IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

TRANSIENT STABILITY ASSESSMENT FOR GENERATORS AND DER INTEGRATION INTO THE IEEE 9 BUS SYSTEM

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Abstract: The stability of a transient IEEE 9 bus system with regard to voltage maintenance, generators, and the incorporation of distributed energy resources (DER) is examined in this research. The term “transient stability” describes a power system capacity to maintain synchronization in the face of difficult circumstances such a sudden loss of generation or substantial load swings. It is difficult to incorporate renewable energy sources (RES) within the constrained transmission line capacity, which has an impact on generator capacity. The reduction of system inertia caused by RES integration may have an effect on transitory situations. In order to solve this, we built a wind turbine generator (WTG) inside the point of connection (PoC) and tested the stability of transients by adding faults to the bus.

Keywords **– DERs (Distributed Energy Resources), wind turbines, Synchronous Generator (SG), the Doubly-Fed Induction Generator (DFIG), Squirrel-Cage Induction Generator (SCIG), Power System Stabilizer (PSS) controller**

I. INTRODUCTION

Many worldwide power systems are already approaching their stability limitations as a result of the growing load on transmission networks and the increased demand for energy. Transmission networks now have to manage greater power levels than they were originally planned due to a number of variables, such as restricted investment in new transmission and production facilities, new regulatory requirements supporting transmission open access, and environmental concerns. Power systems are now more vulnerable to disruptions as a result of this circumstance. In order to set operating boundaries and recommendations, it is essential to assess power system stability, which focuses on a power system's capacity to recover to a stable condition after a disruption.

The conventional approach to stability evaluation takes a lot of time and is inappropriate for the operating conditions of today. Furthermore, recent widespread blackouts in North America and Europe have highlighted the urgent need for a quicker and more precise instrument to evaluate the stability of the power system, particularly for real-time assessments in a dynamic system.

Power system stability necessitates a thorough examination of the dynamics of the system under disturbance. It alludes to the system's ability to bounce back and resume steady, regular functioning after interruptions. According to a traditional definition, the loss of synchronism, which occurs when certain synchronous machines become misaligned as a result of certain shocks, is what causes power system instability. Stable-state, transient, and dynamic stability are the three forms of stability that need the most attention.

II. FLOW DIAGRAM OF THE PROPOSED IEEE 9 BUS SYSTEM

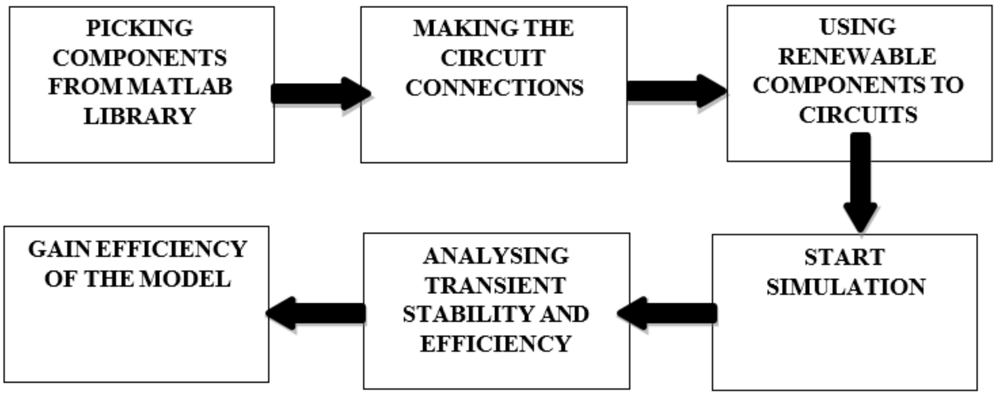


Fig. 1: Flow diagram of the proposed IEEE 9 BUS SYSTEM

The addition of synchronous generators or wind turbine generators (WTG) complicates the power system stability and continuous operation. A noteworthy trend is the increased use of Distributed Energy Resources (DER) and their integration into the current grid structure. However, in extreme disturbance or fault situations, Point of Connection (PoC) voltages may drop sharply to almost zero, significantly increasing the generators stator current transients. This then affects torque and power pulsations, resulting in network imbalances. Modern methods for low-voltage ride-through (LVRT) capabilities are presented in the reference. Prior to system failure, defects must be repaired, which may be done by keeping the critical clearing time (CCT) and rotor angles properly balanced. This in turn controls active and reactive power and stabilizes voltage level changes.

