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Study Of Transmission / Distribution Line Interface For Improved Grid Stability Using Moment Distribution Technique

BRIGGS, Kelly C.B.[1], Idoniboyeobu, D.C.[2], And BRAIDE, S.L.[3]
[123] Department of Electrical Engineering, Rivers State University, Port Harcourt, Nigeria
Corresponding Author: BRIGGS, Kelly C.B

ABSTRACT: *The research paper considered the analysis of transmission/distribution interface take power supply from Afam power generating station to Rumuola injection substation of (33/11kV) Golden-Lilly for improved grid stability using moment distribution technique ,voltage drop ,power losses reactive power flow , line power losses were determine. The Rumuola substation constitute eight(8) outgoing feeders of 11kv Distribution network this paper particularly considered one of the outgoing feeder (Rumuola – 11kv distribution feeder) in order to investigate the violation of some of feeder buses on the distribution network (showing over load of the distribution transformers and buses).this is as a result of the increasing demand of electricity supply does not match the available power, making the line to constantly experience overload beyond its statutory limit. Evidently, investigation shows that some of the bus transformers are overloaded that results in low voltage profile, poor power factor and system collapse due to transfer capability at the receiving end. The power supply network to the study case, Rumuola injection substation are modelled in E-tap environment (Electrical Transient Analyzer) which were used to investigate the relative distribution of voltage profile in the network to check which of the buses/transformers that are critically or marginally were overloaded, on the view to recommended for a penetration of power electronic controller (static var) to the affected buses, etc. the results of the simulation of the study case shows overload on the size of the static var penetration were determined with 0.3MVAR capacity to be installed in the affected buses/transformer in order to improve the efficiency of the network in voltage profile, reactive power flow, line losses which significantly improve the network by 63%.*

KEYWORDS*: Transmission Line Interface, Distribution Line Interface, Improved Grid, static Var, Moment Distribution Technique*

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I. INTRODUCTION

In considering the power generating stations in Nigeria, there are two basic power generating stations such as Hydropower generating stations (located at Kainji, Shiroro, Jabba, etc.) and Thermal-power generating stations which uses fossil fuels for instance natural gas, crude oil, coal, uranium, etc. (Sule, 2010). The electricity generating stations operate three basic techniques; prime-mover-to-generator techniques (conventional techniques) of electricity generation explicitly hydropower systems, Steam turbine power systems and Gas turbine power systems. In electricity generation steam and gas turbines are a function of fossil fuels. Hydropower stations constitute 21.42%, gas turbine power stations 64.29% and Steam power stations 14.29% respectively. The amount of power generated is not adequate to meet the need of end users. Consequently, there is regular power outage either forced or planned; since the national grid network is over loaded. According to [1], the electricity generating stations in Nigeria are interconnected in radial configuration with a single National Control Centre (NCC) in Oshogbo.

Electrical transmission and distribution (T & D) systems are important links to the production and the utilization sectors, the network cover up the utility (or T & D system) and the networks (which are inside the end user's location). The process of transfer of electrical energy from the generating stations to the end users, results in quality, quantity, and capacity losses [2]. Quality losses are connected with the poor quality of power at the user's end as a result of voltage drop, waveform distortion, the presence of harmonics, low frequency, and unbalance in phase voltage/currents. Quantity losses are in cables/conductors, transformers, joint losses, and earth leakage losses. According to [3], the difference between the power generated and distributed account for both technical and non-technical losses in power system network. Transmission losses are estimated 17% while distribution network losses account for 50% approximately, therefore the distribution networks in the entire power sector has the most losses. Similarly, technical losses are generally 22.5%, and directly dependent on the network characteristics and the mode of operations [3]. Capacity losses are those leading to the underrating of the power transfer capacity of the system due to the low power factor, low voltage and low frequency which lead to sub-optimal performance of the electrical network [4].

The separation between the transmission and distribution systems was discrete, electric generating facilities connected to the transmission system which transport electricity to end users through the distribution system. The transmission-distribution (T-D) interface enabled responsible entities to separately and clearly regulate, plan, and operate markets, and manages the safe, reliable operation of the power system [5].

The power industry has experienced a significant shift, primarily concerning the location and the type of resources upon which end users rely to satisfy their electricity needs. Significant amount of renewable, intermittent generation are being included into the transmission system, creating a need for new, flexible operating capability, and more essentially to the T-D interface, the prolific or impending integration of energy resources connected to the low-voltage distribution system [6].

