FAULT ANALYSIS ON AN INTERCONNECTED POWER SYSTEMNETWORK USING POWER SYSTEM STABILIZER

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ABSTRACT

In this study, the fault responses on power system networks, the impact of power system stabilizers on current as well as bus voltages on machines and affected buses in the Nigerian Grid System (NGS) and the IEEE 9-bus network was considered. In order to achieve this aim, load flow analyses was carried along the network to determine the natural flow of power thereafter, codes were written on the MATLAB environment to analyze the effect of three-phase faults along the network at various buses. The results from the study show that the system loss synchronism and was therefore unstable at the occurrence of a three phase short circuit fault without the presence of PSS. For stability of the network to be regained therefore, it was observed that faults of this type should be cleared within the first 0.16s. It was also shown that prior to introducing supplementary control in the form of PSS; the system was unstable but regained stability within 4-10s after the incorporation of PSS.Conclusively, the mean percentage deviation or change for current and voltage at the IEEE 9-bus system are 11.1 and 53.4 respectively. For the NGS, the average percentage current and voltage change in values are 29.4 and 11.8 respectively. The nonlinear simulations are presented for the selected power systems to validate the increased damping of currents and voltages experienced by application of Power System Stabilizers (PSS) to some selected buses with high oscillations was pronounced within 5s of fault clearing establishing enhanced power system dynamic.

Keywords: Bus, Fault, NGS, Power, PSS

INTRODUCTION

Nigeria electricity is transmitted at a frequency of 50Hz with an allowable tolerance margin of ±1.5. When the frequency reaches its minimum or maximum level, there is a risk of failure of the transmission lines. The breakdown of transmission lines due to over or under frequency is called power grid failure (System failure). This could be because of power overdrawn by excessive loading of the transmission lines(Olajiga and Tolulope, 2019). Transmission line network in a state or a country is called a grid and the specific grids connected via tie lines forms a regional grid while these regional grids further interconnected together form a country wide or national grid. Currently, in Nigeria, the primary transmission lines voltage is 330KV (i.e. national grid voltage) whereas the secondary transmission lines voltage is 132KV (regional grid voltage – Sub-transmission) (Idoniboyeobu et al., 2017). Given that most of the current generating stations in Nigeria are located far from the load centers with a partial longitudinal network, it is possible to experience low bus voltages, overloaded lines, frequency fluctuations and poor system damping within the network, thus rendering the network's stability fragile when fault occurs (Airoboman and Tyo, 2018).

The electrical power networks in all sectors such as generation, transmission, distribution, and load systems are increasing in size and complexity. During normal operating conditions, current flows through all components of the electrical power network under pre-designed values acceptable to the ratings of those elements. By measuring the system voltages, any power system can be analyzed by calculating the system voltages and currents under normal and abnormal scenarios (Santamaria, 2011).The causes of faults are numerous such as lightning, heavy winds, trees falling across lines, vehicles colliding with towers, birds or aircraft hitting line or small animals entering switch gear, line breaks due to excessive loading. Types of faults such as short circuit conditions in the power system network result in severe economic losses and reduce the reliability of the electrical system (Gafari et al., 2017).

Faults can be described as the movement of a massive current through an unsuitable path that could cause catastrophic damage to equipment that would lead to power failure, personal injury, or death. Therefore, the voltage level can fluctuate which can impact the insulation of the equipment in the event of a rise or could cause equipment start-up failure if the voltage drops below a minimum level. Subsequently, the electrical potential difference of the system neutral will increase (Anderson, 1995). Hence, people and machinery will be exposed to the danger of electricity.Power system faults are categorized as single line to ground fault, line to line fault, double line to ground fault and balanced three phase fault. The investigation of power system faults was implemented to avoid such an occurrence. Power system faults may be classified as either symmetrical faults or asymmetrical faults. The fault involving all the three phases on the power system is known as a symmetrical fault or a balanced three-phase fault. Although the symmetrical faults are uncommon, they generally lead to the most severe current flow which the power system must be protected.

Nevertheless, most of the faults involved in the power system are unsymmetrical where the use of symmetrical components can be used to calculate voltages and currents in the system under such unbalanced operating conditions. Faults involving one or two phases are known as unsymmetrical fault. Single Line-to-ground, Line-to-line, and Double line-to-ground faults are unsymmetrical faults (Tijani and Olatunji, 2011).Power system fault analysis is the method of evaluating the magnitude of voltages and line currents during the incident of different types of faults. The frequency of these currents depends on the generator's internal impedance and on the interfering circuit impedance (Electricity Engineers Association, 2007). The analysis of faults leads to appropriate protection settings which can be computed in order to select suitable fuse, circuit breaker size, and type of relay – the ratings of protective switch gear and checking if it is adequate . Fault analysis can also be useful in estimating the size of additional reactors or fault current limiters that may need to be introduced into the network to limit short-circuit currents to a safe value below the ability of the circuit breakers installed (Seetharamayya, 2015).

The magnitude of the fault depends on the location of the short circuit, the direction taken by fault current, the impedance of the network and its degree of voltage. To ensure the continuity of power supply to all customers that is the core purpose of the life of power system, all defective parts must be temporarily isolated from the network by the protection schemes. When a fault exists within the relay protection zone at any transmission line, a relay will trip to open the circuit breaker thereby isolating the faulted line (Ghadban and Abdulwahab, 2015). Faults may occur when a phase creates a link with another phase, lightning, corrosion of the insulation, damage to the wind, trees falling over lines, etc. In addition, faults can be categorized as the shunt faults, series faults and simultaneous faults. When a fault occurs, the fault current will increase in magnitude, the total amplitude of fault current during a fault depends upon a variety of factors, such as fault type, network, fault resistance, failure causes load currents, short circuit levels etc. (Airoboman et al., 2020) . The extent of the fault current depends upon the generator and the network's internal impedance. When evaluating the power system under conditions of fault, a distinction must be made between the types of fault in order to ensure the best possible results during the analysis.