III. PROPOSED METHODOLOGY

A. Wind Integrated system in IEEE 9 bus system

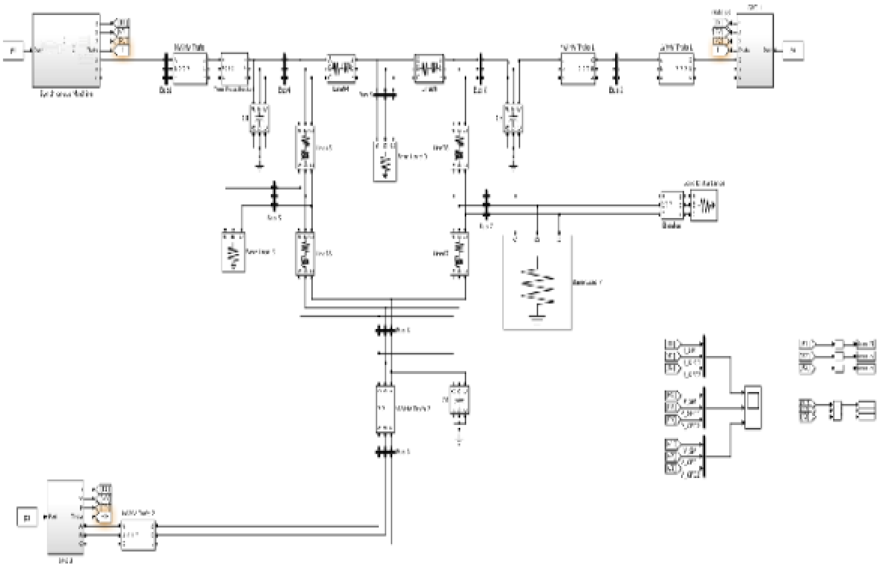


Fig. 2: Wind Integrated system in IEEE 9 bus system

This study investigates the transient stability of the IEEE 9- bus system to assure system stability in a variety of circumstances. For controlling market operations and evaluating the security of electrical networks, contingency analysis is essential. An IEEE 9-bus system using a conventional synchronous generator is initially examined in the research. In order to assess the voltage performance indicators, a contingency study is carried out by gradually removing the transformer, transmission line, and generator. The same research is then done on the IEEE 9-bus system, which replaces one conventional generator with a DFIG-based wind farm of the same rating. The results of juxtaposing these two circumstances are then shown.

The simulation is run using Power Factory, and the severity of outages is evaluated using the voltage performance index. The findings demonstrate that the severity of contingencies endures even with the addition of DFIG. But when DFIG is properly positioned, the system performs better in emergency situations because of less inertia, more synchronizing torque, and closer to the load.

A load flow analysis is first used to stabilize the IEEE 9-bus system and make sure that all state and voltage levels at the buses are within the predetermined ranges. The research starts out by analyzing transients in generators and buses without integrating Distributed Energy Resources (DER).

Reliability and security are crucial issues since the integration of renewable energy into the grid may have a substantial influence on the stability of the power system. Contingency analysis is a crucial technique in power systems to spot possible overloads and other problems that may develop as a result of defects, including transmission line failures or generator outages. Contingency analysis includes altering the system's operational state to assess how it will react in different scenarios.

B. Synchronous machine

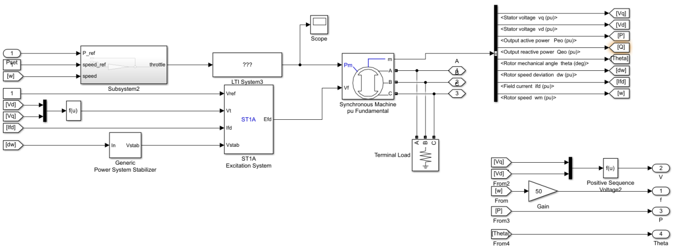


Fig. 3: *Synchronous machine*

As the model develops, simulation becomes a crucial tool for determining its accuracy and usefulness. Simulations aid in confirming that the model performs as predicted. Additionally, Model-Based Design makes it easier to automatically generate code that is suitable for embedded deployment when including software and hardware implementation requirements, such as providing fixed-point accuracy and time limitations. Additionally, it enables the development of test benches to thoroughly examine system performance, saving time and reducing the dangers connected with manually entered mistakes. For system verification, build test benches to save time and prevent the introduction of manually-coded faults.