1.1

1.2 The aim of this research work

This research work is aimed at improving the transmission-distribution line interface for grid stability using moment distribution technique.

1.2 Objectives of the Study

The objectives of this research work in regards to the aim are as follows:

i. Formulate load flow equation to represent the activities of the system under study.
ii. Simulate the formulated load flow equation for purpose of verification
iii. Implement the collected data into the formulated equation
iv. Conduct a validation test for compensation where necessary on the system under study.

II LITERATURE REVIEW

The history of electricity development in Nigeria can be traced back to the end of the 19th century when the first generating power plant was installed in the city of Lagos, when all economic activities have started to expand. This expansion posed serious expansion challenges to the limited generating capacities of the available thermal plant. Thus, the need arose for the development of alternative sources of electricity which would be large enough to produce abundant and cheap electricity to meet the growing demands of electricity. In order to minimize cost and maximize electricity production, hence meeting the above requirement effectively, it was felt that there was need to transfer electricity development from proliferated bodies to a central or national body [7]. This was mainly necessary to avoid the duplication effect which usually resulted in energy wastage. Due to the above give requirement, authorities as in Ibadan and Kano or by the public works departments as in Warri and Port Harcourt were merged together when Nigerian colonial government passed the ordinance no. 15 of 1950 which set up the electricity corporation of Nigeria to control the development of electricity throughout the country. Electricity Corporation of Nigeria (ECN) as given such power and functions that constituted it into an electricity autonomous commercial enterprise with a monopolistic setting for instance, it was the ECN in collaboration with the federal government of Nigeria in its search alternative sources of electricity that commissioned several studies into the electricity potential of the Nigerian major rivers.

Due to increased activities in industrial, commercial and domestic sectors, the electricity industry (NEPA) experienced high growth of industry demand day by day. This situation led to priority being given to the expansion and improvement in the generation, transmission and distribution system of NEPA. In 2009 the electricity generating station installed capacity in Nigeria was 500MW, but only 2900MW was generated as at November 2009 [8].

As of December 2013, the total installed or name plate capacity (maximum capacity) of the power plants was 6,953MW, available capacity was 4,598MW. Actual average generation was 3,800MW. Also as of December 2014, the total installed capacity of the power plant was 7,445MW, available capacity was 4,949MW, and actual average generation was less than 3,900MW. The presidential task force on power's peak demand forecast is 12,800MW (April 2015). On 30 September 2013 following the privatization process initiated by the Goodluck Jonathan regime, PHCN ceased to exist. In its stead, the Nigerian electricity regularly commission (NERC) was formed. The independent regulatory agency, as provided in the electric power sector reform, Act of 2005 was tasked with monitoring and regulating the Nigeria industry, with issuing licenses to market participants and with ensuring compliance with market rules and operating guidelines [9].

Losses and Economic consideration of transmission network have led to the choice of certain standard operating voltages. The choice of higher voltages for use in a long transmission line is aimed at reducing the power loss along the line [10].

The net effect of very high voltage transmission is the increase in the efficiency of power transmission. Although, obvious advantage is of great importance, the choice of higher voltage is limited by economic consideration for any given line; there is a definite voltage which will give the minimum cost. This voltage is referred to as the economic voltage for the line. The main advantages of employing certain standard voltage are to ease the use of standard manufactured equipment. Amongst the standard operating voltages are:

- 330kv – for the supply grid
- 132kv – for the original grid and bulk supply to area with large load.
- 66kv and 33kv for secondary transmission and also bulk supply
- 11kv, 6.6kv and 3.3kv – for the high voltage distribution.
- For consumer supplies, the standard distribution voltage

In electrical power systems, voltage instability is the ability of a power system to maintain acceptable voltages at all bus in the system under normal condition and after being subjected to a disturbance. The term voltage collapse is often used interchangeably with the term system collapse. It is the process by which the series of events accompanying voltage instability leads to a blackout or abnormally how voltages in a significant part of the power system. According to [11], the cause of this can be categorized into two; technical and non-technical causes may be due to tripping of lines on account of faulty equipment or increase in load over and above the available supply. Just as the voltage collapse is a series of events the eventually culminates in the collapse of the system, bringing the power network system back into operation in a series of events that takes time.

