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Stability analysis and fault critical clearing time evalution of 3-machines 9-bus power system network

Pratidhwaj Bhargava and Vivek Rai
LNCT, Bhopal

Abstract

Power Systems Stability Study is an important parameter for financial, reliable and safe power system planning and operations. Power system studies are important from time to time during project planning and conceptual design phases as well as during the operational life of plants. This paper presents the power system stability analysis for IEEE-9 bus system. The Fault is created on different buses (Bus 5) and transient stability is analysed for different load and generation conditions. The critical clearing time (CCT) is calculated by the time of the domain classical extended equal field criteria. The system Frequency and voltage variance is observed for different fault location and CCT. The IEEE-9 bus test system is simulated and stability is analysed. Electrical power system is a network of electrical components in which power supply, transfer and use of power is included. The power system is also explained as a grid, which can be widely divided into generating systems which supply the power power, transmission system, which passes from the generated centers to the power stations and the distribution system, which is nearby Provides electricity to homes and industries. Power system is designed to provide continuous power supply, which maintains voltage stability. However, due to unwanted incidents such as lightning, accidents or any other unexpected event, short circuit between transmission lines or between one phase wire and ground is called fault. Due to fault, due to imbalance between generation and demand one or more generators can be seriously distressed. If the fault persists and is not cleared in a pre-specified time frame, it may cause severe damages to the devices which leads to a power loss and power sources. Therefore, protective equipment's are installed to detect faults and clear and isolate faulted parts of the power system as quickly possible before the fault energy is propagated to the rest of the system. Transient stability analysis place and important role of planning, designing and upgrading an exciting electrical power system network. In this thesis, transient stability analysis is carried out by considering are three phase faults at the bus bar 5 with the effect of fault clearing time. The simulation is carried out Ring Main method. It is found that at fault clearing times of 0.0705 sec the generators (G2, G3) under test are stable with respect to simulation time. In addition, it has been demonstrated that the transient stability of a system can v improved using controlled devices.

Keywords

Power systems, Synchronous generators, Power system stability, Synchronous operation, Rotor angle instability, Mid-term stability, Small-disturbance voltage stability.

1.Introduction

Power systems usually have three steps: (1) generation (2) transmission (3) distribution. In the first stage, generation, electric power is mostly produced using the synchronous generator. Then reducing the line currents to reduce the power transmission losses, the voltage level is raised by the transformer to reduce power transmission losses. After the transmission, the voltage is stepped down using the transformer to deliver accordingly. Power system is designed to provide continuous power supply, which maintains voltage stability. However, due to unwanted incidents such as lightning, accidents or any other unexpected event, short circuit between transmission lines or between one phase wire and ground is called fault. Due to fault, due to imbalance between generation and demand one or more generators can be seriously distressed. If the fault persists and is not cleared in a pre-specified time frame, it may causes severe damages to the equipment's which in turn may lead to a power loss and power outage. Therefore, protective equipment's are installed to detect faults and clear/isolate faulted parts of the power system as quickly as possible before the fault energy is propagated to the rest of the system. In this paper multi machine nine bus systems is modelled in MATLAB/Simulink and transient and voltage stability analysis is done with the fault located in a bus[1-5].

1.1Power system stability problem

The Power system stability is the very important aspect to the supply continuous power. It is defined as that property of a power system that enables it to remain in the state of operating equilibrium under the normal operating conditions and to regain the acceptable state of equilibrium after being subjected to a disturbance. Instability of power system can occur in many different situations depending on the system configuration and operating mode. One of the stability problems is maintaining synchronous operation or synchronism especially that power system relay on synchronous machines. Other instability problem that may be encountered is voltage collapse that is mostly related to load behaviour and not synchronous speed of generators.

1.2Forms of power instability

There are mainly three different forms of power system instability: rotor angle instability, voltage instability, voltage collapse, and mid-term and long-term instability. The power system has the capability of embedded synchronous machines to stay in the rotor angle stability synchronization. Voltage stability is the power system's ability to maintain the acceptable voltage on all the buses in the system and subject to disturbances under normal operating conditions. For the voltage to be stable, synchronous machines should run in sync.