In order to analyses the dynamic behavior of synchronous generators, the research uses a two-axis model and differential equations to explain the behavior of the generators.

$$\frac{\mathrm{d}\delta_i}{\mathrm{d}t} = \omega_i - \omega_s, \tag{1}$$

$$M_i\frac{\mathrm{d}\omega_i}{\mathrm{d}t} = P_{Mi} - (E'_{qi} - X'_{di}I_{di})I_{qi} - (E'_{di} + X'_{qi}I_{qi})I_{di}, \tag{2}$$

$$T'_{d0i}\frac{E'_{qi}}{\mathrm{d}t} = -E'_{qi} - (X_{di} - X'_{di})I_{di} + E_{fdi}, \tag{3}$$

$$T'_{q0i}\frac{\mathrm{d}E'_{di}}{\mathrm{d}t} = -E'_{di} + (X_{qi} - X'_{qi})I_{qi}\,. \tag{4}$$

$$T_{Ei}\frac{\mathrm{d}E_{fdi}}{\mathrm{d}t} = -(K_{Ei} + S_E(E_{fdi})E_{fdi} + V_{Ri}, \tag{5}$$

$$T_{Ai}\frac{\mathrm{d}V_{Ri}}{\mathrm{d}t} = -V_{Ri} + K_{Ai}R_{Fi} - \frac{K_{Ai}K_{Fi}}{T_{Fi}}E_{fdi} + K_{Ai}(V_{refi} - V_i)), \tag{6}$$

$$T_{Fi}\frac{\mathrm{d}R_{Fi}}{\mathrm{d}t} = -R_{Fi} + \frac{K_{Fi}}{T_{Fi}}E_{fdi}\,.$$

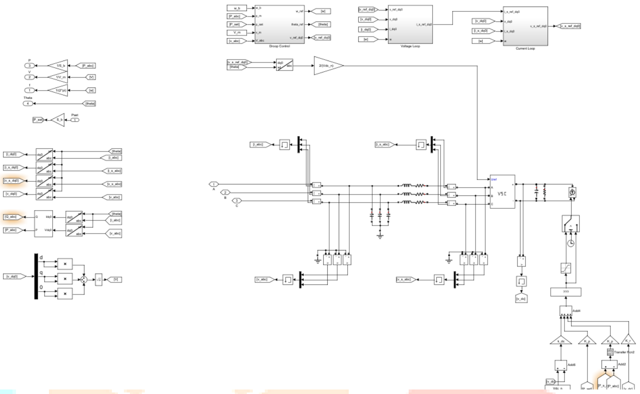
Table 1. SIMULATED IEEE 9-BUS NETWORK RESULTS.

BUS	Simulated results		
	V_LF (pu)	P_LF (MW)	Q_LF (Mvar)
1	1.0400	72.19	26.78
2	1.0250	163.00	6.69
3	1.0250	85.00	-10.79
4	1.0261	0.00	0.00
5	0.9962	125.00	50.00
6	1.0132	90.00	30.00
7	1.0259	0.00	0.00
8	1.0160	100.00	35.00
9	1.0324	0.00	0.00

IV. THEORITICAL MODELING OF THE PROPOSED CONVERTER

This study investigates the transient stability of the IEEE 9- bus system to assure system stability in a variety of circumstances. For controlling market operations and evaluating the security of electrical networks, Contingency analysis is essential. An IEEE 9-bus system using a conventional synchronous generator is initially examined in the research. In order to assess the voltage performance indicators, a contingency study is carried out by gradually removing the transformer, transmission line, and generator. The same research is then done on the IEEE 9-bus system, which replaces one conventional generator with a DFIG-based wind farm of the same rating. The results of juxtaposing these two circumstances are then shown.

The simulation is run using Power Factory, and the voltage performance index is used to gauge how severe the outages are. The results show that even with the addition of DFIG, contingencies remain severe. But when DFIG is properly positioned, the system performs better in emergency situations because of less inertia, more synchronizing torque, and closer to the load.



A methodical technique called model-based design simplifies and expedites the creation of dynamic systems, which includes things like communication, signal processing, and control systems. Throughout the development lifecycle, beginning with the determination of requirements and continuing through the design, implementation, and testing stages, this technique places a system model in the spotlight. Throughout the development process, the model functions as an executable specification that continually grows. As the model develops, simulation becomes a crucial tool for determining its accuracy and usefulness. Simulations aid in confirming that the model performs as predicted. Additionally, Model-Based Design makes it easier to automatically generate code that is suitable for embedded deployment when including software and hardware implementation requirements, such as providing fixed-point accuracy and time limitations. Additionally, it enables the development of test benches to thoroughly examine system performance, saving time and reducing the dangers connected with manually entered mistakes. For system verification, build test benches to save time and prevent the introduction of manually-coded faults.

