fault occurred with consideration of damping coefficient, the oscillation amplitudes and shapes are different. The damping coefficient prevents the growth of oscillations; when the FCT = 110 ms

E. Effect of Generator Armature Resistances (GAR):

The influence of generator armature resistances on transient stability limits is presented in this sub-section. Two scenarios were analyzed. In the first one the GAR is included. The FCT is set at 168 ms, the system without armature resistances is go out of step (FCT > CCT). However ,the system with armature resistances is stable .Figure 8. Rotor angle difference with fault at Bus 1 (FCT = 168 ms) Another's simulations have been performed for different fault locations IEEE 30-bus system, in order to compare accurately CCTs with and without generator armature resistances. The results from the cases study are presented in Table 6 and Figure 9.The comparative results have shown that the impact of generator armature resistances in transient stability analysis .From the obtained results it is investigated that the generator armature resistance has an effect on the transient stability analysis. In some cases the ΔCCT is expected values 5 and 6ms for example the fault at bus 2 with openings of the circuit breakers at both ends of line (2–5), faults at bus 4(2–4), 4(3–4), 4(4–6) and 6(4–6). It is very clear that the effect of generator armature resistances in power system Critical Clearing Time. For this reason the transient stability analysis of power system can be accurately represented by including the armature resistances of the synchronous machines.

6. CONCLUSION

In this study, the effects of various parameters on the transient stability studies of a power system is presented and discussed. The parameters investigated were the Fault Clearing Time, fault location, different load levels, generator damping coefficient and generator armature resistances. A numerical integration method is used to compute CCTs, and IEEE 30-bus test system is required .According to the simulation results, some preliminary conclusions and comments can be summarized as follows: Under three-phase short-circuit fault, the rapid clearing of the fault promotes power system stability; The fault that is nearer to the generating station must be cleared rapidly than the fault on the line distant from the generation station; More then allowed level of load increasing a power generation increased, voltage at all buses dropped and Critical Clearing Time decreased. The damping coefficient prevents the growth of oscillations and improves the power system Critical Clearing Time; Generator armature resistances have an effect on results of the transient stability analysis, for this reason the transient stability analysis of power system can be accurately represented by including the armature resistances of the synchronous machines.

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