Long-term and mid-term sustainability is relatively new for literature on power system sustainability. Long-term stability is associated with slow and long-term events, which are associated with large scale system upsets and continuous discrepancies between the generation and consumption of large and active and reactive power. In the mid-term stability, the focus is centered on synchronizing electrical frequencies between the machines, which include the effects of some slow events and potentially large voltage or frequency trips [6-7].

2.Proposed methodology

2.1Critical fault clearing time

The critical fault clearing time is defined as the longest duration of a fault that does not lead to any generator loss of synchronism in the system or any other inadmissible repercussion for the system such that the power system is transiently stable. During large disturbances such as a three-phase short circuit, the protection system senses the presence of fault and the corresponding relays initiate the tripping of the nearest circuit breakers to isolate the fault. The time duration from the instant the disturbance occurs until the circuit breakers isolate used to estimate the CCT in order to specify a quantified index for transient stability assessment. CCT is normally calculated by uniformly increase the fault clearing time until the system instability. In order to shortage the computation time, Bisection technique is used to find the CCT for each fault in order to avoid the repetitive time-consuming with step increase fault duration. The Bisection technique, which can be used to estimate the CCT for each contingency. The technique starts with initial FCT and searches for the boundaries, which includes the CCT. An initial fault clearing time (FCT = t0) is assumed where the time boundaries are initially assumed within (t0). If the CCT is found between these time boundaries, the Bisection technique can be applied to estimate the CCT, otherwise these time boundaries should be changed until the system is stable atone boundary and unstable at the other boundary to clarify that CCT found between the two limits. Then, the dynamic response of the system is evaluated at mid-point (tmid) between higher and lower limits. If the system is stable, the lower limit (t1) is replaced by mean value (tmid). Otherwise, the higher value (t2) is replaced by mean value (tmid) in the next calculation. The sectioning process continues until the acceptance tolerance, ε between the limits is satisfied. Then the CCT selected to be the higher limit. The total time of computation depends on various parameters. The chosen parameter σ should be large enough to restrict the number of simulations. In addition, this value can be adaptive during the simulation from one contingency to another to reduce the total simulation time sever contingency. The corresponding CCT specifies the distance at this particular operating point from transient stability boundary.

The application of the Bisection technique reduces the required computation time to calculate the CCT using TDS. TDS provides the opportunity to consider the detailed power system modelling and all expected scenarios. It provides detailed time response of the electrical signals following faults with high degree of accuracy. The total time required to calculate the credible degree of a contingency set still very high to screen the system states during online applications. Online TSA based computational intelligence has been proposed to overcome the drawbacks of traditional methods. ANN as an efficient computational intelligence is used to assess the power system stability in this study. ANN is trained offline using pre-analysed input-output patterns tube applied in online applications.

3.Implementation and results

3.1Simulation Model

The MATLAB software is used to analysis of voltage and transient stability of the multi-machine, nine-bus bar power system network. The base MVA and system frequency are considered to be 247.5 MVA 16.5 KV, 128MVA 13.8KV and 192 MVA 18 KV and 50 Hz, respectively. The single-line diagram of the three-machine power system is shown in Fig. 5.1. Here, generator G1 is connected to slack bus 1, whereas generators 2 (G2) and 3 (G3) are connected to bus bars 2 and 3, respectively. Loads A, B and C are connected in bus bars 5, 6 and 8 respectively. The voltage and transient stability analysis has been carried out by monitoring the performance of the generators (G1, G2 and G2) and different buses.[6],[17]-[21] Two cases have been considered in the voltage stability analysis of this power system network. The first case is without three phase fault in power network system and second case is the performance of power system network when three phase fault occurs in Y phase.