V. CONTROLLER MODELING

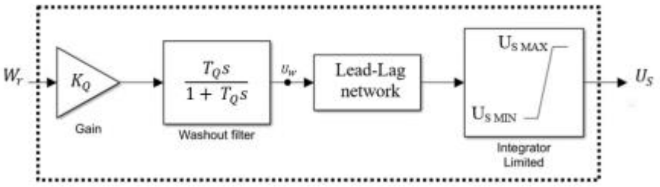


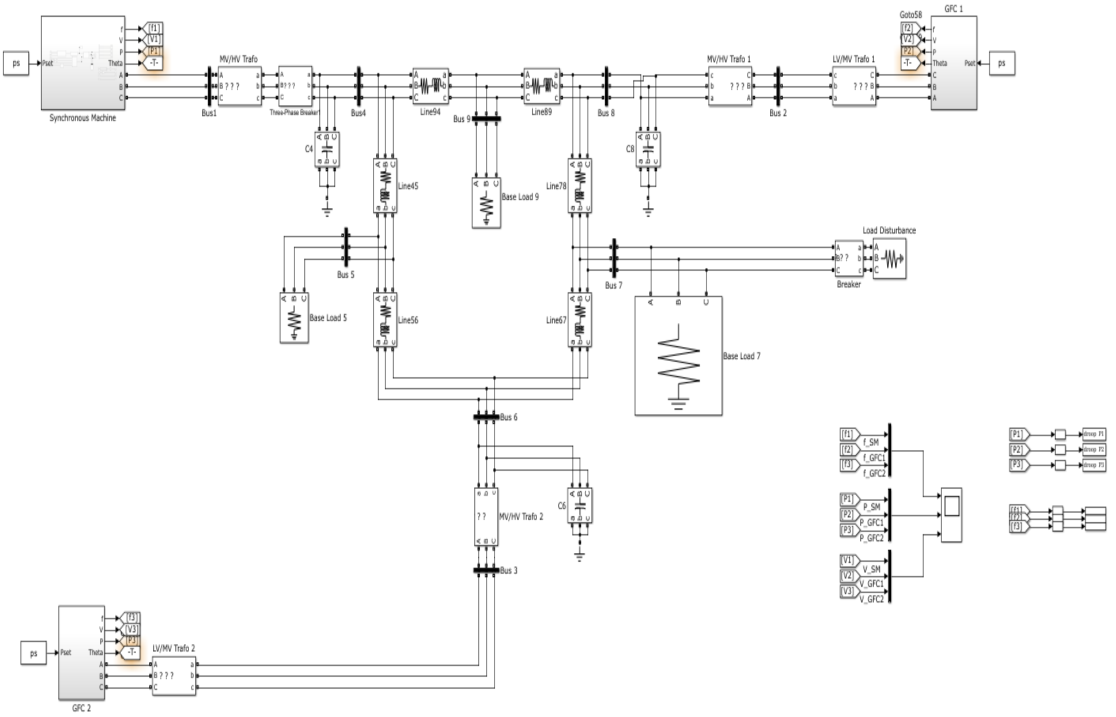
Fig. 5: PSS structure

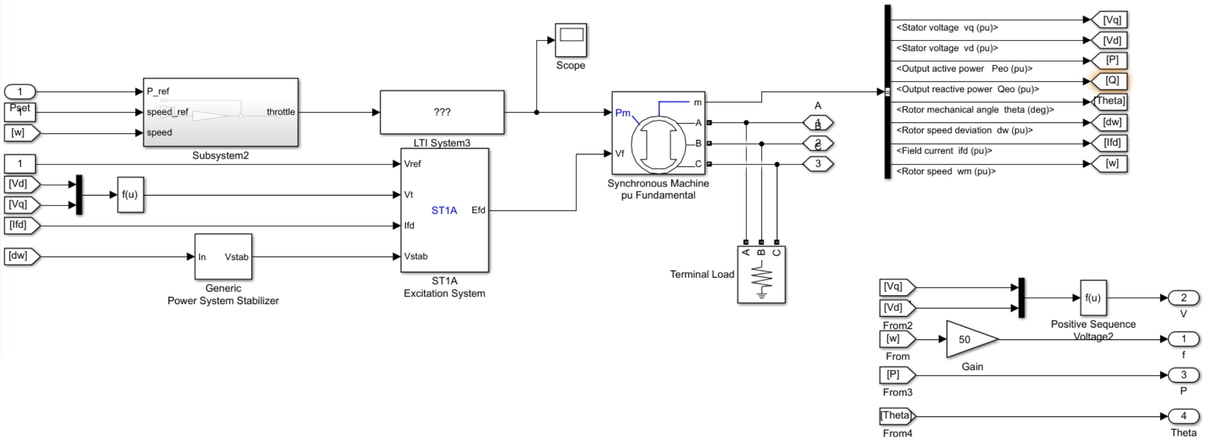
The traditional method of stability evaluation is time- consuming and unsuitable for current operating circumstances. The urgent need for a quicker and more accurate tool to assess the stability of the electrical system has also been underlined by recent extensive blackouts in North America and Europe, particularly for real-time assessments in a dynamic system.

