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The Effect of Application of Artificial Neural Network (ANN) in Restoration of Power Failure in 330KVA Lines

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ABSTRACT

Power system failure/blackout is a major problem we face in the country. When they occur, the negative effects on commerce, industry and everyday life of the general population can be intense. The essence of this research work is to bring about the effective power restoration in the Nigerian national grid system using the Artificial Neural Network Intelligence

Nigerian 330kV Network was modeled for the south eastern part of the system. The entire network was modeled in PSAT and the south eastern part was mapped out and modeled with power library in MATLAB SIMULINK. The current signal of the system without fault occurrence was presented. The output result from the initial data was encouraging. This proves that with the use of artificial neural network on our nation 330kva Line grid will bring a great solution to power failures we encounter most at time on our Power lines.

KEYWORDS: PSAT, MATLB SIMULINK, Artificial Neural Network ANN, High Voltage Transmission Lines HVTL, Power Restoration

1. INTRODUCTION

Power is the transmission of energy from one form to another and vice versa.

The Power plant generates the power which is step-up or step-down through the transformer for transmission. The transmission line transfers the power to the various substations. Through substation, the power is transferred to the distribution transformer which step-down the power to the appropriate value which is suitable for the consumers

The High Voltage Transmission Lines (that transmit the power generated at the generating plant to the high voltage substations) are more prone to the occurrence of a fault than the local distribution lines (that transmit the power from the substation to the commercial and residential customers) because there is no insulation around the transmission line cables unlike the distribution lines. The reason for the occurrence of a fault on a transmission line can be due to several reasons such as a momentary tree contact, a bird or an animal contact or due to other natural reasons such as thunderstorms or lightning. Most of the research done in the field of protective relaying of power systems concentrates on transmission line fault protection due to the fact that transmission lines are relatively very long and can run through various geographical terrain and hence it can take anything from a few minutes to several hours to physically check the line for faults.The automatic location of faults can greatly enhance the systems reliability because the faster we restore power, the more money and valuable time we save(Jen HaoTeng etal., 2014). Hence, many utilities are implementing fault locating devices in their power quality monitoring systems that are equipped with Global Information Systems for easy location of these faults.

Fault location techniques can be broadly classified into the following categories:

1. Impedance measurement-based methods
2. Travelling-wave phenomenon-based methods
3. High-frequency components of currents and voltages generated by faults-based methods Intelligence-based methods.

Therefore the application of artificial neural network to power system restoration is to make sure of a steady supply of electric power and fault diagnosis in power systems because the importance of electricity in our day to day life has reached such a stage that it is very necessary to protect the power system equipment from damage and to ensure maximum continuity of power supply.

2. OVERVIEW

Power Failure

In our modern world, it's easy to take certain things for granted. And one of the easiest things to take for granted is the invisible force that powers virtually everything in the home and industries: electricity. Since electricity has become such an integral part of everyday life, it's easy not to think much about it until it becomes unavailable. A sudden loss of electricity, otherwise known as a power outage, can negatively affect everything from working to cooking to being able to see at night. The worldwide electricity power grid is robust in most populated areas, designed to withstand the physical elements and human errors that can potentially shut down the system. While this works most of the time, sometimes the system fails and power goes out. Power outages are what occur when electricity — particularly the electrical power network, or electrical grid — is unavailable. There are many different causes for power outages, but the thing they all have in common is that they affect whole areas or regions, not just a single home. There are many causes for why power outages occur. However, the three most common causes are natural causes, human error, and overload.

Basically, any interruption between power generation and the supply of electricity to homes can cause a power failure. It can stem from inclement weather conditions, human error, equipment failure, and even animal interference. Scheduled maintenance can also cause a power outage, though this is usually communicated to households in advance by the utility company.

Power Plants and Control Problems

A power plant converts energy from non-electrical to electrical form. Based on the energy transformation, the plants are classified as fossil, nuclear, solar, geothermal, hydro, etc. A plant consists of several generating units which work together to meet the electric load demand. For a fossil power plant, each unit consists of three basic components: the boiler, the turbine and the generator. The complexity of the operation comes from the variability of the load, and the high efficiency demanded over a wide range of operation. The main difficulties for the control task then arise by the high coupling among the process variables and the non-linearities of the process. Fossil plants at the beginning were designed to operate over a base-load. Single input - single output controllers were used. Control strategies using requirements at that time. However, the high growth of the demand, the fuel crises and the new restrictions for environmental protection demanded different and more efficient types of operations for the electric powerplants.

In more detail, there are three types of operation:

*Base-load *Load-following *Cyclic

*Base-load operation: This mode of operation is in general the most economic for the plants. Plants operate at fixed demand, at maximum capacity, with variations no bigger than 15-20% of nominal capacity over long periods of time (months). Plants in this mode basically require regulators or steady-state controllers.

*Load-following operation: Plants in this operation mode, along with those operating in cyclic operation are responsible for maintaining the fixed frequency at 60Hz.These plants absorb the fast and random load changes that occur during the day. The Automatic Generation Control (AGC) plays a very important role in these plants.

*Cyclic operation: In this mode of operation, plants follow the slow load variation during the day. Typically, they are old plants that have lost their economic advantages. Their main characteristic is the ability to start up and stop at their quired times.

In order to achieve the objectives of the cyclic and load-following operation modes, modern control techniques are needed. As a perspective and historical point of view, EPRI indicated the importance and necessity to begin to use multi-input multi-output (MIMO) control techniques in power plants.

Modern multi variable techniques were classified as:

*Modeling and Simulation

*Multivariable Control Systems Design and Analysis

*Multivariable Estimation Design and Analysis

It is interesting to note that these techniques had proved to be useful in process control and aerospace problems a long time ago. However, for the electric industry in 1981 they were considered new. Some of the reasons of the reluctance of the power industry were:

*Designed control systems had "proved" to be adequate

*Costs associated with simulation and modeling of multivariable control system was high

*Problems in design and implementation of such control systems were anticipated.

At present, these arguments are no longer valid, and modern control techniques are providing some answers to the new operation problems.

Types of Power Failure/Outage

A. Blackout

A blackout is a complete loss of power to an area. This is the most severe type of power outage, typically affecting large numbers of people over sometimes incredibly large areas. Blackouts usually result from major damage to electrical generation facilities (such as structural damage from violent wind storms or lightning strikes) and are particularly difficult to fix quickly — this is why these types of outages can last for several weeks in the worst-case scenarios.

B. Brownout

Brownouts typically occur if there is a drop in electrical voltage or a drop in the overall electrical power supply. The term for these types of outages derives from the dimming that happens to lights when the voltage sags. While brownouts do not cause a complete loss of power, they can cause poor equipment performance and some devices — such as hair dryers or electric ovens — may not operate with the lowered voltage during one of these outages.