Review of Related Work

A calculation method which is an effortless technique for short circuit analysis was proposed (Gokulpure and Jain, 2015). The paper introduced conventional methods for the short circuit analysis of a power system and provides a study of the research work that had been done in the field of short circuit analysis. Mi power software is utilized which is highly featured and highly interactive. In (Chilakala and Rao, 2018), a test system (IEEE 14-Bus system) was considered, the maximum and minimum short circuit currents for three-phase and single line to ground faults applied at various buses was obtained in ETAP software and validated with hand calculation. In this work, the power flow direction was not considered. A simulation model of IEEE 14 bus system for short circuit studies and analysis of symmetrical fault using MiPower software was carried out in (Mahapatraand Singh, 2016). In comparison with simulation studies done earlier with other software tools, the result of this paper is better as it provides detailed information for fault current, fault MVA, post fault voltages at all the buses, values of making and breaking current, contribution of various elements towards the fault. Furthermore, it gives complete system behavior during occurrence of three phase faults although the power flow direction was not considered.

Three phase symmetrical fault which was simulated on the Nigerian 330kV National Grid using Nigerian 24 bus power system from Power Holding Company of Nigeria was worked on in (Adepoju and Komolafe, 2013). Two separate programs based on MATLAB were written; one was for Load Flow Studies to determine pre-fault conditions based on Newton-Raphson process, while the other was for short-circuit three-phase studies. Load flow analysis was carried out on the Nigeria power system to determine the steady state values. The results of the fault analysis were used to determine the circuit breaker ratings for the power system. In this work, the buses were chosen and analyzed for only 3 phase faults only. In this study, (Shiva et al, 2017) fault analysis and both symmetrical and unsymmetrical faults was conducted and studied. The fault analysis codes are normally able to generate accurate results based on the input data defined by the theory of symmetrical components. It is noted that only symmetrical fault analysis can disclose the post fault bus voltages while the unbalanced faults analysis can only generate results for total fault current, bus voltages and line currents during the fault. Right component modeling and proper fault analysis are essential to ensuring safety and reliability in power systems. Fault analysis enables to determine the change in system parameter due to a fault and the variation in supply by various sources to loads and enables the determination of the critical and noncritical elements of a power system.Computation of fault currents in power system is best done by computer. Computer formulation is accomplished by programming. In the utmost of fault calculation techniques, pre-fault, or load, component of current is neglected typically because currents are zero previous to the fault, this is never severely true; however the error produced is minor, since the fault currents are usually much greater than the load currents. A study on comparison between different software used for power system and fault analysis was performed in (Selvan and Anita, 2017).

The comparison is focused on user-friendliness, accessible modules, specific equipment models, special equipment, bus limitations, and cost. In this paper, he has taken on applications such as Mi Power, ETAP, Easy Power and Power World and evaluated their results. In that, real-time data were taken to analyze the Mi Powerand ETAP software output. Guidelines and comparison provided in this paper will be a revelation for new user to select the right software. According to Folarin and Sakala (2017), a detailed description of the integration of faults in distribution network systems (DNS) was presented. Simulation and modeling are carried out using MATLAB/Simulink software package. The suggested model is user friendly and can be used as a common platform for manufacturers of both control and power systems. A new simulation technique of the integration of faults in distribution networks was introduced in this paper. The method used to develop the simulation environment was MATLAB / Simulink. The strength of this simulation method falls in the ability to study the effect of different kind of faults on the system behavior and its flexibility in building different kind of faults and ability to appraise the gravity of effect on network systems and assist to validate the results of reliability appraisal using real data from IBEDC which was used as the case study.

MATERIALS AND METHODS

The power system models used in this study are the IEEE 9-bus test network and NGS 40-bus network. Both confirm the effect of PSS on damping of oscillations after fault clearing.The IEEE 9-bus test system consists of 3 generators, 9 buses and 9 transmission lines. Bus 1 is a slack bus; buses 2 and 3 are generator buses while bus 4-9 is load buses. In Figure 1, the single line diagram data of the IEEE 9 -bus system is presented. Also, the data for the NGS was collected from the National Control Centre (NCC), the record showed has a total number of eleven (11) power stations with available capacity of 4000MW. The single line diagram of the NGS is presented in Figure 2 which is essentially an 11-Machine, 40-Bus System.

Power Flow and Fault analysis Program Development

The research methodology encompasses the he power system network parameters that will be required in this work include: Bus data, Generator data, Transmission line data, Transformer data and Load data. The power system models are developed for the analysis using these parameters for each element in the network. Power flow or load flow studies are performed to determine pre-fault conditions (fault currents and voltages) of the simulated model using the Newton- Raphson method. The fault analysis was carried out with the aim of identifying the magnitudes of fault output parameters like currents, voltages, machine angles and speed along with bus voltages. This method is carried out for both a test system and the real-life power system. The proposed analysis of the fault condition is performed in the following order:

i. Represent the given power system by its positive, negative, and zero-sequence networks (the zero-sequence network is omitted for faults without earth, and both the negative and zero-sequence networks are omitted for the balanced three phase fault condition). This representation requires the calculation of per unit (p.u.) impedances for generators, transformers, lines, cables, and other elements of the power system.

ii. Reduce each of the sequence networks to its simplest form. The equivalent positive, negative, and zero-sequence networks are represented as a series and series-parallel combinations of the p.u. impedances. For each sequence network these are replaced by the single equivalent impedance. The use of the delta-star or star-delta transformations may also be involved.

iii. Use appropriate symmetrical-component equations to find faulty phase sequence components of the current under a specific short-circuit condition.

iv. Determine the required p.u. phase-current values at the point of fault.

v. Calculate the real phase-current values by multiplying the obtained p.u values by the base current at the fault point. This is done to identify buses and generators that produce high oscillations.

vi. Step (i) to (v) is repeated with PSS added to the generators of the power system.

vii. A plot of the values of the rotor angle, speed, and bus voltage magnitude against time for the power system with and without PSS simultaneously to compare and understanding the responses after the fault is cleared.The process listed above is represented using the flow charts as presented in Figure 3.

