IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, April 2025
Impact Factor: 7.67

Transient Stability Analysis On IEEE-9 Bus System Under Multiple Contingencies

Jadhav Dnyaneshwari Baban[1], Patil Varsha Gorakh[2], Sangale Sarika Kailas[3], Dongare Pratibha Vedu[4], Prof. Balapure S. S.[5]
Department of Electrical Engineering[1-5]
SND College of Engineering & Research Center, Yeola, Maharashtra , India

Abstract: *Transient stability analysis is essential in power system studies to ensure the secure and reliable operation of interconnected systems, especially during disturbances like faults or sudden changes in load or generation. This study investigates the transient stability of the IEEE 9-bus system under multiple contingencies. The IEEE 9-bus system, a simplified representation of a typical power network, is widely used for transient stability studies due to its balanced topology and complexity. In this work, various fault scenarios are simulated to assess the system's response to disturbances and the effectiveness of system recovery measures.*

In this research, various fault scenarios, including three-phase faults and line outages, are introduced to observe system responses and analyze critical parameters such as rotor angle stability, frequency deviations, voltage profiles, and fault clearing times. Key metrics are evaluated to determine the system's ability to regain stability after disturbances, with attention to how factors like fault duration, system damping, and control actions impact recovery. This study also examines the effectiveness of different protection and control mechanisms in maintaining stability.

Keywords: IEEE 9- bus system, Fault Scenarios,

I. INTRODUCTION

Transient stability, a subset of overall system stability, refers to the ability of a power system to maintain synchronism when subjected to significant disturbances such as sudden faults, line outages, or changes in load demand. These disturbances, if not managed effectively, can lead to cascading failures and even large-scale blackouts. Thus, analysing transient stability is crucial to understanding how a system will behave under dynamic conditions.The IEEE 9-bus system is frequently utilized as a benchmark model for transient stability studies because of its simplicity and ability to replicate the dynamic behavior of larger power grids. This system consists of three generators, nine buses, and three loads, making it an ideal model for evaluating system response under various contingencies without the computational burden of larger systems. By studying the IEEE 9-bus system, researchers can explore the impacts of faults, line tripping, and generator outages on system stability, gaining insights into the critical factors that influence synchronism and response.

Transient stability analysis of the IEEE 9-bus system under multiple contingenciessimultaneous or sequential disturbanceshas become particularly important. As power grids increasingly integrate renewable c stability management. By assessing transient stability under these conditions, power system operators can identify vulnerabilities, develop control strategies, and ensure a stable, resilient grid capable of handling complex operational scene

II. IMPORTANCE OF TRANSIENT STABILITY

Transient stability is a key aspect of power system stability that refers to the ability of the system to remain in synchronism when subjected to large and sudden disturbances such as short circuits, line outages, sudden loss of generation, or abrupt changes in load. These disturbances typically last for a very short period (a few milliseconds to seconds), but their impact on system stability can be significant. The primary goal of analyzing transient stability is to ensure that all generators in the system continue to operate in synchronism and maintain a stable power flow throughout the network after the disturbance is cleared.

Transient stability is fundamental to the secure and uninterrupted operation of power systems. It ensures the ability of the system to withstand and recover from disturbances without losing synchronism or experiencing cascading failures. With the evolving structure of modern power systems and the integration of variable renewable energy sources, the importance of transient stability continues to grow. Continuous research, technological advancements, and the application of intelligent control systems are essential to enhance the transient stability of power systems and ensure their resilience in the face of growing challenges.