C. Permanent Fault

A permanent fault is a sudden loss of power typically caused by a power line fault. These are simple and easy to deal with: once the fault is removed or repaired, power is automatically restored. This type of outage typically doesn't affect large areas as it tends to trip up lines that are further down the supply line to homes. While larger blackouts and brownouts are caused by problems in the generation, this is caused by problems in the supply mechanism, which are usually easy to find and simple to fix.

D. Rolling Blackouts

Rolling blackouts are much different from the other three as they are planned power outages. These are usually implemented in areas with unstable grids or with infrastructure that cannot handle the population it serves. Rolling blackouts can also be caused if there's not enough fuel to run power at full capacity, whether for the short term or long term.

Factors Influencing Power Failure includes:

Storms, especially ones involving wind, are the leading cause of power outages, but there's a very unlikely cause that is responsible for many more power outages than you probably realize. Every year, more than one thousand power outages are reported, on average, due to electrical failures caused by animals. In fact, squirrels are responsible for up to 30% of power outages in some areas!

Reporting and Tracking Failures

Reporting and tracking power failure is essential to understanding them and how they progress over time. It also provides quick power restoration in instances that involve permanent faults. Below are some ways to report and check power outages in your area.

How Do You Report Power Failure?

Reporting power failure/outages is simple and straightforward. All you need to do is locate your local Transmission and Distribution Service Provider (TDSP) and call them from a phone that's working during the outage. You can also call your TDSP if you require support restoring power to your home.

Reliable electrical power is very important. Plans for economic development in developing countries are incomplete without including planned reliable electricity supply. This is virtually indispensable in modern society and requires dependable generation, transmission and distribution stages. For grid systems, there is an interrelation between weather events and outage events; an increase in weather events leads to an increase in the rate of grid fault occurrence. This makes the supply less reliable with higher maintenance costs. To solve this problem, electricity outage predictive models that are dependent on weather events are important for reliable and efficient electricity supply.

Perspective of Power Systems

While Power Plant topics mainly concern electric power generation, those corresponding to Power Systems concern transmission, sub transmission and distribution of electric power. An Electrical Power System (EPS) can be seen as a network of interconnected components with the purpose of:

- Converting non electrical energy into electrical form.
- Transforming electrical energy into a specific form subject to strict requirements.
- Transporting electrical energy over long distances
- Converting electrical energy into another energy form

The (EPS) can be classified in five sub areas:

1. Generation
2. Transmission
3. Sub-transmission
4. Distribution
5. Use

1) Generation: represents the sources of Electrical Energy. It implies conversion of the energy from non-electrical form into electrical form. Power plants such as nuclear, geo thermal, solar ,are used for this purpose.
2) Transmission: Considers the movement of the power from generation sites to the areas of use (voltage range:115-765KV.and capacities:100-4000MVA)

3) Sub transmission: Saying "yesterday's transmission is today's sub transmission" (voltage range: 12-69KV. and capacities: less 100MVA)

4) Distribution: Considers the individual circuits from the substation to the customer's location (voltage range for primary distribution :2.4-12KV, for secondary distribution: 120,240,480V)

5) Use: All electrical devices which convert electrical energy into more usable forms such as light, heat, sound, motion of mechanical force etc.

Among the applications of ANNs (Artificial Neural Network Intelligence) in power systems, alternative solutions to problems related with security assessment, transient stability, load modeling, forecast and fault diagnosis have been proposed. To have a complete idea of the kind of problems, the applications areas are outlined in the subsections below.

System Security

System security corresponds to the ability of the power system to withstand some unforeseen but probable disturbances with the minimal disruption of service or its quality. Security assessment is a function that predicts the vulnerability of the system to possible events on a real time basis. Note the system being operated is different from that which was planned. Maintenance requirements, forced outages/failures, different pattern loads market he differences. Thus, the system security levels are constantly changing. Security assessment can be seen as an algorithm that forecasts the future evolution of the system assesses the probability of a security violation into determined period of time and determines if a preventive control action should be taken to prevent hazardous operating conditions.

The security assessments based on:

i. Knowledge of system dynamics

ii. Measurement of system variables

iii. Models for measurement uncertainty and system disturbances

iv. Well-defined criterion for security.

Maximal admissible currents of the transmission give the boundaries of the secure domain of the states pace (operating points are defined by a vector whose components are active and reactive power).

In the field of power system operation, system security can be seen as the counterpart of system reliability in the field of system planning. In reliability assessment, the configuration of the system and the probability distributions of individual component failures are given. The process of planning then consists of adding components (e.g. generating units) or reconfiguring the system in order to meet accepted system reliability. Since this analysis is carried out via a planning mode, the chosen options can be implemented in due time.

Normal: Voltage and frequency specifications are met without violating limits on any power device for all system loads.

Emergency: Some operating limits are violated (over voltage, very low frequency, overloaded lines)

Restorative: Portion of the system loads are not met (partial or total blackout) but the operating portion is in a normal state. Static security corresponds to those states where the transients following a disturbance have died out. In these states the system has some limit violations that can only be tolerated for a short period of time (i.e. overloads line, over voltage conditions). If a corrective action is not possible, then the pre-disturbance state must be classified as seriously in secure and should be avoided by preventive measures. Dynamic security corresponds to the investigation of disturbances which may lead to transient instabilities (e.g. loss of synchronism among generator). Dynamic security assessment is a very complex and difficult task. The difficulties arise from a compounding of the following elements:

* The EP Sis time-varying, highly non-linear, and very large scale.

* The inputs of interest are multi-dimensional statistical distributions of random events,

* It requires complex and time-consuming forecasts (since robustness evaluation of the system is carried out over a future interval) of the system behavior for all possible and events.

* The assessment must be executed on-line.

In the past several approaches have been proposed using dynamic estimation, statistical modeling events and perturbations, stochastic forecasting and stochastic contingency evaluation.

Transient Stability

An electrical power system is a non linear, high order system which is subjected to both predictable and unpredictable disturbances. These disturbances can also be classified as internal (random load) and external (lightning strikes, wind).