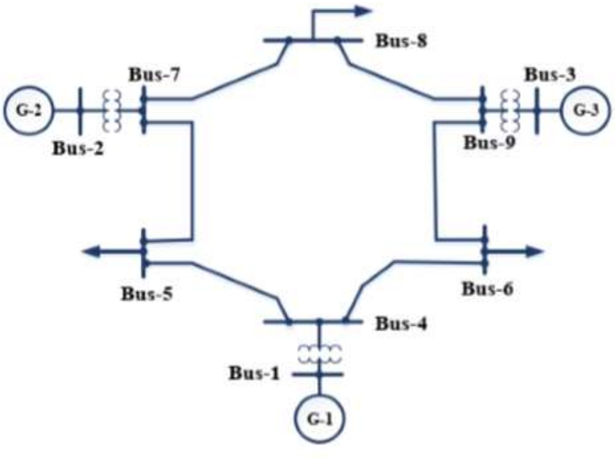

Figure 1: Single line diagram of the IEEE 9-Bus.

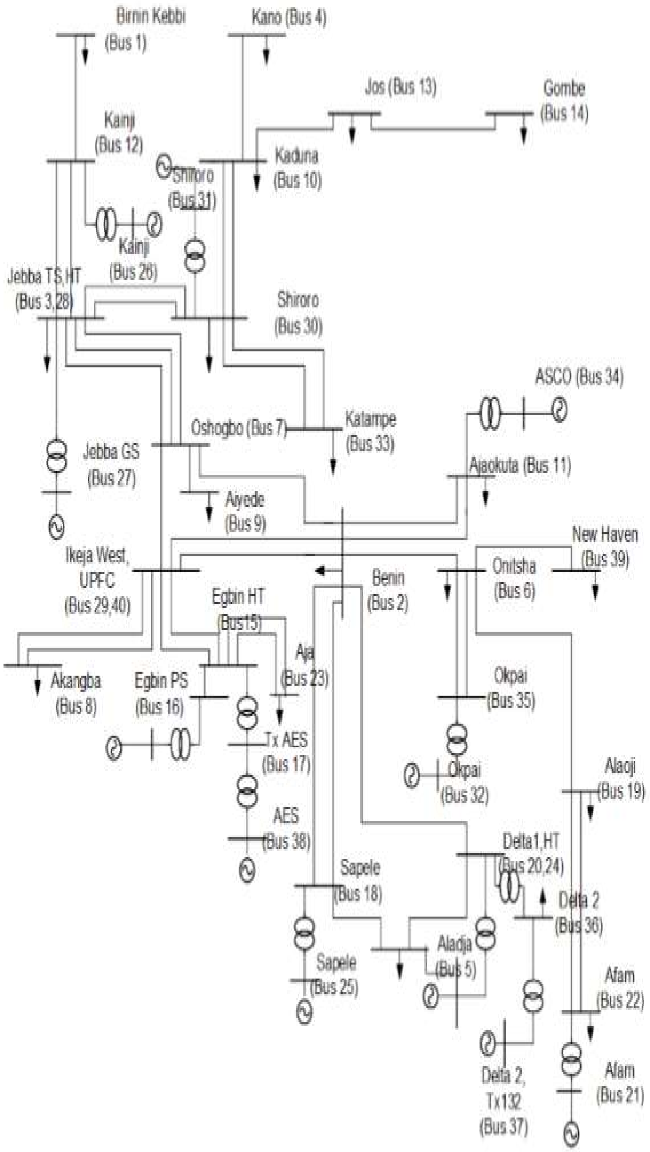

Figure 2: The NGS.

The load flow for the network was carried out in accordance with [18] – [19] as presented in equations (1) – (2)

Generally,

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}J_1 J_2\\ J_3 J_4\end{bmatrix}\begin{bmatrix}\Delta\delta\\ \Delta|V|\end{bmatrix} \tag{1}$$

The expressions J_1, $J_2 J_3 and J_4$ are elements of the Jacobian matrix (J) and are represented as The Jacobian matrix are then computed using partial derivative of equationsas

$$\begin{bmatrix}\Delta P_i^k\\ \vdots\\ \Delta P_n^k\\ \hline \Delta Q_i^k\\ \vdots\\ \Delta Q_n^k\end{bmatrix} = \left[\begin{array}{c|c}\begin{bmatrix}\frac{\partial P_i}{\partial\delta_i}\cdots\frac{\partial P_i}{\partial\delta_n}\\ \vdots\ddots\vdots\\ \frac{\partial P_n}{\partial\delta_i}\cdots\frac{\partial P_n}{\partial\delta_n}\end{bmatrix}^{(k)} & \begin{bmatrix}\frac{\partial P_i}{\partial|V_i|}\cdots\frac{\partial P_i}{\partial|V_n|}\\ \vdots\ddots\vdots\\ \frac{\partial P_n}{\partial|V_i|}\cdots\frac{\partial P_n}{\partial|V_n|}\end{bmatrix}^{(k)}\\ \hline \begin{bmatrix}\frac{\partial Q_i}{\partial\delta_i}\cdots\frac{\partial Q_i}{\partial\delta_n}\\ \vdots\ddots\vdots\\ \frac{\partial Q_n}{\partial\delta_i}\cdots\frac{\partial Q_n}{\partial\delta_n}\end{bmatrix}^{(k)} & \begin{bmatrix}\frac{\partial Q_i}{\partial|V_i|}\cdots\frac{\partial Q_i}{\partial|V_n|}\\ \vdots\ddots\vdots\\ \frac{\partial Q_n}{\partial|V_i|}\cdots\frac{\partial Q_n}{\partial|V_n|}\end{bmatrix}^{(k)}\end{array}\right]\begin{bmatrix}\Delta\delta_i^k\\ \vdots\\ \Delta\delta_n^k\\ \hline \Delta|V_i|^k\\ \vdots\\ \Delta|V_n|^k\end{bmatrix} \tag{2}$$