An interface is the frontier and it's as defined by common physical interconnection characteristics with properly defined different voltage levels. According to [12], states that most design efforts occur at the connections between components, and attention to the interfaces and flows through them are important to product development. He further sees interface as the boundary area between adjacent regions that constitutes a point where independent systems of diverse groups interact. Functions occur in the interfaces between components and that interface is means through which the product will be designed to meet the functional requirements. Interface is considered as a facilitating mean that enables an interaction between transmission and distribution network.

There, are two methods employed to clamp transient voltages to a level that tracks the protected circuit power supply voltage. The simplest method is to use diodes between the line interface and the power supply that are forward biased when transients exceed the circuit supply voltage by at least one diode drop.

According to [13], Distributed Generation (DG) will efficiently improve the active power and loss reduction which correspond to power losses technique that can be minimized in a distribution feeder by optimizing distributed generation (DG) model in terms of size, location and operating point of DG. A typical size of Distributed Generation is of the ranges from less than a kilowatt to few megawatts of Power Generation. FACTs devices supply passive element except for DG units position that provides an active element to improve the power system network. Therefore the Installation of DG units in a given power system network will rapidly improve the voltage profile twice or thrice that of passive injection of reactive power through static VAR compensator (SVC) to reduce power losses. In their research carry out, sensitivity analysis was carried out to minimize the power losses, optimal sizing of the DG and its operating point. They anticipated that sensitivity indices can indicate the changes in power losses with respect to DG current injection. Nevertheless, the proposed technique was developed considering load characteristics and representing a constant current model. The usefulness of the proposed method was tested and verified using MATLAB software on long radial distribution system [13].

According to [14], the flexible alternating current transmission systems (FACTS) are the useful system that provides very important benefits in the fields of power transmission system network. One of such system/device is the static VAR compensator (SVC) usually of power electronics for switching and control devices. In their research work, low-rated static VAR compensators were installed at the load ends on 33/11 kV distribution network. Software called Electrical Transient Analyzer Program (ETAP) was used to model and simulates the network using load flow analysis to investigate the performance of the network.

III MATERIALS AND METHODS

The power supply network from Afam power generating station, through 132kV transmission line Port Harcourt mains to 33kv injection distribution line at Rumuola injection substation (Golden Lilly Injection Station: 33/11kV). The distribution data was collected from the Port Harcourt Electricity Distribution Company (PHEDC) and Transmission Company of Nigeria (TCN) for purpose of analysis and investigation of this research work. The method of analysis in this research work is described according to the respective case of problem formulation.

3.1 Description of 132/33KV Transformer Substation

The Rumuola injection substation receives its supply via double air unit transfusion line from Afam power generating station 132/33kv level voltage switch yard.

Table 3.1: The Installed Capacity at the Transmission Substation (Golden Lilly Injection), Rated Voltages and the Number of Feedings

Transformer description	Transformer rating	Rated voltage	No of outgoing feeding
T4	15MVA	33/11KV	2
T5	15MVA	33/11KV	2
T6	15MVA	33/11KV	3

Source: Port Harcourt Electricity Distribution Company (PHEDC, 2018)

3.2 The Configuration of the available Rumuola 132/33KV Injection Substation

(i) 3 x 15MV, 33/11KV transformers
(ii) The reactance = 10.01%
(iii) 7 outgoing feeder with circuit breakers
(iv) 7 Unit feeder switch board work circuit
(v) Conductor cross-sectional area, A = 185mm^2 ACSR/GZ (Alumni conductor steel reinforced with galvanized)
(vi) D = distance between adjacent conductor (D = 0.98m)
(vii) Resistivity of aluminum; $\ell = 2.83\ x\ 10^{-8}\Omega\ .m\ at\ 21^{0}C$
(viii) Resistance $R\ = \ell\ {l}/{A(m^2)}({\Omega}/{km})$
(ix) GMD: Geometric mean distance
(x) Go: Conductance of line (siemens)
(xi) DGMD: 1.28D
(xii) L: Point length of the feeder (km)
(xiii) Z: Impedance, P_0 + j x o, P_D + jXQ
(xiv) Y: Admittance of the line y = G_0 + B_0 2

3.3 Methods of Analysis

Considering the activities of power system behaviour, it is important to note that voltage and power flows in the electrical network can be determined for a given set of loading and operating condition. This therefore relies strongly on the use of moment distribution technique, electrical transient analyzer and power flow problem formulations.