Transient stability problems are those related to large-scale disturbances which cause the loss of synchronization in a portion of the system, and in extreme cases, instabilities of the system. Stability of power systems deals with the character of the electromechanical oscillations of synchronous generators created by disturbances in the power system conditions. Electromechanical oscillations represent exchange of energy among generator rotors (via the interconnection network) which is caused by the instantaneous unbalance between generation and consumption of electric power. This imbalance is inherent to an AC power system and varies from low levels during normal changes of system operating conditions, to relatively large levels in the case of major disturbances such as faults. In both cases, the system stability depends on its capability to efficiently preserve synchronous operation of all its parts and damp out electromechanical oscillations between them. When the disturbance is small, the system is confined to a small region around an equilibrium point. Linear models are used and the stability properties of this equilibrium point are studied. If the disturbance is large, the subsequent oscillatory transient will be of significant magnitude. And now the stability of the system is determined following the trajectories related to the attraction region of the equilibrium point. In this case both non-linear model and theories are used.

Existing approaches to assess transient stability:

1. Numerical integration
2. Second method of Lyapunov
3. Probabilistic Method
4. Pattern recognition
5. Neural Networks

1. Numerical methods: The system dynamics are described by a set of first order differential equations. These are solved during the fault and post-fault period by numerical integration algorithms such as Runge-Kutta and its variations. Real-time operation constraints make it difficult to apply this method to power systems.
2. Second Method of Lyapunov : The main idea is to evaluate the Lyapunov function at the instant of the last switching in the system. If the value is smaller than a reference value then the post-fault transient process is stable.
3. Probability method: Probability of stability is defined as the probability that the system remains stable should the considered disturbance occur. Security is measured in terms of the probability of a transition from normal state to the emergency or" in extreme is" state measured relative to a threshold.
4. Pattern Recognition (PR): The transient stability studies using PR have focused on the selection of the initial system description, feature extraction and on the design of classifiers. Dynamic programming and modified search methods are used to improve the future extraction processes. Several kinds of classifiers have been studied: adaptive hyper plane nearest neigh adaptive sphere and prototype hyper plane. Then last one has the best performance of the three.

On the selection of the initial system description four kinds of parameters are used:

- The voltage magnitude and phase angle at each system bus.
- The active and reactive power of each generator plant.
- The active and reactive power of each bus load.
- The active and reactive power flow of all the lines. These parameters refer to static system conditions.

5. Neural Networks: This recent technique is being used as pattern classifier and recognizer in this kind of problems. Up to now, the literature has reported only simulation results taking into account real data.

Load Forecasting

Load forecasting is an important task which allows the system operator:

*To schedule spinning reserve allocation;

*To decide for possible energy interchange with other utilities, and

*To assess system security two approaches shave been traditionally suggested. One treats the load patterns as a time series signal and predicts the future load based on time series analysis .Another one regression approach recognizes the heavy dependency between the system load pattern and weather variables and finds a functional relationship. The future load is then forecast by inserting the predicted weather information into the relationship.

2.3.1 Power Flow Analysis of the Nigerian Transmission System

The 330KV and 132KV systems were initially run by two separate bodies- “Nigeria Dams Authority (NDA)”, and “Electricity Corporation of Nigeria (ECN)” respectively. Central control for the 330KV Network was coordinated from kainji power supply control room, while the 132KV Network was run by load dispatcher located at Ijora Power Supply Lagos. These two bodies were merged formally into single power utility known as National Electric Power Authority (NEPA) in 1972 thus ushering in centralized regulation and coordination of the entire rapidly growing 330KV and 132KV National network. These networks are characterized by many disturbances which cause various hindrances and outages. Generation, transmission, distribution and marketing of electricity in Nigeria are the effective operations of the National Electric Power Authority (NEPA) now known as Power Holding Company of Nigeria (PHCN). Presently, the national electricity grid consists of nine generating stations comprising three (3) hydro and six (6) thermal with a total installed generating capacity of 6500MW. The thermal stations are +

mainly in the southern part of the country located at Afam, Okpai, Delta (Ughelli), Egbin and Sapele. The hydroelectric power stations are in the country's middle belt and are located at Kainji, Jebba and Shiroro. The transmission network is made up of 5000km of 330KV lines, 6000km of 132KV lines, 23km of 330/132KV sub-stations and 91 of 132/33KV substations. The distribution sector is comprised of 23,753km of 33KV lines 19,226km of 11kv lines, 679 of 33/11KV sub-stations. There are also 1790 distribution transformers and 680 injection substations. Though, the installed capacity of the existing power stations is 6500MW the maximum load ever recorded was 4,000MW. Recently, most of the generating units' have broken down due to limited available resources to carry out the needed maintenance. The transmission lines are radial and are overloaded. The switchgears are obsolete while power transformers have not been maintained for a long time. The present installed generating capacity is about 6000MW and the maximum generation of 4000MW for a population of about 160 million. This indeed is grossly inadequate to meet the demand of electricity consumers. The current projected capacity that needs to be injected into the system is estimated at 10,000MW which is hoped to come in through the independent power producers (IPPs) as soon as the deregulation of electricity supply industry is successfully achieved. Also, massive injection of funds is needed to expand the distribution and transmission networks to adequately transport the power generated to consumers.

2.4 NEURAL NETWORKS IN POWER SYSTEMS

They are grouped into papers dealing with identification & modeling, control, sensor validation, monitoring, fault diagnosis and prediction.

Identification and modeling

The use of ANN to deal with the modeling of nuclear power systems: The special emphasis was placed on the interrelationship among sensor outputs. An ANN is used to predict one or more of the sensor outputs. If there exist significant difference between the predicted and the actual outputs, then something in the components, system or instrumentation has changed. Topics described in the article: transient diagnostics, sensor validation, plant-wide monitoring, check valve monitoring, and analysis of vibrations. Interesting approach for sensor validation function and detection of incipient faults. Most of the works mentioned have been realized to demonstrate feasibility of some ANN approach. Eskandarpour*et al* in their book developed a model based on the characteristics of the data used to predict power outage using the support vector machine (SVM) method. The properties of the data considered were the seriousness of, and the distance from, the extreme event, together with component deterioration. Eskandarpour*et al*. also brought forward a method for predicting the component outage of a power grid in expectation of a looming hurricane. The method used was logistic regression, and the performance was validated using a case study. JaechA. *et al.* (2018), which introduced a method for predicting the duration of an outage using field records. They trained neural networks as models and validated the performance using natural language processing. They were able to establish good correlations between environmental properties used and outage causes.

2.5 ARTIFICIAL INTELLIGENCE METHODS

The term AI has been discussed in many studies, starting with definitions provided by Turing in the middle of the 1940s.Also, in present discussions, there is no consensus about one definition. However, most agreed on an information-processing system influenced by an environment that is able to learn and adapt. In this chapter, the basic methods of AI techniques used in the different applications throughout this paper are briefly presented J. Fulcher, Computational Intelligence:It is noteworthy that in many studies, standard algorithms are modified to a certain extent, however, they are classified in one category in this paper. Further information on the different variations of each standard algorithm can be found in the publications. Again, the article does not present a comprehensive overview but the most frequently used techniques.