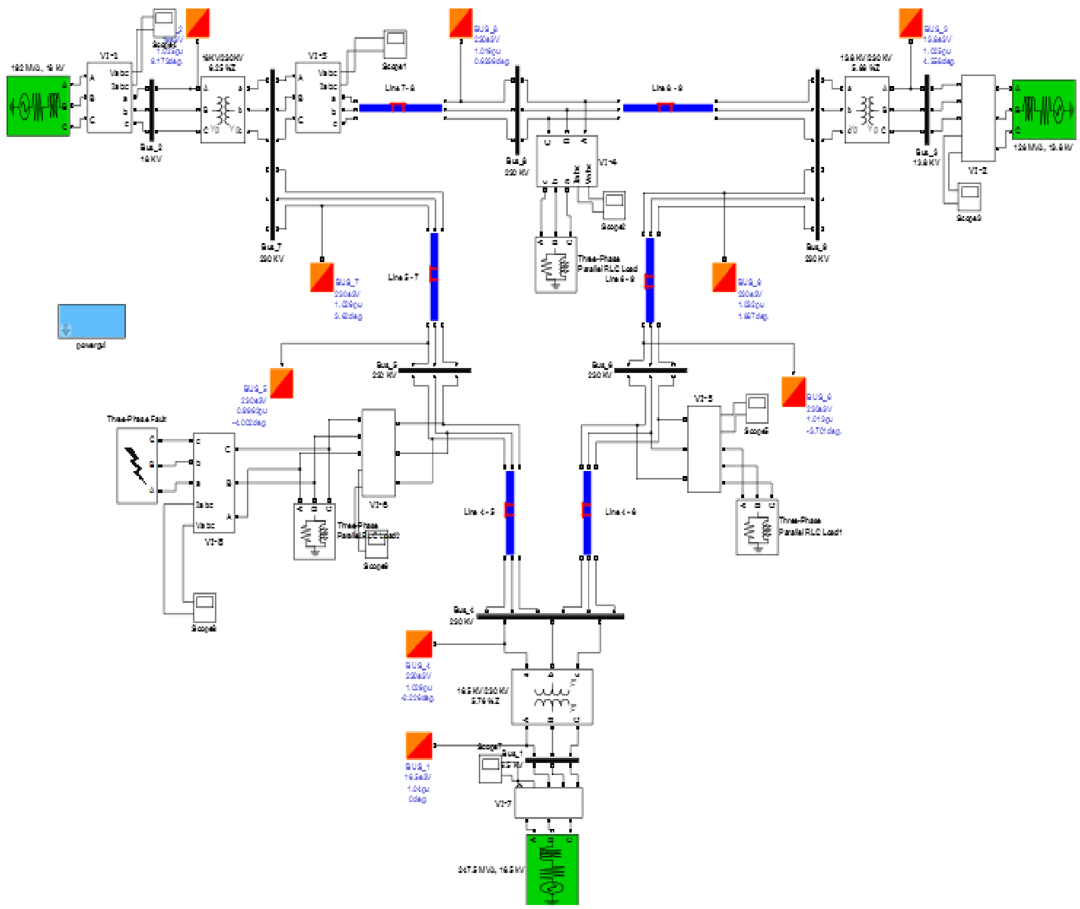

Figure 1 Complete Simulink model of three machine nine bus power system network

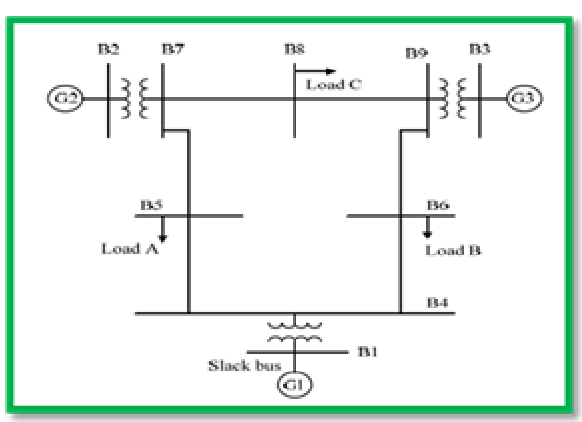

Figure 2 Single-line diagram of three machine power system

3.1.1Parameters in table

Table 1 Generator Ratings

Generator Name	Power Generation	Voltage & Frequency Ratings
G1	247.5 MVA	16.5 KV, 50 Hz
G2	192 MVA	18 KV, 50 Hz
G3	128 MVA	13.8 KV, 50 Hz

Table 2 Load ratings and bus locations

Load Name	Load Power	Bus Location
1st load	100 MW ,35 MVAR	8
2nd load	90 MW ,30 MVAR	6
3rd load	125 MW ,50 MVAR	5

3.2 Results and discussion

The 3- phase fault in Y Phase (Single line to ground) is created at bus 5 at time 0.017 sec and is cleared after time 0.0705 sec. the electromechanical oscillations of electrical power is reduced and field voltage is also kept limited, due to this reason excitation is maintained. The various plots of electrical power, field current, and terminal current individually with ring main's method.