The linear relationship between changes in the phase angle $\Delta\delta_i^k$and change in magnitude of bus voltage $\Delta|V_i|^k$ with little changes in active and reactive power $\Delta P_i^k and \Delta Q_i^k$ has been given by the Jacobian matrix (J).

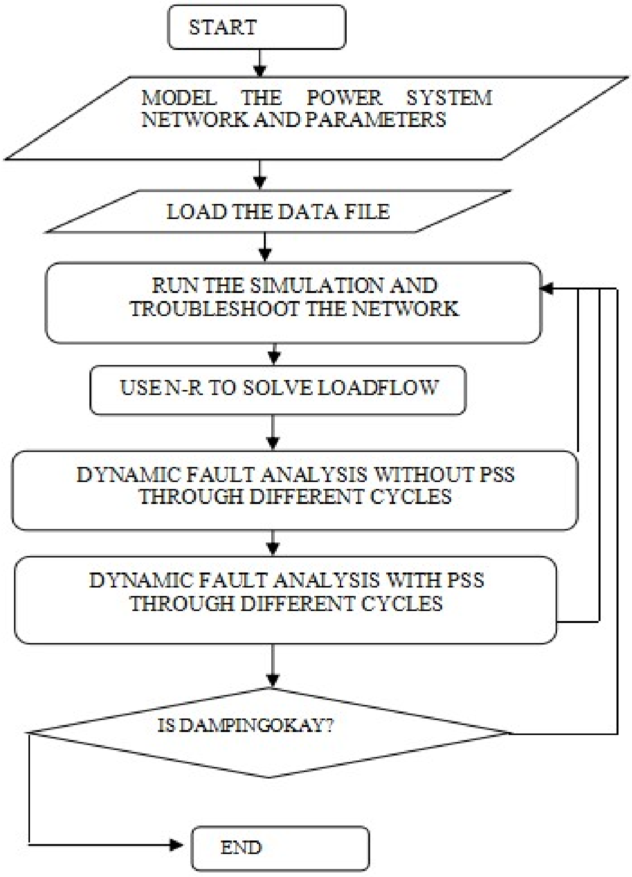

Figure 3: Flow chart for the proposed fault analysis.

RESULTS

The evaluation of fault response of the power system using the damping levels is expressed using graphs for clarity. If the duration of the fault is too long before being cleared, there is a risk of the system losing its equilibrium and stability tending to infinity. To verify and demonstrate the system has been simulated for fault clearing times equal to 3, 5, and 8 cycles and a of plot made for 3 phase faults on selected buses. In three-phase fault, the voltages at every bus dropped to zero during the fault.The Percentage change (Δ%) is calculated using equation (3)

$$\Delta\% = [(PSS_{new} - PSS_{old}) / PSS_{old}] \times 100 \qquad (3)$$

where PSS_{new} is the peak value with PSS and PSS_{old} is the peak Value without PSS.

IEEE 9-Bus

This test system consist of three (3) machines, nine (9) transmission lines and nine (9) buses is studied, to compare the response of some buses to three phase short circuit fault with and without power system stabilizers to aid damping of oscillations. The results obtained from the preliminary analysis of the 9-Bus test system are presented in Tables 1 – 2.

Table 1: Currents after fault clearing for IEEE 9 bus test system.

Bus	Line	Percentage Change (%)	Cycle
7	L3	2.2	3
7	L3	15	5
7	L3	12.5	8
7	L7	14	3
7	L7	45	5
5	L7	10	8
5	L7	12.5	3
5	L7	5.2	5
5	L7	40	8
5	L9	15.7	3
5	L9	2.7	5
5	L9	10	8

Table 2: Voltages after fault clearing for IEEE 9 bus test system.

Bus	Line	Percentage Change (%)	Cycle
2	7-8	44	3
2	7-8	12.5	5
2	7-8	33.3	8
2	3-9	25	3
2	3-9	25	5
2	3-9	25	8
7	3-9	25	3
7	3-9	25	5
7	3-9	25	8
1	5-7	90	3
1	5-7	70	5
1	5-7	50	8
3	5-7	70	3
3	5-7	50	5
3	5-7	80	8
5	5-7	66.6	3
5	5-7	80	5
5	5-7	33.3	8

The fault was createdat 0.2s while its clearance by associated breakers took place at 0.22s on the Matlab environment. It was noticed that most of the generators could only stay in synchronism up to 5.0 seconds. The fault was setup to occur at 0.22s while its clearance was actuated at 0.28s, 0.32s and 0.38s (i.e. the system has 0.06s, 0.10s and 0.16s clearing times). The simulation time of 10s was adopted.The IEEE 9-bus system has been studied. The most affected buses are buses 2 and 3 which extend to transmission lines 7-8, 3-9 and 5-7 as presented in Table 2. These buses are connected to machines or generators which were damped properly with the use of PSS within first five seconds of fault clearance and were less affected. It is apparent that from Table 1that PSS improved the current deviation with a 2.2 % change in the line from bus 7 in 3 cycles but took longer the other cycles (5 cycles and 8 cycles). Also, from fault on line 3-9, bus 2 and bus 7 experience mild damping with 25% change in voltage oscillating within 1 and -1 pu. Furthermore, voltage at bus 1 damps quickly in 3 cycles with a 90% change. A similar response is obtained for bus 3 and bus 5 of line 5-7. The PSS put on machine 2 is most effective as it reduced the oscillations the most on line 7-8 of the power network with an average percentage change of approximately 30%. Figure 6 shows that bus 2 voltage stays between 1 and -1 pu which is lesser in magnitude than the system without PSS beginning from 3 cycles. Bus 5 on the same line experiences a decrease in oscillations early in 3 cycles but continues to oscillate in 8 cycles as shown in Figures 7 - 9. A similar result was obtained for current on line 9 as presented in Figures 10 - 12.