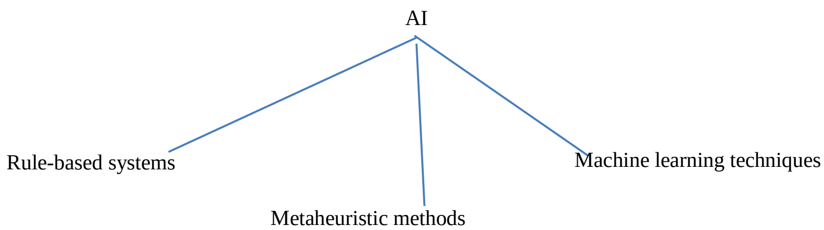


Figure 1: Categories of AI

PattanaikJ. K. et al(2017),proposed the immune algorithm was also developed from the genetic algorithm based on the construction of the immune operator through vaccination and immune selection. Toorajipour R. *et al*(2021), used the Tabu search method which is another metaheuristic algorithm that guides a local heuristic procedure to search the global solution space, based on the incorporation of adaptive memory and responsive exploration. The simulated annealing combines the physical behavior of the cool-down phase of a solid material after annealing with solving large combinatorial problems of optimization. The modern power system is pushed close to critical operating limits in the market environment. High capacity and long transmission networks are widely used to meet the power supply demand of modern society. Wind and solar power as clean and renewable energy are significantly adopted but they are inherently volatile, intermittent and random. Therefore, an improper handling of certain partial failures can easily lead to accidents and severe chain reactions, and thus may cause large-scale/extensive blackout/failure eventually. In recent years, there have been a great number of widespread blackouts around the world. Nigeria's electricity grid amongst other countries experiencing power failure has suffered over 222 partial, total collapses in the past 12 years. Ankit Mishra *et all*, (2021) in their book uses the principle of checking framework for dissemination transformer and to control it at the point when it goes to strange condition for checking and controlling power failure. This artificial intelligence method *utilizes IoTbased innovation* that permits creative two path correspondences between the utility and the clients. It will screen the basic boundaries like current, voltage, force, and temperature persistently and preventive measures will be started if any aggravations have been noticed and accordingly coming about in improving unwavering quality, security, and proficiency of the electric framework

Related review

The objectives of restoration are to enable the power system to return to normal conditions securely and rapidly, minimize losses and restoration time, and diminish adverse impacts on society. Many non-structured methods and technologies and object-oriented expert system have been employed in making restoration schemes to address the above objectives, but the establishment and maintenance of a knowledge base of past restorations remains a bottleneck. Arturo et all, in their paper using artificial neural networks (ANNs) investigated PSR. Limitations encountered in some currently used PSR techniques and a proposed improvement based on artificial neural networks (ANNs). The proposed scheme is tested on a 162-bus transmission system and compared with a breadth search restoration scheme. The results indicate that the use of ANN in power system restoration is a feasible option that should be considered for real-time applications.

The proposed use of ANN in restoration has already been a subject of research in small distribution systems and small transmission system Hsu *et al*., (2017) provide an overview of applications using deep reinforcement learning to solve problems in modern power systems. Another study about reinforcement learning was proposed by Glavic et al. [2017], presenting decision and control applications of reinforcement learning in power systems. Sun et al. [2019] focus on voltage control and give an overview of the challenges and opportunities of this control type. An extensive review about load flow control and its challenges and opportunities including the integration of AI was proposed by Alhelou*et al*. [2018], Chaiet*et al.* [2019] and Darab et al. [2019] investigate different approaches and their applications of AI in fault detection and diagnosis in power systems

3. METHODOLOGY

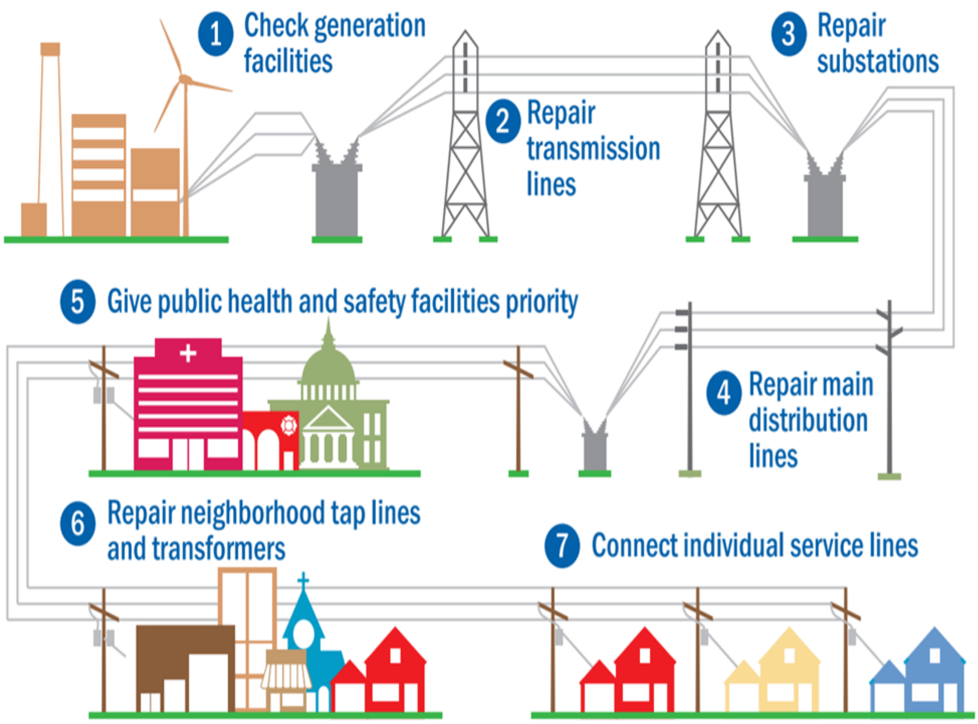
3.1 THE NATIONAL GRID TRANSMISSION SYSTEM