Power system stability necessitates a thorough examination of the dynamics of the system under disturbance. It alludes to the system ability to bounce back and resume steady, regular functioning after interruptions. According to a traditional definition, the loss of synchronism, which occurs when certain synchronous machines become misaligned as a result of certain shocks, is what causes power system instability. Stable-state, transient, and dynamic stability are the three forms of stability that need the most attention.

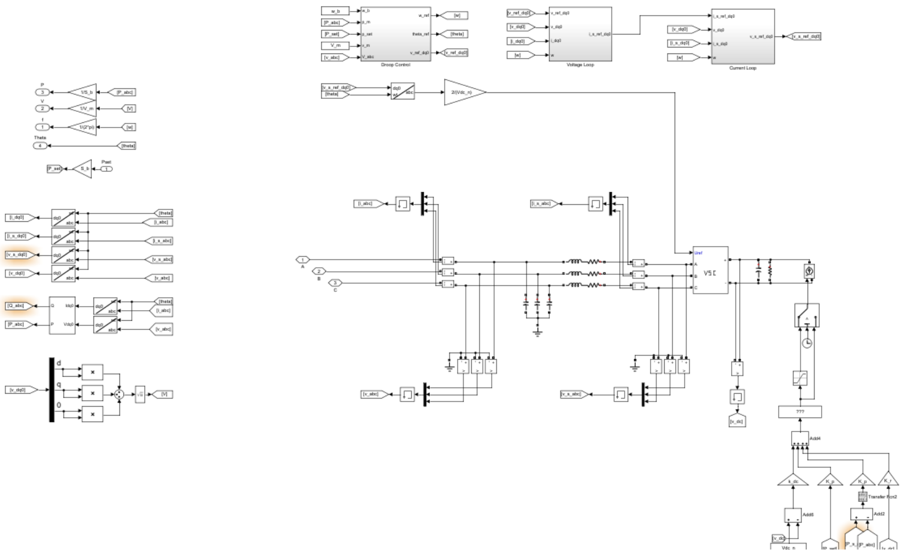
VI. RESULT AND DISCUSSION

The IEE 9 bus system is discussed in this chapter along with the system's transient stability