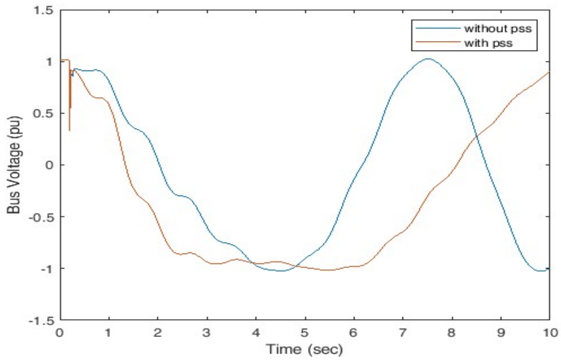

Figure 4: Voltage at bus 2 on line 7-8 for 3 cycles.

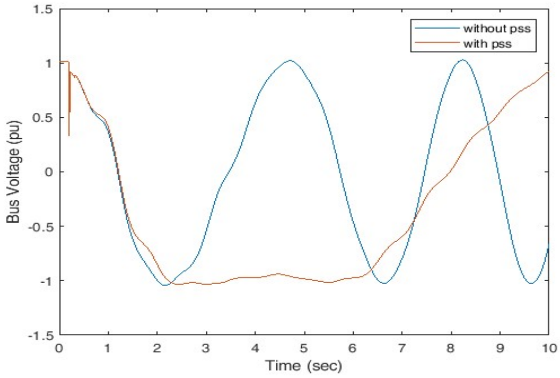

Figure 5: Voltage at bus 2 on line 7-8 for 5 cycles.

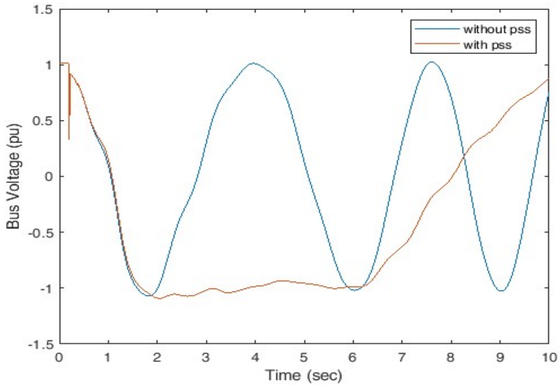

Figure 6: Voltage at bus 2 on line 7-8 for 8 cycles.

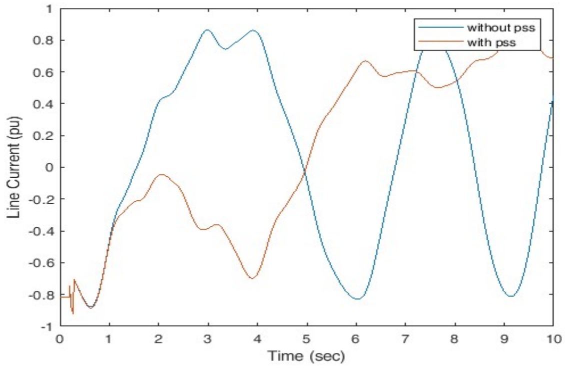

Figure 7: L7 current on bus 5 for 3 cycles.

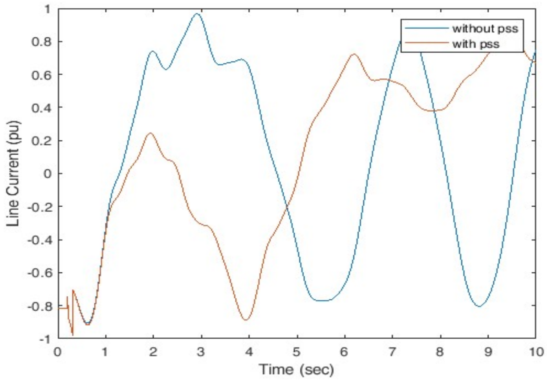

Figure 8: L7 current on bus 5 for 5 cycles.

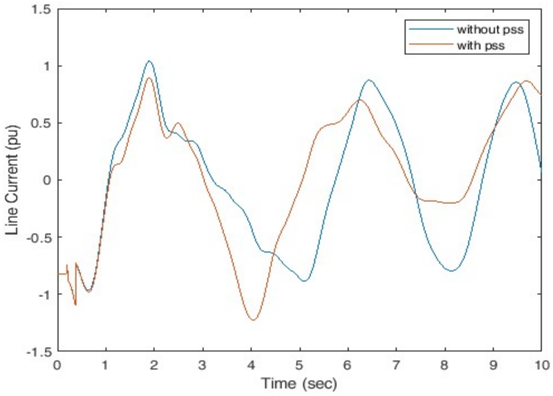

Figure 9: L7 current on bus 5 for 8 cycles.