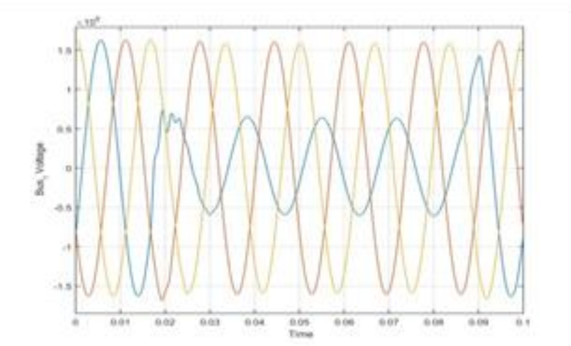

Figure 3 Shows the waveform of bus_1 voltage

Figure 3 represents the voltage-time response of Bus_1. It is observed that approach takes 0.06 seconds for stabilization

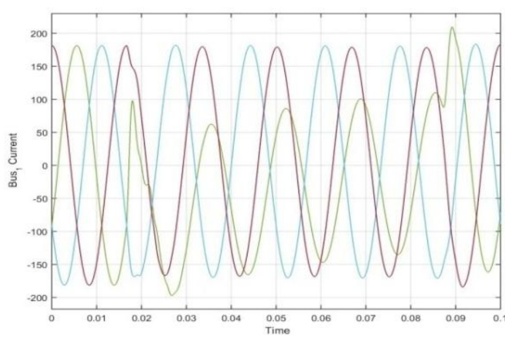

Figure 4 Shows the waveform of Bus_1 Current
it represents the Current-time response of Bus_1. It is observed that approach takes 0.06 seconds for stabilization.

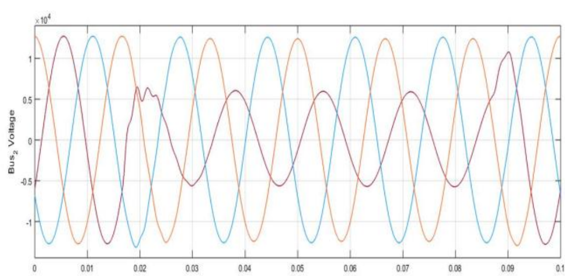

Figure 5 Shows the waveform of Bus_2 Voltage

it represents the voltage-time response of Bus_2. It is observed that approach takes 0.06 seconds for stabilization.

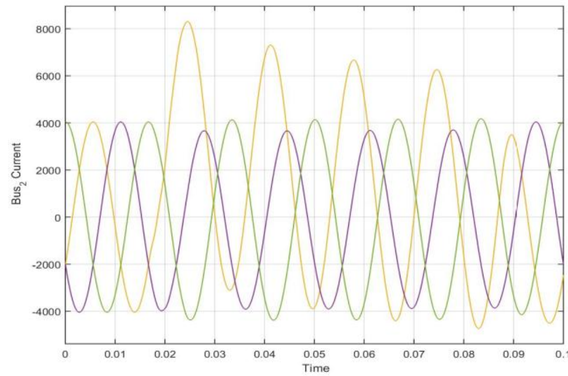

Figure 6 Shows the waveform of Bus_2 Current

Figure 6 represents the Current-time response of Bus_2. It is observed that approach takes 0.06 seconds for stabilization.

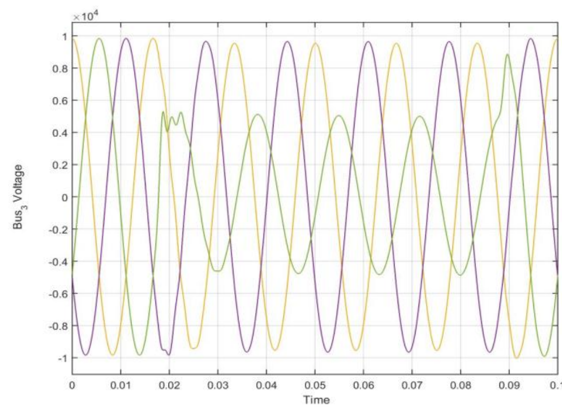

Figure 7 Shows the waveform of Bus_3 Voltage
it represents the voltage-time response of Bus_3. It is observed that approach takes 0.06 seconds for stabilization.