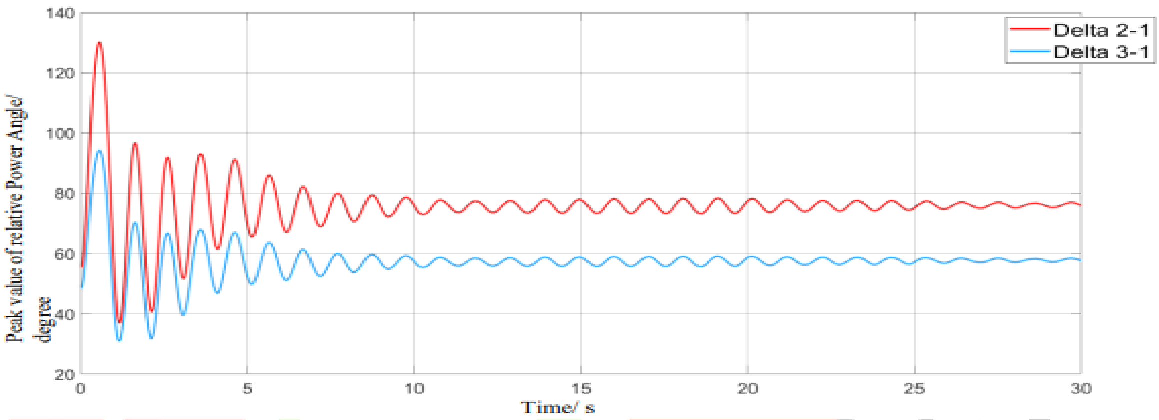


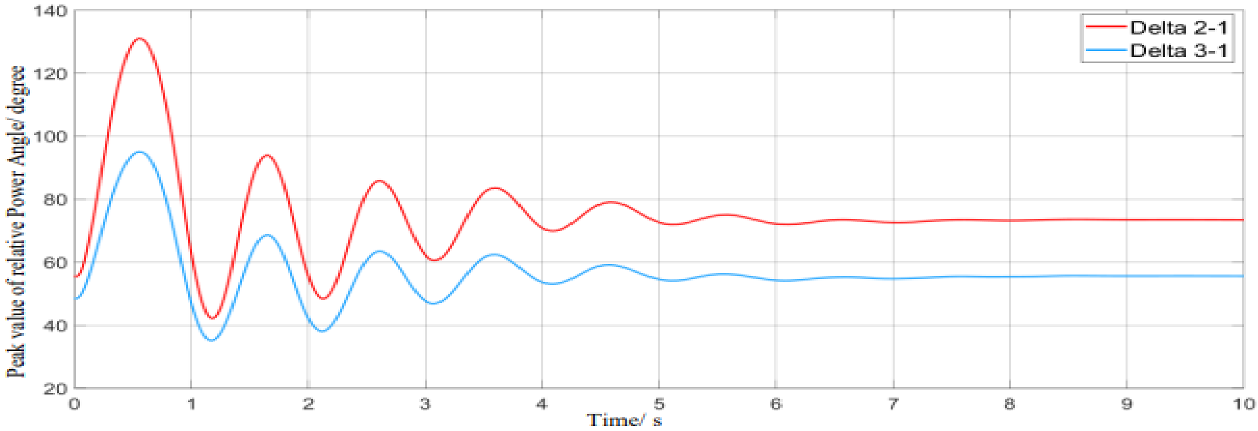


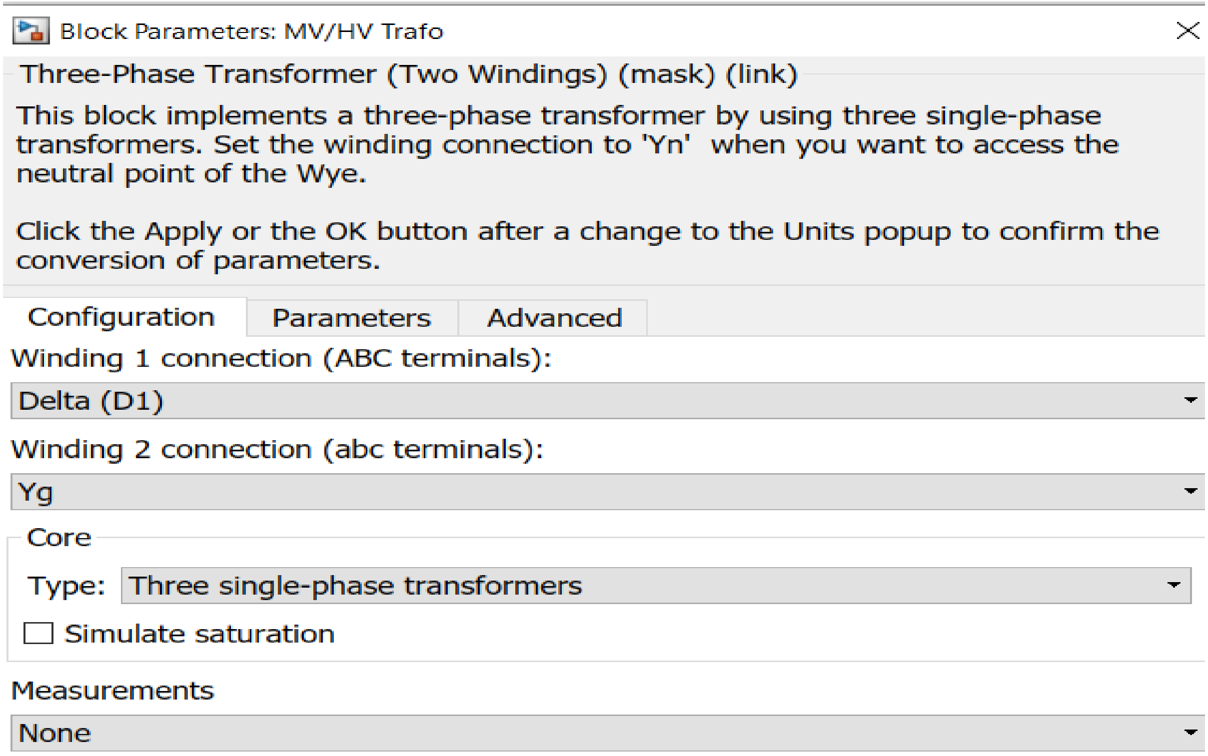
Synchronous machine



Generalized frequency controller







Block Parameters: MV/HV Trafo

Three-Phase Transformer (Two Windings) (mask) (link)

This block implements a three-phase transformer by using three single-phase transformers. Set the winding connection to 'Yn' when you want to access the neutral point of the Wye.