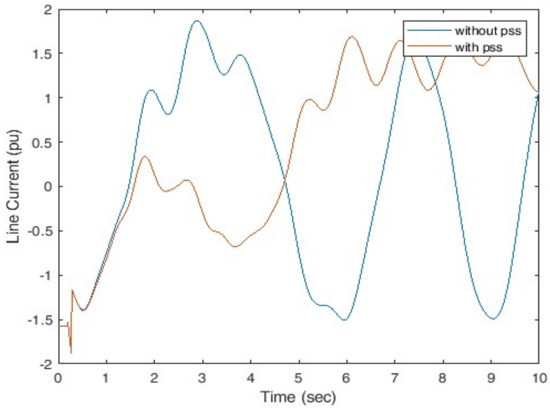

Figure 10: L9 current on bus 5 for 3 cycles.

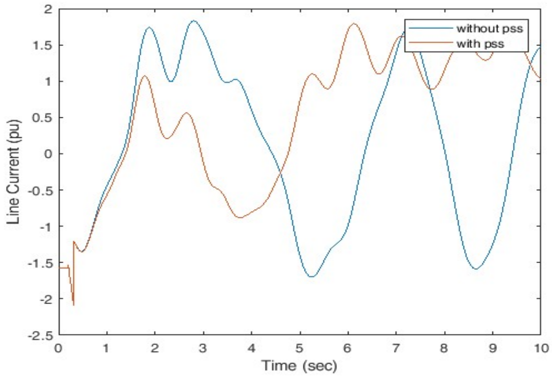

Figure 11: L9 current on bus 5 for 5 cycles.

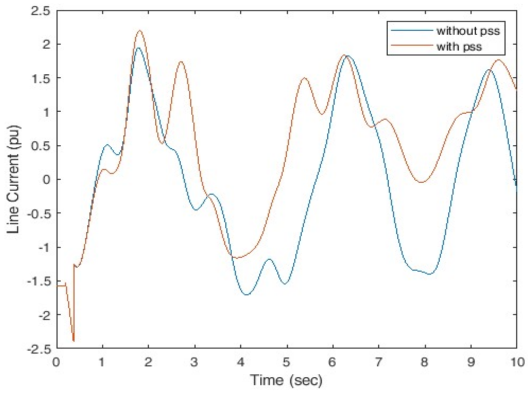

Figure 12: L9 current on bus 5 for 8 cycles.

Nigerian 40-Bus network

The 40-bus Nigerian national grid network has been studied. The machines that were affected the most are machines 1 (AES), 3 (Delta 2) and 7 (ASCO). The bus voltages were said deviate from normalizing. The buses attached to the other machines or generators were damped properly with the use of PSS within five seconds of fault clearance and were less affected.The most affected buses are buses 2 (Benin), 5 (Aladja), 7 (Oshogbo), 19 (Alaoji), 24 (Delta HT), 36 (Delta 2) and 40 (Ikeja west) which extends to transmission lines 2-24 (Benin to Delta HT), 5-24 (Aladja to Delta HT) and 7-2 (Oshogbo to Benin) which were considered. These buses are connected to machines or generators were damped properly with the use of PSS within five seconds of fault clearance and were less affected. The results are presented in Tables 3– 4.

Table 3: Voltages after fault clearing for 40-Bus Nigerian national grid Network.

Bus	Line	Percentage Change (%)	Cycle
1	2-24	10	3
1	2-24	10	5
1	2-24	9	8
5	2-24	18	3
5	2-24	18	5
5	2-24	18	8
19	2-24	15	3
19	2-24	14	5
19	2-24	13	8
36	2-24	12	3
36	2-24	10	5
36	2-24	20	8
2	5-24	18.1	3
2	5-24	9	5
2	5-24	9	8
3	5-24	11.4	3
3	5-24	21	5
3	5-24	20	8
5	5-24	9	3
5	5-24	9	5
5	5-24	8	8
7	5-24	11.6	3
7	5-24	10	5
7	5-24	9	8
24	5-24	8	3
24	5-24	9	5
24	5-24	11.1	8
40	5-24	20	3
40	5-24	9	5
40	5-24	8	8
1	7-2	4.4	3
1	7-2	4.6	5
1	7-2	12.5	8
3	7-2	4.2	3
3	7-2	4.5	5
3	7-2	4.6	8

Table 4: Currents after fault clearing for 40-Bus Nigerian national grid Network.

Bus	Line	Percentage Change (%)	Cycle
2	L1	8.9	3
2	L1	10.2	5
2	L1	3.2	8
2	L16	17.1	3
2	L16	17.1	5
2	L16	83.3	8
2	L39	33.3	3
2	L39	30.7	5
2	L39	40	8
5	L1	15.8	3
5	L1	11.7	5
5	L1	14.3	8
5	L16	32	3
5	L16	33.3	5
5	L16	5.8	8
7	L1	80	3
7	L1	82	5
7	L1	85	8
7	L39	18.6	3
7	L39	18.1	5
7	L39	4.4	8

The normalizing effect of PSS is evident in the voltage responses of bus 1 current on bus 5 that stabilizes with time increase and the system goes towards stability independent of PSS on its own with a percentage change of 14% through all the cycles For line 16 current on bus 5, PSS was effective on all clearing times. The same response was obtained for voltage (approximately 1 pu) and average change of 8.7% on bus 2 and bus 5 for line 5-24. Also, Voltages (approaches 1 pu) on bus 3 (20% change) and bus 7 (9% change) experience the most effective damping at 8 cycles of clearing fault. Table 3 presents voltages at bus 24 and bus 40, the results showed that the impact of the PSS in the system is visible and effective in the voltage responses of bus 24 (9.4% mean change) and bus 40 (12.3% mean change) both of which remain at 1 pu. Line 1 and line 39 current from bus 7 deviation suffers strong oscillations and the PSS proves ineffective in this case as depicted.The PSS damping action was minimal for all cycles for voltage on bus 1 (7.2 % change on average) and bus 3 (Average 4.4% change) for fault on line 7-2 as it will take longer for the oscillations to die out. For bus 5 from line 2-24, oscillations begin to straighten out on 3 cycles and more at other cycles consistently. Same results were obtained for voltage on bus 19 and bus 36 with value approximate to 1 pu. Figures 13-15 presents the power system stabilizing action as clearing time increases and ripples the more without PSS for line 1 current from bus 2 with percentage change of 7.43. The same response was obtained for line16 (Average 39.2%) and line 39 (Average 34.7%) currents from the same bus as depicted in Figures 16 - 21. Voltage oscillations (less than 1 pu) on bus 1 increases slightly and smoothly with PSS while the power system continues to oscillate as presented in Figures 22 – 24.