The Nigerian 330KV Grid system is characterized with major problems like voltage instability (voltage profile violation), long line transmissions, nature station lines and high-power generation and distribution systems. Transmission system in Nigeria comprises of 330 KV and 132 KV circuits and substations. The thermal generation is located in the south of the country, generally near to the sources of gas, while the hydro generation is located further north at Jebba, Kainji and Shiroro. Distribution is spilt into 11 zones and the distribution networks comprises 33 KV, 11KV and low voltage circuits. System nominal frequency is 50Hz. The Nigerian power network consists of generating stations mostly sited in remote locations near the raw fuel sources which are usually connected to the load centers by long transmission lines. Generation, transmission, distribution and marketing of electricity in Nigeria are the statutory functions of the National Electric Power Authority (NEPA) now known as Power Holding Company of Nigeria (PHCN). Presently, the national electricity grid consists of nine generating stations comprising three (3) hydro and six (6) thermal with a total installed generating capacity of 6500MW. The thermal stations are mainly in the southern part of the country located at Afam, Okpai, Delta (Ughelli), Egbin and Sapele. The hydroelectric power stations are in the country's middle belt and are located at Kainji, Jebba and Shiroro. The transmission network is made up of 5000km of 330KV lines, 6000km of 132KV lines, 23km of 330/132KV sub-stations and 91 of 132/33KV substations. The distribution sector is comprised of 23,753km of 33KV lines 19,226km of 11kv lines, 679 of 33/11KV sub-stations. There are also 1790 distribution transformers and 680 injection substations. Although, the installed capacity of the existing power stations is 6500MW the maximum load ever recorded was 4,000MW. Presently, most of the generating units' have broken down due to limited available resources to carry out the needed maintenance. The transmission lines are radial and are overloaded. The switchgears are obsolete while power transformers have not been maintained for a long time. The present installed generating capacity is about 6000MW and the maximum generation of 4000MW for a population of about 160 million.

The Nigeria 330-kV transmission network used as the case study in this research work consists of eleven (11) generators, twenty one (21) load buses and thirty six (36) transmission lines, which cut across the six (6) Geopolitical zone (South-West, South-South, South-East, NorthCentral, North-West and North-East Region) of the country with long radial interconnected transmission line.

Power Restoration Process

When a power outage happens, we first ensure public safety, then crews check the lines and begin repairs. We prioritize jobs that will restore electric service to the most people. We appreciate your caution, cooperation, and patience as we work to restore service as quickly and as safely as possible.



Power Restoration Process

After a Blackout

Restoring power after a widespread blackout is much different than the process we follow to repair damage to the electrical grid caused by a storm or other physical hazards. In a blackout situation, the balance between generation and load is affected, causing the transmission grid to become unstable and collapse and customer load to be lost.

Restoring power from a blackout situation requires the successful initiation of a pre-planned sequence of events beginning with the firing of peaking units and hydro plants, which, in turn, prompt start-up of larger generating units, such as coal, nuclear and gas-fired power plants. This is a skillful and delicate process requiring system control operators to precisely match the amount of power and energy released on the transmission grid with the customer load being restored at the "end of the line." This process is carefully followed and repeated until all customers have power restored and the grid is stabilized.

Research Procedure

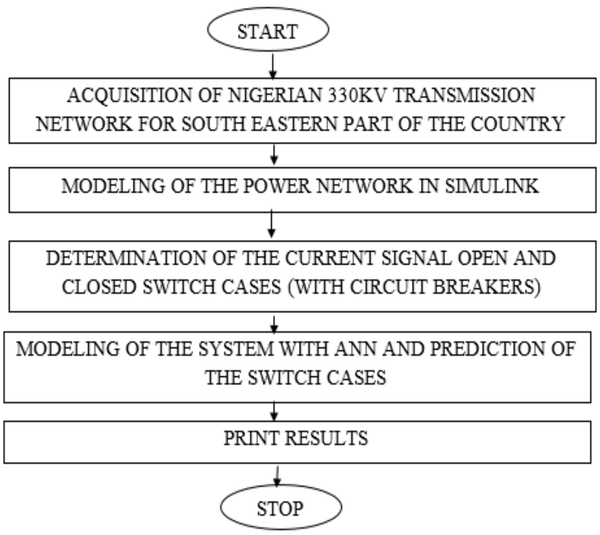


Figure 3.1 A summary of the research procedure

For the purpose of this research work, the south eastern part of the Nigerian 330KV Transmission Line was mapped out. The data used were collected from the Power Holding company of Nigeria (PHCN). Study and assessment of the generation and distribution stations was carried out and analysis where made on the causes of power failure around the areas on their existing data and consequently techniques for effective power restoration was carried out. The grid collapsed twice in March 2022 within 48 hours. There are a number of factors to explain this situation and thus inform what needs to be done about it. They include insufficiently trained personnel, deficiency in local manufacturing, poor utility performance, theft of grid equipment, weather, gas supply, insufficient funding and the age of grid infrastructure. The causes of power failure the national grid is designed to function under controlled limits to ensure stable grid operations. Exceeding the limits leads to instability – and often leads to collapse. The transmission company is supposed to allocate the load to the distribution companies based on demand information received from the National Control Centre. This ensures that there is no mismatch between power supply and demand to avoid national grid system collapse. In some situations, the amount of electricity supplied to the grid is lower than the electricity demand. When this occurs, an automatic load shedding plan is activated. But if this fails, the generators switch off one after another until there is a complete collapse of the national grid.

3.3 MODELING OF THE NIGERIAN POWER SYSTEM WITH PSAT AND SIMULINK

Starting with the Kainji Dam Power Station, Figure 3.2 shows the SIMULINK model of the Kainji Dam power generation station, the generation is said to contain 2 turbines generator and one of them modeled to have a fault affection the transmission, the other line shows the loaded line, the generation unit is deigned to contain 3 buses and will be used as a medium for the implementation of for implementation of power restoration in the Nigerian national grid.

