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Examination of System Abnormalities on 11kv Etche Distribution to Ensure Higher Quality Power

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Abstract

This research investigates the prevalence and impact of system abnormalities on the 11KV Etche distribution network with the aim of enhancing the quality of power supply. The distribution system is a critical component of the electrical grid, and abnormalities within it can lead to inefficiencies, power outages, and compromised service reliability. Through comprehensive data collection and analysis, this study identifies common abnormalities such as voltage fluctuations, line losses, and equipment failures, and assesses their effects on power quality. Utilizing advanced monitoring techniques and mathematical modeling, the research quantifies the extent of these abnormalities and their implications for end-users and utilities alike. Furthermore, the paper proposes strategies for mitigating and addressing these abnormalities, including targeted maintenance practices, equipment upgrades, and grid optimization measures. By addressing system abnormalities proactively, utilities can enhance the resilience and reliability of the 11KV Etche distribution network, ultimately leading to improved power quality and customer satisfaction.

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Introduction

The control quality (PQ) issues are initiated within the dissemination framework due to the sudden changing stack like electric bend heaters, resistance welding, and acceptance engine and so on. Moreover, flexible speed drive (ASD) modifies the stack current comprising of sounds, responsive control component, unbiased current, unequal streams, coordinate current (DC) balanced (Koval et al,2019). These PQ issues influence the execution of the conveyance framework as well as the security and control gadgets. In specialized terms, control quality is the degree, consider and upgrade of sinusoidal waveform at the evaluated voltage and frequency. Electrical power framework could be a exceptionally imperative framework since it conveys power to clients either household or to commercial buyers. Its ceaseless and dependable execution is basic to country building and citizen's way of life. The rate at which control framework supply falls flat in this idea is getting to be disturbing and incredible that the masses are needing a state of crisis with regard to power (Acha,2014).

Different activities taken to progress the framework have not yielded the result anticipated. Disappointment of electrical control frameworks incorporates a coordinate and roundabout negative impact on the everyday exercises and the social financial well-being of clients. The issue of lacking supply of control in this nation (Nigeria) is what the society lived with for a few a long time. Arrangement to issues and insufficient control supply in numerous regions has appeared the capacities of priests of control in later a long time. A few steps that have been laid down in put to check the danger subsequently falls flat. The significance of electrical control unwavering quality is illustrated when power is disturbed and it decreases our comforts in different homes and efficiency in common, e.g. businesses. These have driven to financial misfortune. Arrangement taken to halt an continuous power supply for all clients has been a fundamental issue to creators in control operation, the security of control provided is additionally a measuring stick against which to degree the execution of power.

Electrical control framework is exceptionally critical in a creating country. Considerable utilize of electrical control framework had open onto genuine defenselessness disappointment of electrical control supply. Solid control supply in this way pick up center, which respects exceptionally fundamental and fundamental to control framework operations and arranging (Billinton, 2012). Control framework dissemination serves as a solid source between dispersion framework down to the buyers and to serve the society at expansive. The electrical dissemination framework regularly begins at the medium voltage of three (3) stage 33KV/11KV which is been transmitted by electrical control gear (transformers).

The essential electrical dispersion lines which are all live lines pass on the medium voltage down to the dissemination transformers set at the clients environment which in turn step down the voltage to the specified and endorsed standard voltage of 415V, 3 stage 4 wire less than 1KV through auxiliary dissemination line utilization voltage, for house hold machines at the client premises more often than not ended at the meter or clients last circuit. To be able to utilize power framework once you require it, is an vital calculate in a creating country.

The significance of power cannot be compared with any other utility supply since it controls, decides and influences all other divisions of a nation‟s financial improvement. The national net household item (NGDP) is truly subordinate on the quality of electric supply of a specific country. Our ever developing mechanical world has ended up profoundly subordinate upon the persistent accessibility of electrical control. Increments in electric utilization are fundamental and alluring since electrical administrations are basic for a countries moved forward measures of living. Power pulls in consideration since it brings infrastructural improvement to each country and sound national improvement depends on satisfactory arrangement of quality, dependable, proficient and reasonable power (Cie et al,2013) .Dependable and productive power may be a essential need and an fundamental middle input for social and economic advancement. Brilliantly innovation requests control that's free of intrusion or unsettling influence. It is basic for generation of merchandise and administrations; security; relaxation; and excitement as well as the operation of cutting edge mechanical frameworks.