III. POWER SYSTEM STABILITY

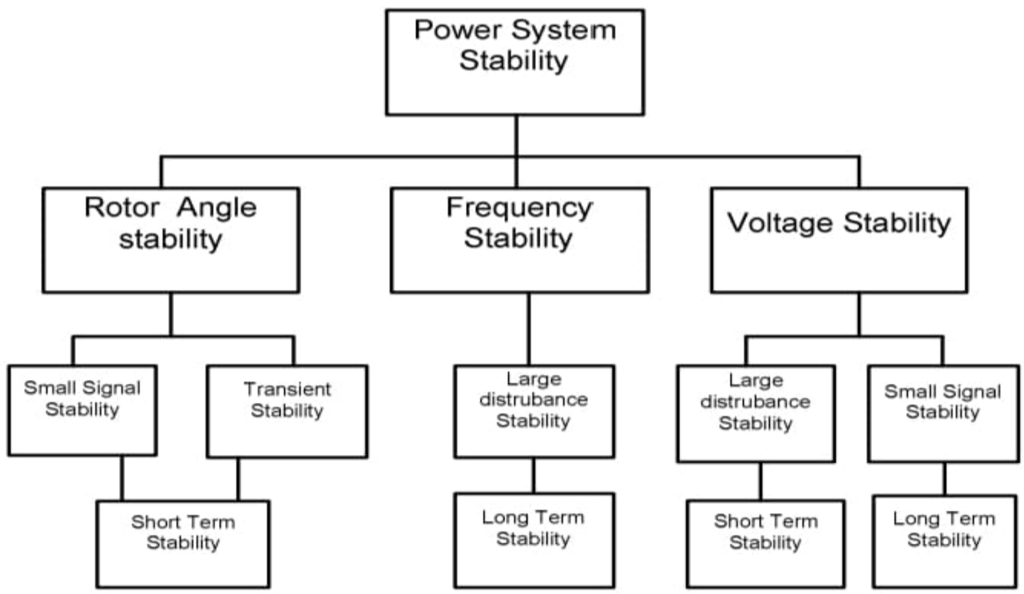

Fig.1 Classification of Power System

Power system stability is categorized based on the following considerations:

i. The nature of the resulting instability mode indicated by the observed instability on certainsystem variables.

ii. The size of the disturbance which consequently influences the tool used to assess the systemstability.

iii. The time margin needed to assess system stability.

IV. FACTORS AFFECTING TRANSIENT STABILITY

1. Type of Disturbance

The kind of disturbance that occurs in a power system has a significant effect on its transient stability. A three-phase fault, for example, is the most severe kind of disturbance and can cause large disruptions in power flow and rotor angle stability. Less severe disturbances, such as single-line-to-ground or line-to-line faults, generally have a smaller impact. The system's ability to recover depends on how extreme the disturbance is.

2. Location of Fault

The proximity of a fault to the generator plays a crucial role in transient stability. Faults that occur close to generators or major buses tend to be more disruptive than those occurring farther away. This is because faults near the generator terminals cause larger changes in generator output and rotor angle, which can more easily push the machine out of synchronism.

3. Clearing Time of Fault

The duration for which a fault persists on the system before being cleared by protection systems (such as circuit breakers) greatly influences stability. The longer the fault remains, the more the system deviates from its normal operating conditions. Quick fault clearance minimizes disturbance and helps maintain synchronism among generators.

4. Generator Inertia

The inertia of a generator is a measure of its resistance to changes in rotational speed. Systems with high-inertia generators tend to be more stable because the mechanical system resists sudden changes in speed caused by faults or disturbances. Low-inertia systems experience faster changes in speed and angle, which increases the risk of instability.

5. Excitation System Response

The excitation system of a generator helps control the voltage at the generator terminal. During a disturbance, a fast and effective excitation system can quickly adjust the generator’s field voltage to support terminal voltage. This response helps maintain synchronism and improves transient stability by limiting the generator's voltage drop during disturbances.

6. Power System Loading

The level of loading on the power system before a disturbance affects how much margin is available for stable operation. A heavily loaded system operates closer to its maximum power transfer capability, leaving less room to absorb disturbances. Lightly loaded systems have more margin and are generally more stable under similar disturbances.

7. Transmission Line Reactance

The reactance of the transmission line affects the power that can be transferred between generators and loads. Higher line reactance reduces the maximum power transfer capability and weakens the electrical coupling between generators. This reduced coupling can cause greater angle swings during disturbances and lead to instability.