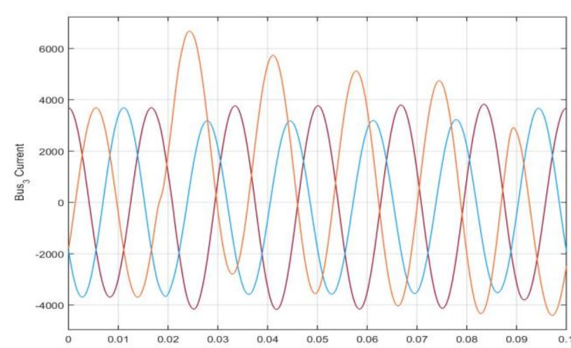

Figure 8 Shows the waveform of Bus_3 Current

It represents the Current-time response of Bus_3. It is observed that approach takes 0.06 seconds for stabilization.

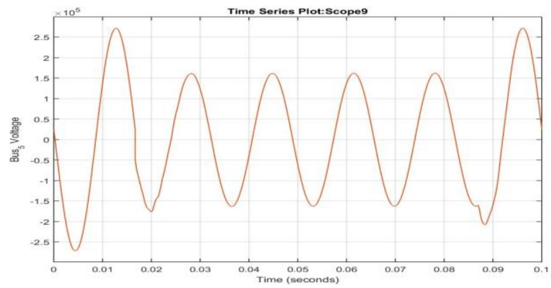

Figure 9 Shows the waveform of Bus_5 Voltage

Figure 9 The 3- phase fault in Y Phase (Single line to ground) is created at bus 5 at time 0.017 sec and is cleared after time 0.0705 sec. the electromechanical oscillations of electrical power is reduced and field voltage is also kept limited, due to this reason excitation is maintained

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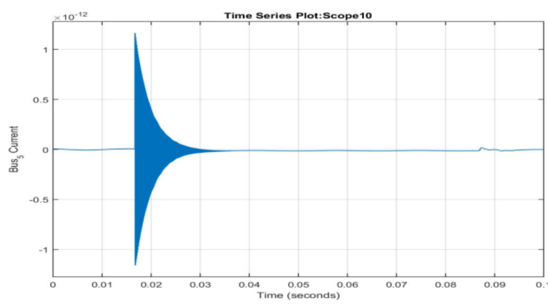

Figure 10 Shows the waveform of Bus_5 Current

Figure 10 The 3- phase fault in Y Phase (Single line to ground) is created at bus 5 at time 0.017 sec and is cleared after time 0.0705 sec. the electromechanical oscillations of electrical power is reduced and field current is also kept limited, due to this reason excitation is maintained.

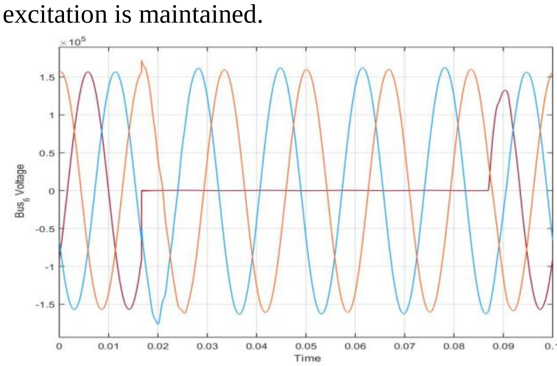

Figure 11 Shows the waveform of Bus_6 Voltage

Figure 11 represents the voltage-time response of Bus_6. It is observed that approach takes 0.06 seconds for stabilization.

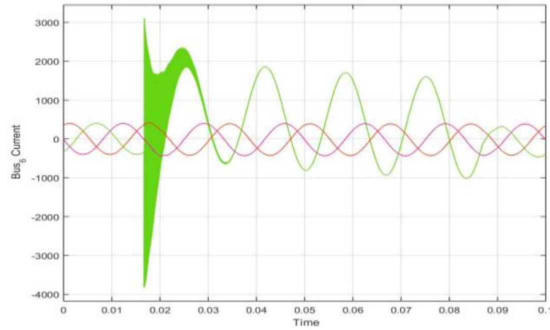

Figure 12 Shows the wave form of Bus_6 Current

Figure 12 represents the Current-time response of Bus_6. It is observed that approach takes 0.06 seconds for stabilization.