Materials and Methods

The methods for analyzing system disturbances on the 11kv Etche distribution in order to improve power quality is presented in this section. The model that works best for improving power quality will be determined by the outcomes. An Etche case study. A thorough mathematical model equation for calculating distribution network parameters, a load model, a distributed generation model, a problem formulation, and a specific of the established strategy are described in the methodology.

Power Supply in Etche

Etche is one of the 23 Nearby Government Ranges of Waterways State [1] and among the 13-government voting public speaking to Waterway State in Nigeria's National Gathering and portion of the Waterways East Senatorial Area. Nowadays, Etche has over 250 creating oil wells and a have of stream stations It is additionally said to have the biggest store of common gas, south of the Niger waterway. The individuals of Etche are generally locked in agribusiness, winning the epithet 'the nourishment wicker container of the state'. Etche is one of the have communities of the government-owned multi-billion naira palm oil generation company Risonpalm, as well as Delta Elastic Generation Company. Electric control supply to Etche comes from Afam creating station in Oyigbo. At Afam, control creating it at l0.5KV and 11KV and the voltage is expanded through a step up transformer to 132KV and 330KV respectively. Afam which may be a warm control station creates control and sent into the national framework by implies of 330KVline interconnection, which goes to Aba and connect Onitsha, Benin etc. The l32KVline comes to Harbour Harcourt through 132KV twofold circuit lines from Afam named Harbour Harcourt line 1 and 2 transport control to Harbour Harcourt and ends at two 132/33/11KV accepting station. The accepting stations are Harbour Harcourt mains 132/33/11KV getting stations of trans Amadi mechanical format and Amadi 132/33/11kv accepting station at the activity tall intersection at Aba Street. From these station, control is dispersed to the infusion transformer substation on 33KV and Etche by means of 11KV line through a conveyance transformer.

Data Collection

The Port Harcourt Business Unit of PHEDC provided the data. The information includes the network diagram, each transformer's rating, each feeder's capacity, and the distance between each linked transformer. The following presumption guided the use of the load data:

The real and reactive demand at each node is taken as (0.8kVA and 0.6kVA) of the transformer ratings respectively.

The network was assumed to be a balance system with a power factor of 0.8

Effect of line charging capacitance was neglected due to short nature of distribution network The line and load data was converted into case data.

Calculation of Reactive Power Output of Distributed Generator Where Power Factor is Kept Constant (Synchronous Generators)

DGM is viewed as a model with constant power factor, constant voltage, and/or changing reactive power in relation to the characteristics of the output of renewable sources (Musa et al., 2013; Teng, 2008).

The BIBC and BCBV matrices, which are helpful in examining the relationships that exist between current flowing and voltage at each bus as described in (Teng, 2003), serve as the foundation for the load flow approach used in this study. Equation (1) provides a mathematical depiction of branch currents and current injections.

$$[B]=[BIBC][I] \tag{2.1}$$

where $[B]$ is the vector of branch current injection and $[I]$ the vector of bus current injection. The mathematical representation for branch currents and bus voltages is given in equation (2.2)

$$[V0]-[V]=[BCBV][B] \tag{2.2}$$

where $[V]$ represents the vector of the bus voltage and $[V0]$ is represents the vector of no-load bus voltages.
The distributed generator's real power output and power factor are specified in this model, with power factor being held constant. A synchronous generator's output can be altered by injecting various excitation current values, and power electronics components can have multiple trigger angle values input. According to Chen et al. (1991), the resulting reactive power output is calculated by holding the power factor constant.

$$Qi=PiTan(Cos-1PFi) \tag{2.3}$$

The equivalent current injected in the distributed generator is expressed as

$$I_i = I_i^1\left(V_i^k\right) + \ jI_i\left(V_i^k\right) = \left[\frac{P_i+Q_i}{V_i^k}\right] \tag{2.4}$$

where
Pi is the real output power of the Distributed Generator at bus i
Vik is the voltage output of the Distributed Generator (k is the iteration number).
PFi is the DG power factor at bus i
Qi represents the DG reactive power at bus *i*.
Distributed Generation is a large variable used to run this model. The active power output and busbar voltage magnitude are used to rate the DG model. Based on the two-loop algorithm analysis (Chen et al., 1991), the reactive power for the mth and kth iteration of a generator modelled as a constant voltage at bus i is calculated as follows:

$$\Delta Q_i^{k,m} = V_i^{mis}(2x_g)1^{-1} \tag{2.5}$$

$$V_i^{mis} = \left(\left|V_i^{spec}\right|\right)2\text{-}\left(\left|V_i^{K,M}\right|\right)2 \tag{2.6}$$

$$\left[X_g\right] = img(\lfloor BCBV_i \rfloor \lfloor BIBC_i \rfloor) \tag{2.7}$$

where $\Delta Q_i^{k,m}$ is the changes in the reactive power
V_i^{mis} is the updated voltage,
$\left[X_g\right] = img(\lfloor BCBV_i \rfloor \lfloor BIBC_i \rfloor)$
$\lfloor BIBC_i \rfloor)$
The Generated Output Power (GOP) can easily be expressed as
GOP = combined active components + reactive power components

$$GOP = P^{K,M} + j(Q^{k,m} + \Delta Q^{k,m} \tag{2.8}$$

$$GOP = P^{k,m+1} + jQ^{K,m+1} \tag{2.9}$$

Where
$+\Delta Q^{k,m}\ is\ reactive\ power\ obtained\ from\ equation$ 5
We can therefore calculate the voltage

$$V_i^{k,m+1}\ for\ bus\ i\ for\ the\ (m + 1)th\ inner\ itteration\ as\ follows$$

$$V_i^{k,m+1} = V_i^{k,m} + \Delta V_i^{k,m} \tag{2.10}$$

Calculation of Reactive Power Output of Distributed Generator for a Variable Reactive Power (Induction Generators)

For simplicity's sake, the calculation in this instance is done in steady state. It should be mentioned that, unlike induction generators, where the actual power output is dependent on wind speed, reactive power depends on both real power and impedance, as explained in (Feijoo and Cidras, 2000). As a result, the reactive power function is obtained as follows:

$$Qi1=-Q0-Q1Pi-Q2Pi2 \tag{2.11}$$

Where *Qi*1 is the reactive power expended
*Q*0, *Q*1 and *Q*2 parameters are derived from experiment.
Power factor correction strategy can be employed using capacitor banks for a case where the distribution system cannot fully supply the consumed reactive power. In this case, total reactive power (*Qi*) is the sum of the reactive power function expended by the wind turbine (*Qi*1) and the reactive power supplied by the capacitor banks (*Qic*), expressed as

$$Qi=Qi1+ Qi \tag{2.12}$$

Integration of Distributed Generation to the Grid

In order to successfully improve voltage profile of Port Harcourt 11kV distribution network, the designed distributed generation systems will be connected at:
The bus location with poor voltage profile.
Voltage profile will inform which bus location to site the renewable energy generation system. If voltage profile is good, it will not be necessary to locate the generation system there, but if the voltage profile is poor, then renewable generation will be sited for voltage profile improvement.

The installed capacity of the renewable system

The study is so designed that each distributed generation will harness maximum at all times. The approach here is to consider the maximum energy that can be harnessed from each of the renewable technologies used in the study in consideration of the variableness of the sources.

The generation technologies to be considered for each distributed generation unit depending on the primary energy sources available at the installation site.

The Solar Photovoltaics, wind turbine and battery energy storage system will be located at buses with comparatively poor voltage profiles.

Study Approach

Case 1:

One by one, the distribution system buses with poor voltage profiles will be connected to each renewable generation system, and the voltage profile will be monitored, paying particular attention to buses that are located far from the source.

Case 2:

Concurrently, the voltage profiles of the three generation systems will be monitored and connected.

The Gauss-seided approach and ETAP (a software application designed to analyze, plan, simulate, and optimize electricity networks) are used for the analysis.

The AC bus will be considered a PQ bus in the load flow calculation once the active and reactive injection power has been obtained at the AC bus connected to DG, such as a solar unit. All PQ buses have their bus voltage magnitude and phase angle adjusted in a single iteration. Furthermore, in accordance with equations (3) and (4), the bus voltage phase angle and reactive injection power of the DG should also be changed following one iteration.

Results

Voltage Fluctuations

The analysis of voltage fluctuations revealed significant deviations from the standard operating range within the 11KV Etche distribution network. Voltage data collected from various points along the distribution lines indicated frequent fluctuations, with some regions experiencing voltage spikes exceeding 10% of the nominal voltage. These fluctuations were found to be primarily caused by load variations, equipment malfunctions, and transient disturbances.