Evidently, it is a requirement to consider planning, design/redesign operation of power system for purpose of investigating the voltage magnitude (v) and phase angle (s), active power (p), reactive power (Q), line power losses using voltage drop equation etc. it is also extensively important to note that the solution of static load flow problems is highly challenging because of its nonlinear characteristics of equations, as bus voltage are involved in product form as sine, as cosine term present.

However, solutions are possible only through interactive numerical techniques. the method used to solve this static load flow problem is; Gauss-Seidel method,.

3.4 Load Flow Analysis using Gause-Seidel Method

Gauss-Seidel Method for Power Flow Studies

In the analysis of Gauss method, we assume the voltage for all the buses except the slack bus where the voltage magnitude and phase cycle are specified and remain fixed. That is we assume the voltage magnitude and phase angle of these buses equal to that of the slack bus and work in per unit system. The assumed bus voltage and the slack bus voltage along with P and Q (that is active and reactive power) are substituted into voltage equation to obtain new set of bus voltages. After the entire iteration is complete, the new set of bus voltages is again substituted along with the specified slack bus iteration in order to obtain new set of bus voltages. This process is continued till; $V_i^{r+1} - V_i^r \leq \varepsilon\ for\ i = 2,3\ \ldots .n$

Gauss iterative method is much slower to converge and may sometimes fail to do so.

Gauss-Seidel method consider the value of bus voltages calculated for any bus immediately replace the previous values in the next step while in the case of Gauss method. This means that the calculated bus voltages replace the earlier value only at the end of the iteration. Gauss-Seidel method converges much faster than that of Gauss method compared to Gauss-method.

3.5 Formulations for Gauss-Seidel Equations

In the analysis of the application of Gauss-Seidel method of power flow studies,

- Let it be assumed that all buses other than the swing or slack bus are P-Q or load bus buses.
- At slack bus both V-voltage and S- are specified and they remained fixed throughout.
- There are (n-1) buses where P and Q are given.
- Initially we assume the magnitude and angle at these (n-1) buses and update these voltages at every step of iteration.
- The complex power injected by the generating source into the ith bus of a power system is given as:

3.6 Interface between Transmission/Distribution System Using Moment Distribution Techniques

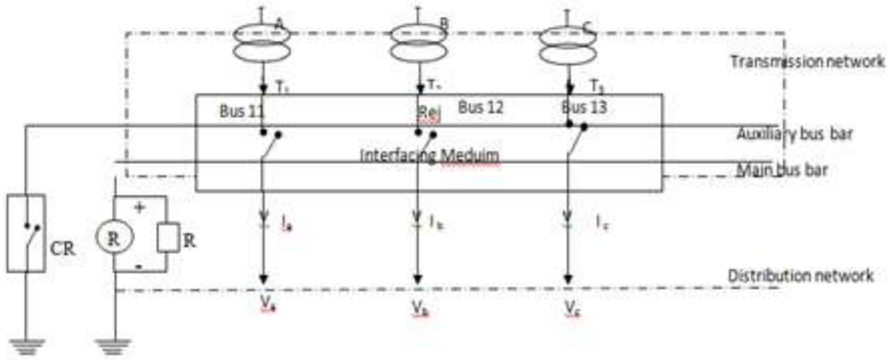

Fig 3.1: Transmission Distribution Interface Power System (132/11KV)