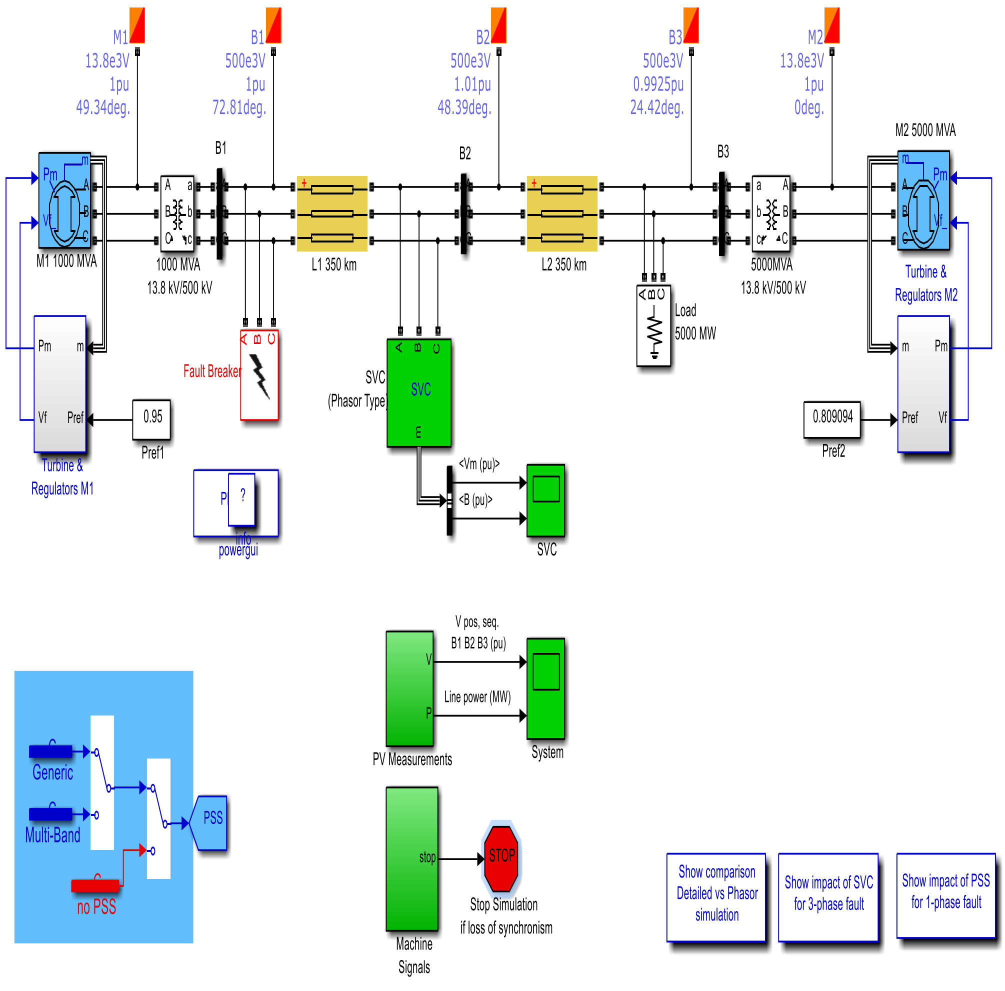


Figure 3.2: SIMULINK model showing a typical implementation of a generation company in the national grid.

A specialized tool in MATLAB environment is developed using Power System Analysis Toolbox (PSAT) for providing fundamental examination of 10 generators, 28-bus Nigeria power network transient stability analysis. Power System Analysis Toolbox (PSAT) is a Simulink-based open-source library for electric power system analyses and simulations, distributed via General Public License (GPL). It contains the tools for power flow (busbars, lines, two/three winding transformers, slack bus(es), shunt admittances, etc), Continuation Load Flow(CLF) data (power supply/demand bids and limits, generator power reserves and ramping data), small Signal Stability Analysis and Time Domain Simulations. Moreover, line faults and breakers, various load types, machines, controls, OLTC transformers, FACTs and other can be also modeled. For 10 generators, 28-bus Nigeria power network transient stability, there are two state equations for each generator, with initial power angles $\delta 0$ and $\Delta\omega 0i = 0$. The program developed in MATLAB is employed to solve the above 2m first-order differential equations. When the fault is cleared, which entails the removal of generator bus or any faulty line, the bus admittance matrix is computed over again to reflect the change in the network. Next, the post-fault reduced bus admittance matrix is evaluated and the post-fault electrical power of the ith generator shown by Pipf is readily determined from equation. Using the post-fault power Pipf, the simulation is allowed to go on, so as to determine the system stability until the plots reveal a definite trend as stability or instability. program. The generator connected at bus no. 5 (Sapele PS) is shut down and the transient stability effect and impact on the 28-bus power network are analyzed. The starting time of the outage is 0.0001 second and transient phenomenon lasts in the 28-bus power network for a period of time ranging from 0.6 to 0.9 seconds. The transient stability analysis performed for 10 generators, 28-bus power network for various 3-phase fault locations and 3-phase fault clearing time showed that the network is stable in 0.80 seconds, critically stable in 0.815 seconds and unstable in 0.9 seconds. The Nigerian 330 kV network model in power system tool with the marked south eastern location in shown in figure 3.3 using the MATLAB.

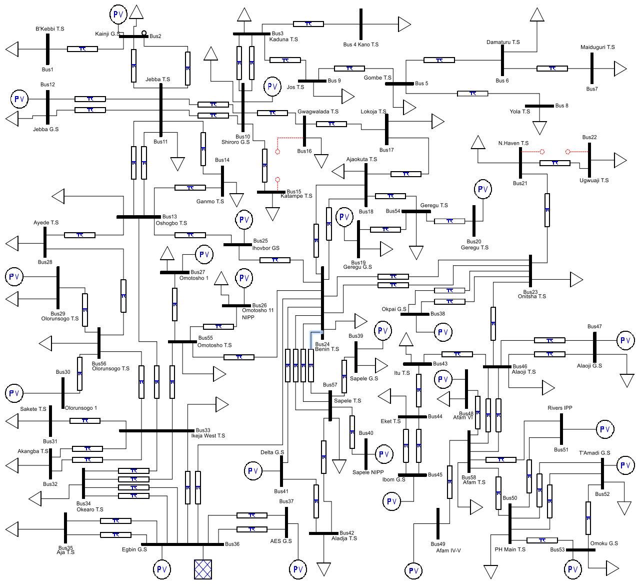


Figure 3.3: Nigerian 330kV transmission Network

4. RESULT AND DISCUSSION

4.1 POWER RESTORATION IN KAINJI POWER PLC

Table 4.1 The existing generating stations in the country

S/No	Power Station Name	Location/State	Status Capacity (MW)
1.	Egbin Thermal Power Station	Lagos	Operating 1320
2.	Afam Thermal Power Station	Rivers	Operating 969.6
3.	Sapele Thermal Power Station	Delta	Operating 1020
4.	Ijora Thermal Power Station	Lagos	Operating 40
5.	Thermal Power Station	Delta	Operating 912
6.	Kainji Hydro Power Station	Niger	Operating 760
7.	Jebba Hydro Power Station	Niger	Operating 578
8.	Shiroro Hydro Power Station	Niger	Operating 600
9.	AES Thermal Power Station	Lagos	Operating 300
	TOTAL CAPACITY		6500

Figure 4.1 shows the plot describing the application of the ANN power restoration scheme to the Kainji power station, the plot compares the scheme with a conventional restoration scheme.

The plot shows the effect of the ANN scheme to the turbine speed and also the voltage generated, the power restoration scheme without ANN is said to show a lot of power distortion at the beginning of simulation, but the application of ANN to the system removes the distortion completely by firstly detecting the area of fault and hence apply neural logics to mitigate faults at much affected areas.