Click the Apply or the OK button after a change to the Units popup to confirm the conversion of parameters.

Winding 1 connection (ABC terminals): Delta (D1)

Winding 2 connection (abc terminals): Yg

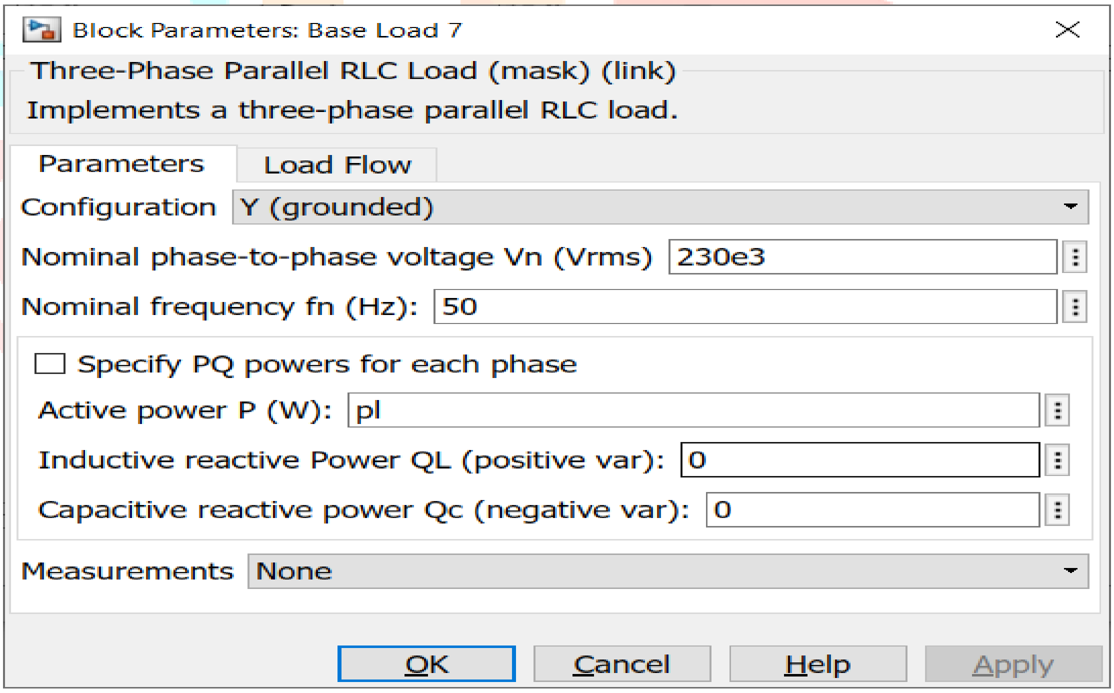
Core

Type: Three single-phase transformers

☐ Simulate saturation

Measurements: None

Three phase transformer



Block Parameters: Base Load 7

Three-Phase Parallel RLC Load (mask) (link)

Implements a three-phase parallel RLC load.

Configuration: Y (grounded)