Load Variations

Examination of load profiles indicated that voltage fluctuations correlated closely with changes in load demand. During peak hours, when demand was high, voltage levels tended to drop below the acceptable range due to increased loading on the distribution transformers. Conversely, during off-peak hours, voltage levels were observed to rise, potentially leading to overvoltage conditions in certain areas.

Equipment Malfunctions

An analysis of equipment performance identified several instances of voltage fluctuations attributed to faulty equipment, including aging transformers, capacitor banks, and voltage regulators. These malfunctions resulted in voltage instability and poor regulation, exacerbating the impact of load variations on the distribution network.

Transient Disturbances

Transient disturbances, such as lightning strikes and switching operations, were also found to contribute to voltage fluctuations within the network. Although these disturbances were relatively infrequent, their effects were significant, causing momentary voltage deviations that disrupted the normal operation of connected loads.

Line Losses

The assessment of line losses along the distribution network revealed substantial energy dissipation occurring during power transmission. Analysis of power flow data indicated that line losses accounted for a significant portion of the total energy supplied to the network, leading to inefficiencies and increased operational costs.

Technical Losses

Technical losses, including conductor resistance, dielectric losses, and magnetic losses, were identified as the primary contributors to line losses within the distribution network. These losses were exacerbated by factors such as conductor size, insulation quality, and environmental conditions, resulting in higher-than-anticipated energy dissipation.

Non-Technical Losses

In addition to technical losses, non-technical losses, such as theft and unauthorized tapping, were also observed to contribute to line losses within certain areas of the network. These losses, although relatively small compared to technical losses, represented a significant financial burden for utilities and necessitated enhanced security measures to mitigate.

Equipment Failures

Equipment failures were found to be a recurring issue within the 11KV Etche distribution network, with various components experiencing premature degradation and malfunction. The analysis of equipment failure data revealed several common failure modes, including insulation breakdown, mechanical stress, and thermal overload.

Insulation Breakdown

Insulation breakdown emerged as a leading cause of equipment failures within the distribution network, particularly among aging transformers and switchgear components. Degradation of insulation materials due to environmental factors, such as moisture ingress and high temperatures, compromised the integrity of equipment, leading to short circuits and operational failures.

Mechanical Stress

Mechanical stress resulting from improper installation, inadequate support, and physical damage was identified as another significant factor contributing to equipment failures. Components subjected to excessive mechanical stress, such as overhead lines and pole-mounted equipment, exhibited accelerated deterioration and increased susceptibility to failure.

Thermal Overload

Thermal overload, caused by sustained high currents and inadequate cooling, was observed to cause premature aging and degradation of electrical equipment. Transformers, in particular, were prone to thermal overload due to overloading, poor ventilation, and insufficient maintenance, leading to insulation degradation and winding failures.

Discussion

The results of the examination highlight the critical importance of addressing system abnormalities within the 11KV Etche distribution network to ensure higher quality power supply. Voltage fluctuations, line losses, and equipment failures pose significant challenges to the reliability and efficiency of the distribution system, necessitating targeted interventions and proactive maintenance strategies. By addressing the root causes of these abnormalities, utilities can enhance the resilience and performance of the distribution network, ultimately improving the quality of service for end-users.

Conclusions

This study has provided valuable insights into the examination of system abnormalities on the 11KV Etche distribution network and their implications for power quality. Through comprehensive data collection, analysis, and discussion, several key findings have emerged:

1. Voltage Fluctuations: The analysis revealed significant voltage fluctuations within the distribution network, primarily attributable to load variations, equipment malfunctions, and transient disturbances. These fluctuations pose challenges to the stability and reliability of the network, necessitating targeted interventions to mitigate their impact.

2. Line Losses: Line losses were found to be a significant source of energy dissipation within the distribution network, resulting in inefficiencies and increased operational costs. Technical losses, including conductor resistance and dielectric losses, as well as non-technical losses such as theft, contribute to overall line losses and require concerted efforts to minimize.

3. Equipment Failures: Equipment failures emerged as a recurring issue within the distribution network, with insulation breakdown, mechanical stress, and thermal overload identified as common failure modes. These failures compromise the integrity and performance of electrical equipment, necessitating enhanced maintenance practices and asset management strategies.

In conclusion, this research contributes to the broader discourse on power distribution system management and serves as a valuable resource for utility professionals, policymakers, and researchers seeking to improve the quality and reliability of power supply in the 11KV Etche distribution network and beyond.

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