The plot shows that the power factor angle theta for a system with ANN is lowered as compared to a system without ANN

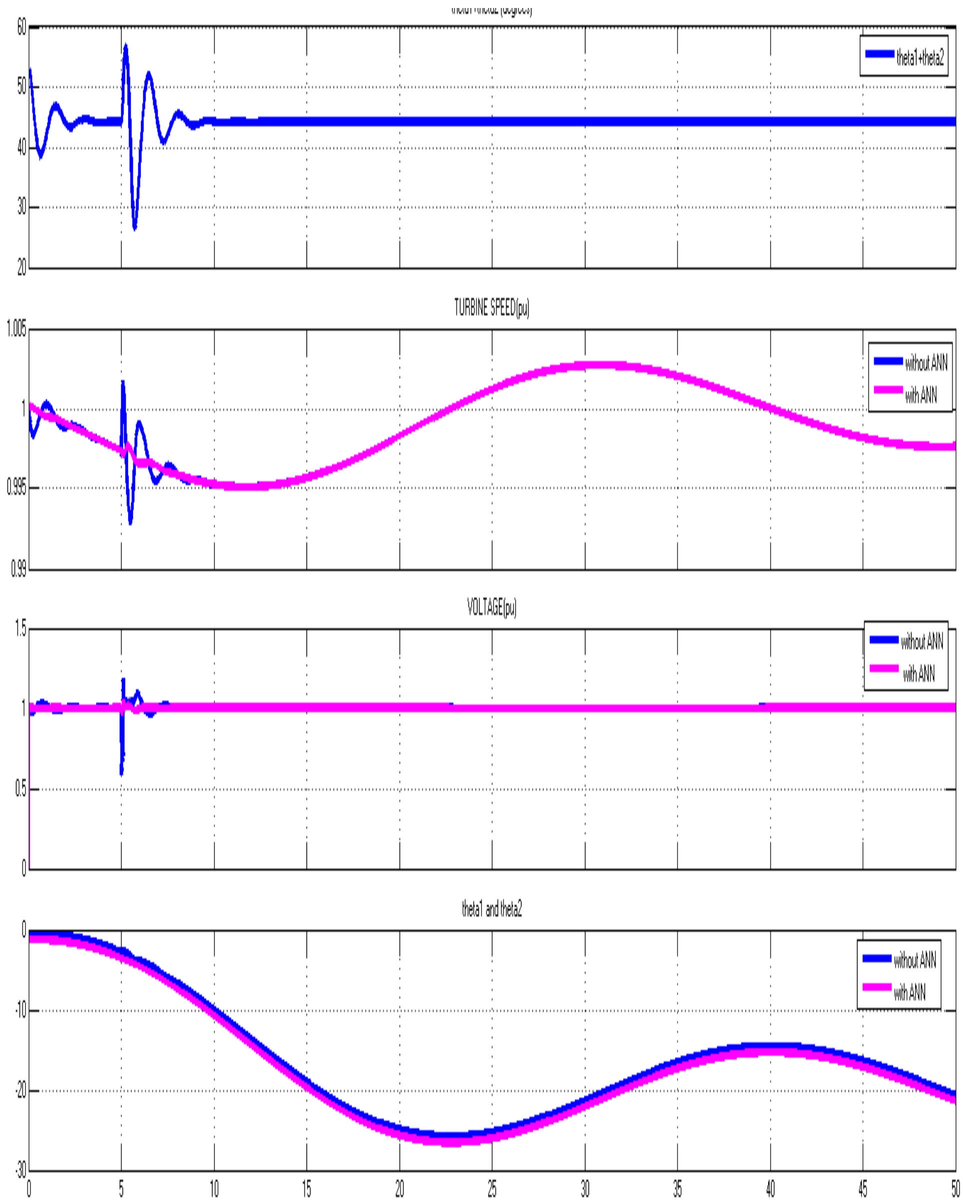


Figure 4.1: plot showing comparison of ANN restoration scheme and conventional restoration scheme in Kainji power station.

4.2 POWER RESTORATION IN AFAM POWER PLC

The Afam power station implements the use of hydro plants and gas turbines, the simulation results shows a lot of distortion during power generation as shown by the plot in figure 4.3, the ANN scheme has been seen to reduce the ripples in the turbine speed and generated voltage to a large extent as compared to the conventional restoration scheme without ANN. It can be also seen from the plot that the power factor angle for the compared scheme are same phase, hence showing the effect of the scheme more on turbine speed and voltage restoration more than power factor restoration on the Afam generation station