8. Network Configuration

The configuration of the power network determines how power flows during normal and faulted conditions. A strongly meshed network with multiple paths for power flow provides greater flexibility and fault tolerance. In contrast, a weakly connected or radial network is more vulnerable to disturbances and has lower transient stability.

9. Use of Stabilizing Devices

Power system stabilizers (PSS) and Flexible AC Transmission System (FACTS) devices like STATCOM, SVC, and TCSC are used to enhance dynamic performance. These devices help control voltage, reactive power, and damping of oscillations, all of which contribute to improved transient stability by quickly responding to changes in system conditions.

10. Generator Operating Conditions

The pre-disturbance operating point of the generator, especially the output power and excitation level, influences its ability to remain in synchronism after a disturbance. A generator operating near its power limit or with low excitation has less stability margin and is more likely to lose synchronism under stress.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 11, April 2025
Impact Factor: 7.67

V. BUS SYSTEM

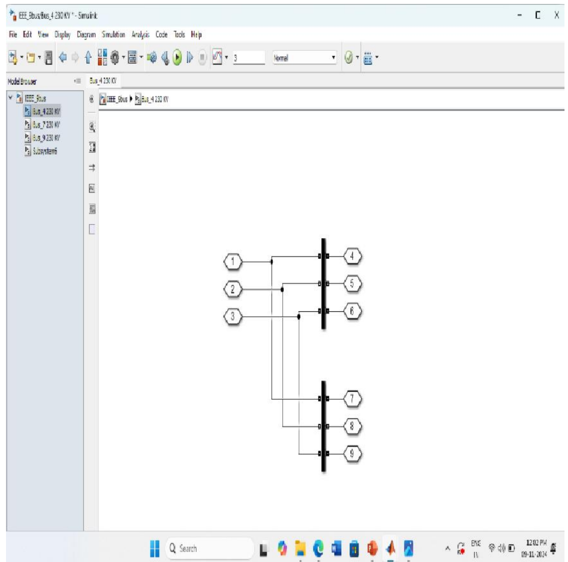

Fig. 2 Bus System

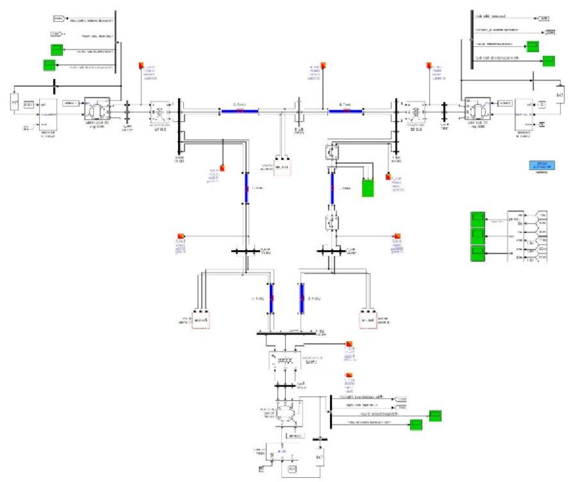

Fig. 3 IEEE 9 Bus Transient Stability Analysis

VI. RESULT AND OBSERVATIONS

Using IEEE 9 Bus System matlab simulation is performed wit 3 phase faults which occurred at bus 5 for 1 sec. in the system. The simulation is also performed when 50 % of sudden load increase on bis 5 at 1.03 second due to which resultant frequency of multiple machine decreased. The observed results for the increased and decrease of load are as follows shown in the figures.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Volume 5, Issue 11, April 2025