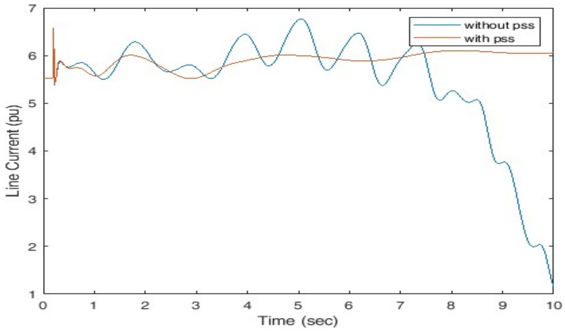

Figure 13: L1 current on bus 2 for 3 cycles.

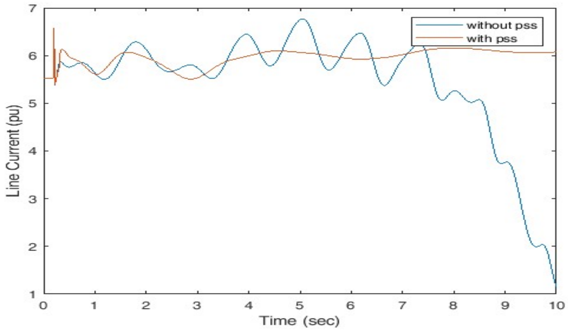

Figure 14: L1 current on bus 2 for 5 cycles.

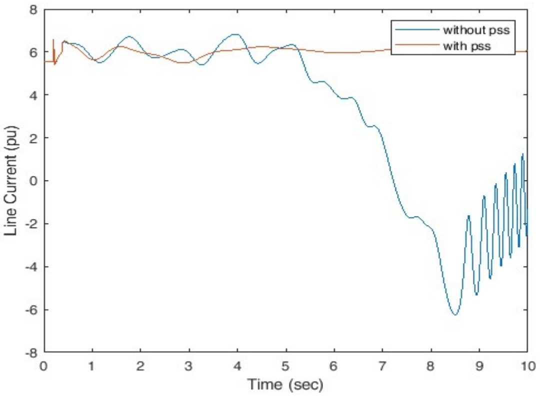

Figure 15: L1 current on bus 2 for 8 cycles

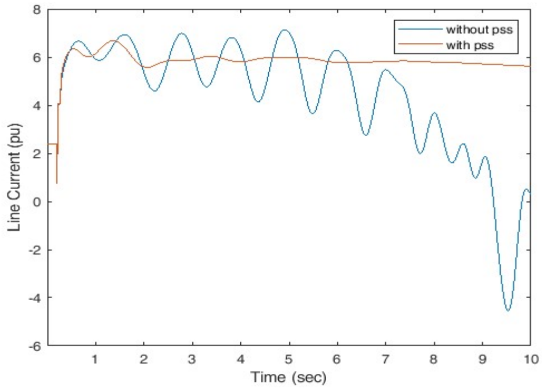

Figure 16: L16 current on bus 2 for 3 cycles.

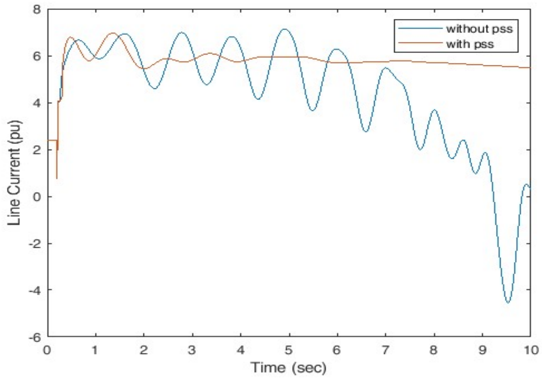

Figure 17: L16 current on bus 2 for 5 cycles.

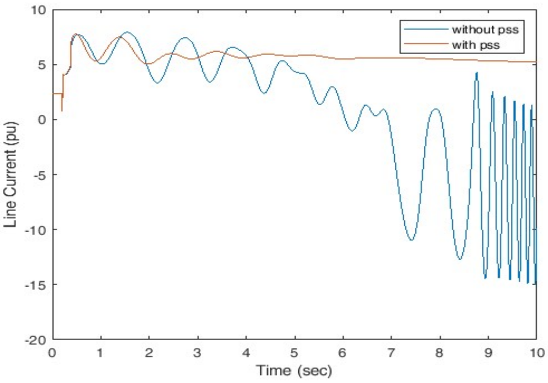

Figure 18: L16 current on bus 2 for 8 cycles.

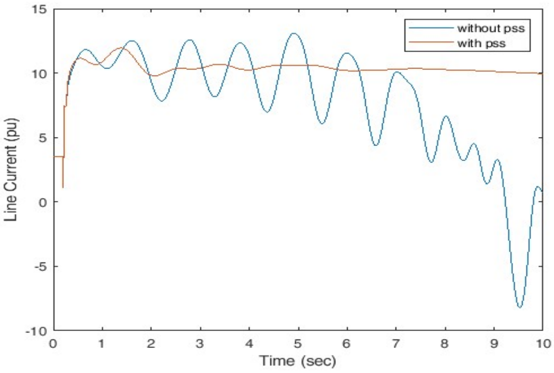

Figure 19: L39 current on bus 2 for 3 cycles.