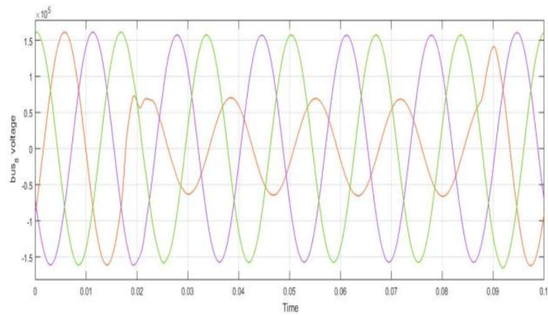

Figure 13 Shows the wave form of Bus_8 Voltage

Figure 13 represents the voltage-time response of Bus_8. It is observed that approach takes 0.06 seconds for stabilization.

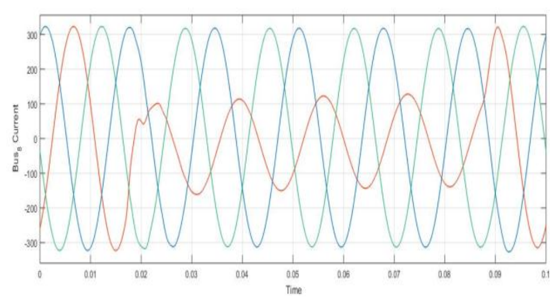

Figure 14 Shows the waveform of Bus_8 Current

Figure 14 represents the Current-time response of Bus_8. It is observed that approach takes 0.06 seconds for stabilization.

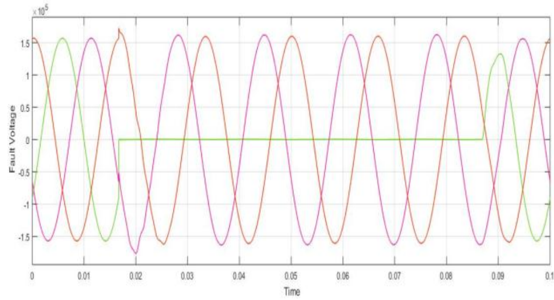

Figure 15Shows the wave form of Fault Voltage

Figure 15shows results of three phase fault in power system network is compared and found that the voltage stability of the system is regained after 0.0705 sec by system during the three phase fault condition by Ring Main method when fault occurs in Phase Y.

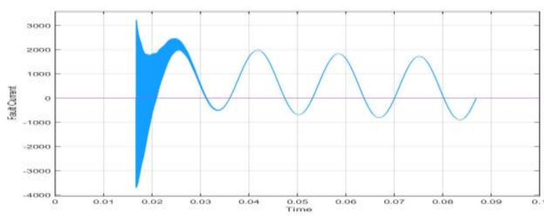

Figure 16 Shows the wave form of Fault Current

4.Conclusion

This paper presents the improved behavior of transient and voltage stability of a 9-bus multi machine system using MATLAB software. The comparison of transient and voltage stability performances of the multi-machine system. Initially, results of without three phase fault and fault in power system network is compared and found that the voltage stability of the system is regained after 0.0705 sec by system during the three-phase fault condition by Ring Main method when fault occurs in Phase Y. Nowadays, power systems are being operated under increasingly stressed condition due to the prevailing trend to make the most of existing facilities. Increased competition, open transmission access, and construction and environmental constraints are shaping the operation of electric power systems which present greater challenges for secure system operation. This is clear from the increasing number of major power-grid blackouts that have been experienced in years such as, Northeast USA-Canada blackout of August 14, 2003. Planning and operation of today's power systems require a careful consideration of all forms of system instability. Significant advances have been made in recent years in providing better tools and techniques to analyse instability in power systems. The main requirement of system stability is to keep the synchronous operation of power system with adequate capacity and the fast reaction to meet fluctuations in the electric demand and changes in system topology. Successful operation of a power system depends largely on the engineer's ability to provide the reliable and uninterrupted service to the all loads and supply required amount of the loads by the available facilities. Distance between current state and a hypothetical state wherein the units may lose the synchronization evaluated after each state of estimation and after each new power flow. In the evaluation, the concern is the behaviour of the power system when it is subjected to transient disturbances. If the oscillatory response of a power system during the transient period following a disturbance is damped within acceptable time and the system can settle in a finite time to a new steady state, it is considered stable.

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