ISSN: 2581-9429

Impact Factor: 7.67

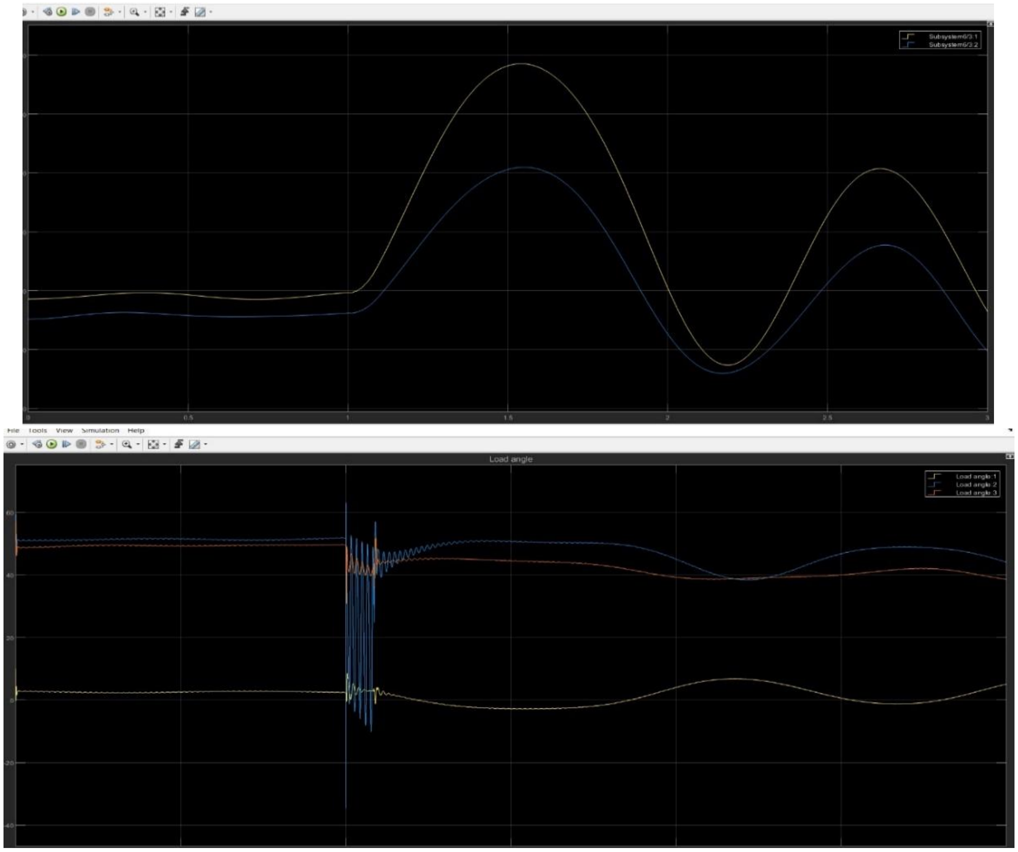

Fig.4 Result Analysis

VII. CONCLUSION

The transient stability analysis of the IEEE-9 bus system under multiple contingency scenarios provides critical insights into the system's dynamic behavior following disturbances. This study has shown that the IEEE-9 bus system, while relatively simple, is sensitive to both the location and severity of faults, as well as the timing and sequence of multiple contingencies. Through simulation, it was observed that certain buses and generators are more prone to instability, especially under simultaneous or sequential disturbances.

REFERENCES

[1]. P. Kundur, Power System Stability and Control, New York: McGraw-Hill. 1982 pp. 104-120

[2]. Ramandeep Kaur, Divesh Kumar, Transient Stability Analysis of IEEE 9 Bus System in Power World Simulator, IJERA

[3]. Ramnarayan Patel, T.S. Bhatti and D.P.Kothari, Study of Power System Transient Stability with Simulink, IIT.

[4]. Chao Duan, Student Member, IEEE, Lin Jiang, Member, IEEE, Wanliang Fang, and Jun Liu, Member, IEEE, "Moment-SOS Approach To Interval Power Flow"

[5]. A.S. Debs and R. E. Larson. A Dynamic Estimator for Tracking the State of the Power System, IEEE Transactions on Power Apparatus and Systems, Vol. 89, No. 7, September/October 1970, pp. 1670-1678.