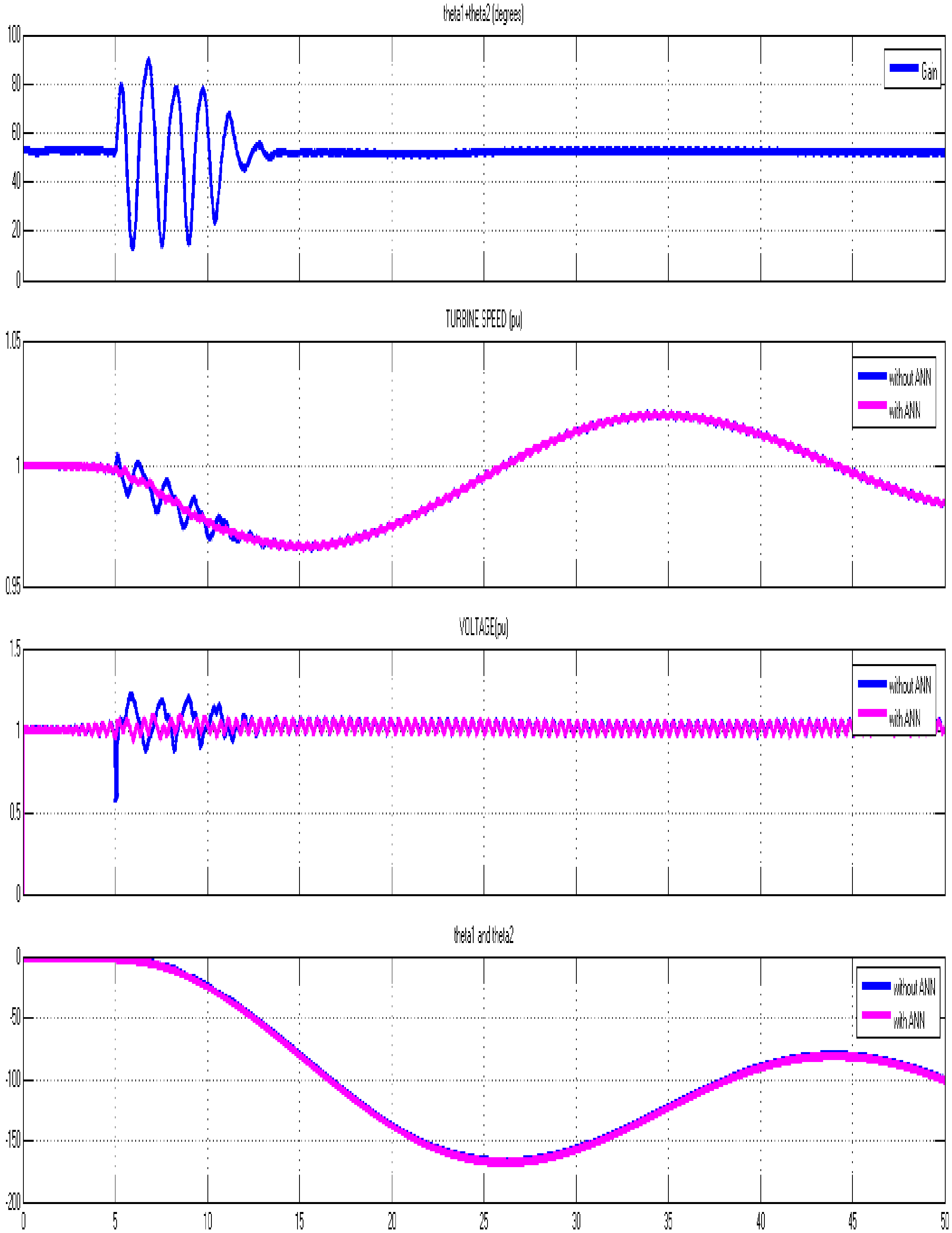


Figure 4.2: plot showing comparison of ANN restoration scheme and conventional restoration scheme in Afam power station

Figure 4. shows the turbine speed restoration as the system generated voltage is been restored, the system becomes more stable on the application of the ANN scheme on the three-phase transmission line as compared to the system without the ANN scheme which shows an unstable speed going off the graph.

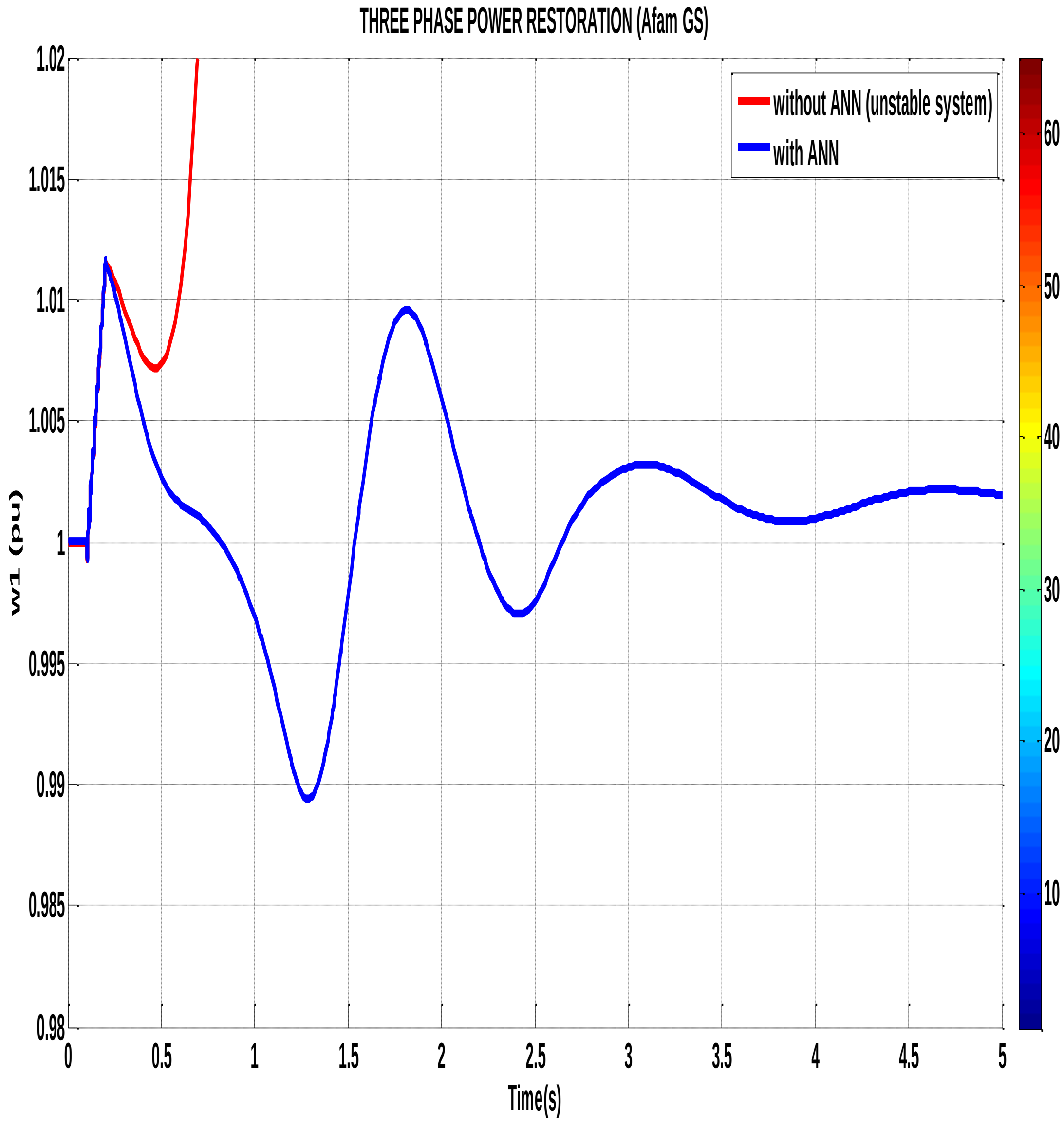


Figure 4.3: three phase system; turbine speed restoration in Afam station

5.CONCLUSION

Nigerian 330kV Network was modeled for Nigerian system. The entire network was modeled in PSAT and modeled with power library in Matlab SIMULINK Environment. The current signal of the system without fault occurrence was presented. The current signal for each location after switching of each of the location's circuit breaker was obtained and utilized in generating the ANN model. ANN model was applied to the power system model in SIMULINK and used to predict the effect switching locations of the circuit whose predictions were almost the same as the circuit breaker location used as target. The real meaning here is that ANN can embark on quick fault location and initiate the swapping or reconnecting process so as to reduce power outages in unaffected location.

5.2 RECOMMENDATION

Based on the efficiency of ANN to ensure switching of the circuit breaker and predict the fault location, In this case we strongly recommend that ANN should be used when building future Nigerian Power system Network to curb the rate of power failure in the system.

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