Nominal phase-to-phase voltage Vn (Vrms): 230e3

Nominal frequency fn (Hz): 50

☐ Specify PQ powers for each phase

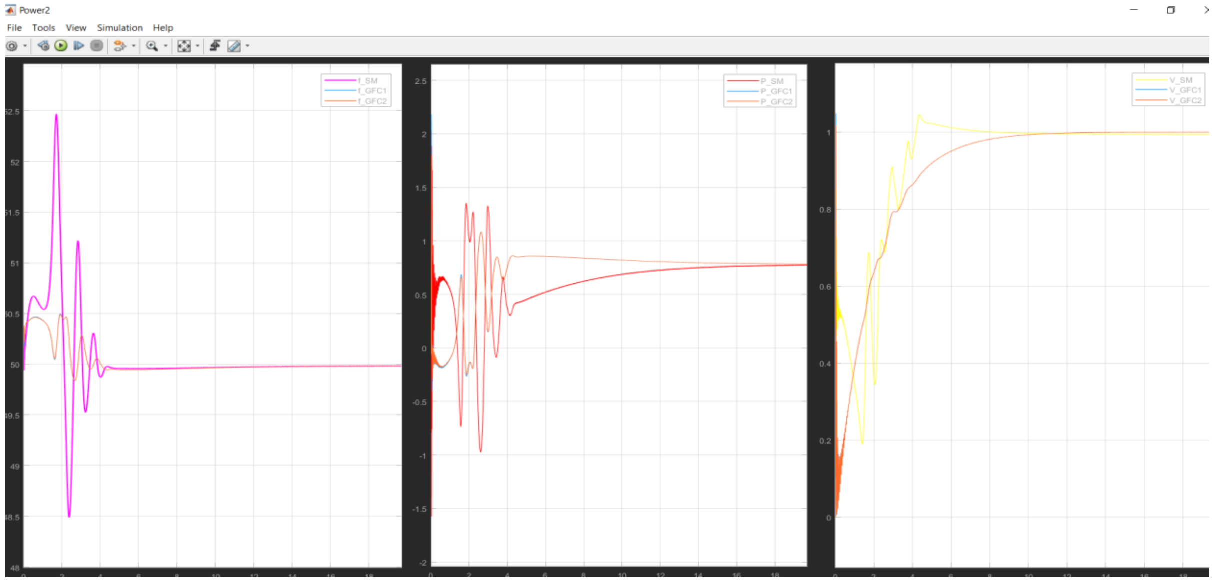
Active power P (W): pl

Inductive reactive Power QL (positive var): 0

Capacitive reactive power Qc (negative var): 0

Measurements: None

Three phase RLC load



Transient stability of ieee 9 bus system (i) frequency stability (ii) power stability (iii) voltage stability

VII. CONCLUTION

To conduct transient stability analysis in the case of a 3-phase failure, Distributed Energy Generation (DEG) has been integrated into the IEEE 9-bus system. We examine the transient behaviour of the generators in the original scenario, which excludes the presence of Wind Turbine Generators (WTG) and fault clearing methods.

It is interesting to observe that throughout this examination, the generator swing angle reaches its maximum, shown by the symbol = 180°, and then stops moving for 3 seconds. Due to the significant current flow inside the generators, the maximum and lowest current values both noticeably rise during this stationary period. Generator G1, which functions as a slack bus generator and supplies reactive power to the system, is of special note. The maintenance of consistent voltage levels across the multiple buses, nevertheless, presents difficulties. When a 3-phase fault occurs at bus 8, the WTG maintains grid connectivity at the Point of Common Coupling (PoC). It keeps providing the electrical system with constant reactive power. We see a slow rise in terminal voltage after the fault is resolved after 1.114 seconds, finally reaching 98%. Due to the existence of residual transient currents that continue to exist inside the PoC, this voltage displays very small pulsations.

VIII. ACKNOWLEDGEMENT

This is a great pleasure and immense satisfaction to express my deepest sense of gratitude and thanks to everyone who has directly or indirectly helped me in completing our paper work successfully. I express my gratitude towards guide Mrs. G. Nithya who guided and encouraged me in completing the work in scheduled time.

IX. REFERENCES

[1] The authors are C. "Transient stability analysis of a combined cycle power plant using etap software," 2017 IEEE 7th International Advance Computing Conference (IACC), S. Kumari. 510–515 in IEEE, 2017.

[2] P. N. J. Balu, Kundur, and M. Power system stability and control, G. Lauby. (2009) McGraw-hill New York, vol. 7.

[3] Y. , and S. In Iwamoto's article "Transient stability preventive control for stable operating condition with desired cct," published in IEEE Transactions on Power Systems, vol. 17, no. 4, pp. 1154-1161, 2002

[4] J. In addition to L. International journal of electrical power & energy systems, vol. Mili, "Dynamic gradient method for pebs detection in power system transient stability assessment," 23, no. 2, pp. 155-165, 2001.

[5] Z. "Issues of connecting wind farms into power systems," in IEEE/PES Transmission & Distribution Conference & Exposition: Asia and Pacific, by Chen. IEEE, pp. 1-6, 2005

[6] E. A. Muljadi, B. Parsons, C. Butterfield, and M. National Renewable Energy Lab (NREL), Golden, CO (United States), Tech. Ellis, "Characteristics of wind turbines under normal and fault conditions," Rep., 2007

[7] B. S. and Singh. Wind power connectivity into the electricity system: A study of grid code requirements, Singh

[8] B. S. N. Singh, L., S. Rajpurohit, and S. "Electric grid connection and system operational aspect of wind power generation," by Wang, Wind Energy Conversion Systems. 2012, Springer, pp. 267–293.