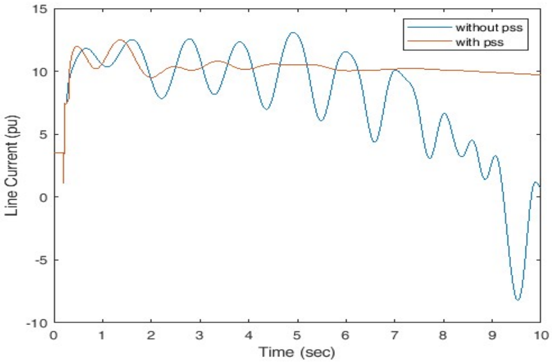

Figure 4.20: L39 current on bus 2 for 5 cycles.

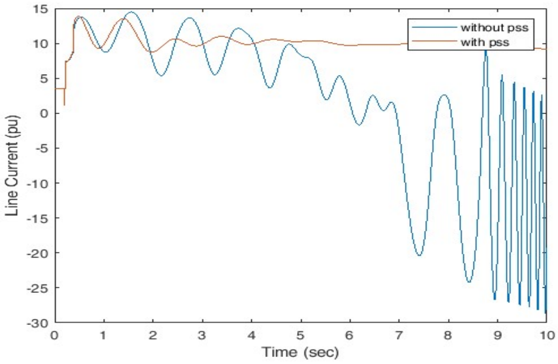

Figure 21; L39 current on bus 2 for 8 cycles.

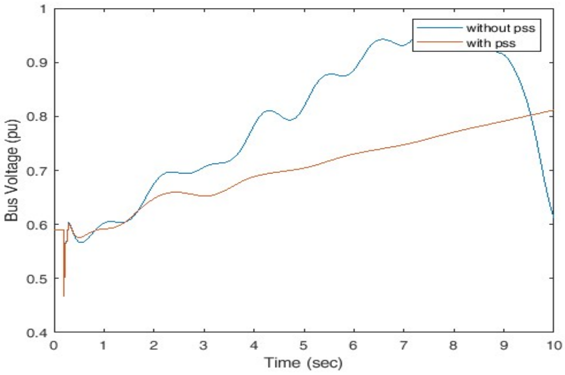

Figure 22: Voltage at bus 1 on line 2-24 for 3 cycles

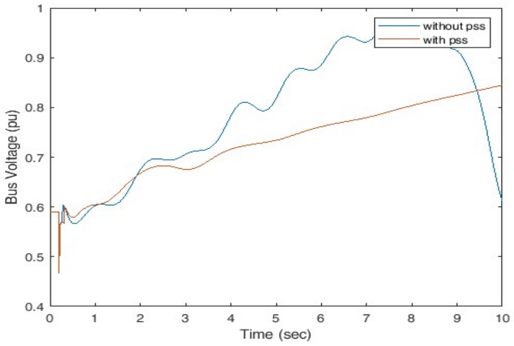

Figure 23: Voltage at bus 1 on line 2-24 for 5 cycles.

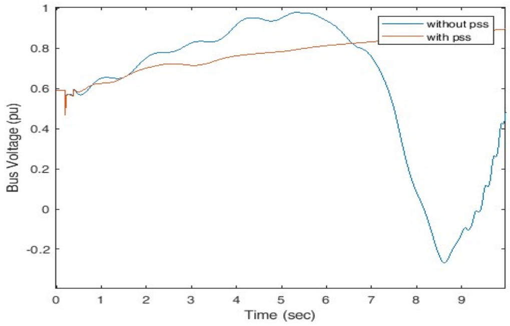

Figure 24: Voltage at bus 1 on line 2-24 for 8 cycles.

Generally, the observations made based on the results obtained from the analysis indicate 330kV lines were affected by the thee phase fault as is evident in poorly damped oscillations. For severe disturbance such as three-phase short-circuit, the research results show that when PSS is not equipped, despite applying the measures such as removal of fault components, the system still lost its stability. In a nutshell, for the stability of power system to be maintained after the occurrence of faults, protection systems in the network should clear faults within first 0.16s of fault occurrence. For the lines that don't stabilize after this timing of fault occurrence, power system stabilizers are applied to such generators with affected buses to improve the stability of the sample power system and also in the Nigerian Power system evidenced by power system oscillations damping out. It can be shown that before introducing supplementary control in the form of PSS, the system was unstable while after installing PSS, line currents and bus voltage magnitude are getting stabilized within 4 -10 seconds.

CONCLUSION

With the non-linearity of power system, oscillations from fault conditions are unavoidable but control is desired. This research work was undertaken to investigate fault analysis with different clearing fault times and as a result, a systematic procedure for modeling and simulation of power systems installed with and without PSS was designed and evaluated. The model is developed in the MATLAB/PST environment which provides a means for carrying out power system fault analysis and for explaining the generator dynamic behavior as effected by PSS. Based on the analysis of the obtained results, it can be said that in an interconnected power system if there is a fault occurring at a bus, all the system voltages and system currents are affected and must be improved otherwise it will create fault of circuit parameters to other lines. The first swings in the current and the bus voltage are also suppressed, and the settling time is reduced with the simultaneous design approach. The outcome of this research study impacts positively on the protection and stability of supply in the nation's power system and also its economic growth and security by developing counter-active and proactive systems thereby eliminating irregularities that are presently experienced and it serves as a basis for further analysis of the power system.

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