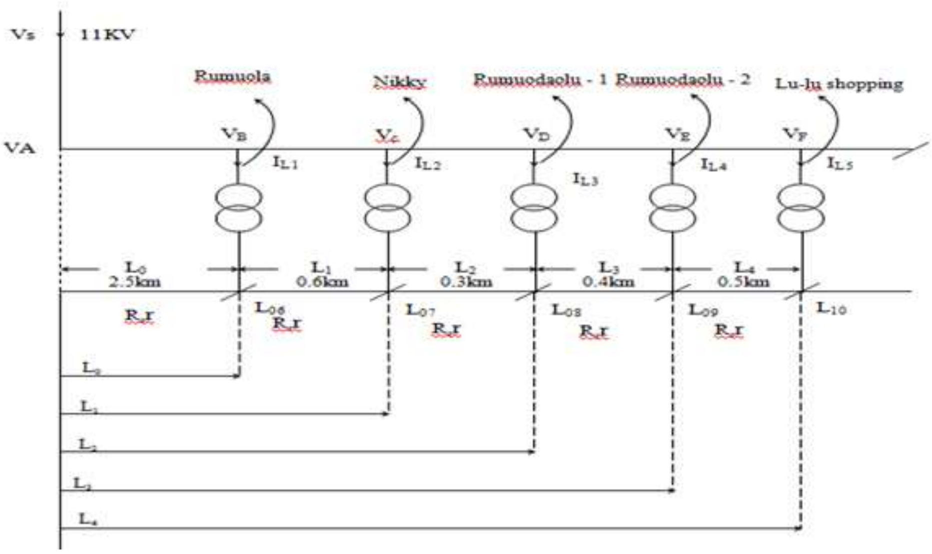

Fig. 3.2: Distribution of load current and section length for different feeder connected as individual load point

3.6.1 Case A: Transmission Distribution Interface Injection Current given as:

$$I_S = \sum(I_a + I_b + I_c)$$

Similarly,

$I_S = \sum(I \times L_0 + I \times L_1 + I \times L_2 + I \times I_3 + I \times I_4)$

Where: $I_{L_0} + I_{L_1} \ldots\ldots I_{L_4}$ are the load current at each section

Similarly,

$I_0 = I_1 = I_2 = I_3 = \frac{P(kVA)}{\sqrt{3} \times KV \times pf}$

3.6.2 Case B: The Resistance (R) of the conductor (ACSR) given as:

$R = \frac{\ell l}{A},$

This means that;

$R = \frac{\ell l_1}{A}, \; R = \frac{\ell l_2}{A}, \; R = \frac{\ell l_3}{A}, \; R = \frac{\ell l_4}{A},$

Where;

R = Resistivity of the conductor

L = Length of line section

A = Cross sectional area (mm^2)

3.6.3 Case C: Resistance (r) Offered Per meter length of line section

The resistance (r) of the conductor per meter length is given as;

r = R/L

Where;

R = resistance of the conductor

l = length of line section

Hence,

The resistance (r) per section length of the line conductor is given as;

$r = \frac{R}{L_1} = r = \frac{R}{L_2} = r = \frac{R}{L_3} = r = \frac{R}{L_4}$

3.6.4 Case D: Voltage Drop Due to Interfacing Current

The voltage drop due to the interfacing current flowing is given as;

$V_{drop} = I_S \times L \times r$

This implies;

$V_{AB,drop} = I_S \times L_0 \times r \quad = V_{BC,drop} = I_S \times L_1 \times r = V_{CD,drop} = I_S \times L_2 \times r$

$V_{DE,drop} = I_S \times L_3 \times r$

3.6.5 Case E: Determination Total Voltage Drop due five distributed section length

$V_{Total\,drop} = \frac{R}{2L}\left(L_0 \times I_{L_1} + L_1 \times I_{L_2} + L_2 \times I_{L_3} + L_3 \times I_{L_4} + L_4 \times I_{L_5}\right)$

The equivalent node interfacing current can be expressed in terms of conductance

$G_{eq} = R_{eq}{}^{-1}$

This means that the expression can be extended to;

$G_{eq} = \frac{1}{R_{eq}}$

Multiply both sides by (V_s) we obtained as;

$G_{eq} V_S = \frac{1}{R_{eq}}(V_S)$

Or

$G_{eq} . V_S = \frac{V_S}{R_{eq}} = l_{abc}$

Hence,

$G_{eq} V_S = l_{abc}$

3.7 Static Var Compensation

The static var, power electrical device for control are used for the compensation of affected feeder/buses in the network; which are presented mathematically for purpose of sizing the capacity (rating) of the “static var” as:

$Q_c = \frac{P}{Pf_1} sin\left[\left(cos^{-1}(pf_1)\right) - \frac{P}{pf_2} sin(cos^{-1}(pf_2))\right]$

(i) The existing power factor = 0.83

(ii) The proposed power factor = 0.84

(iii) Active power (MW) is given as: MVA x pf = MW

(iv) The existing capacity of substation transform feeding are study = case feeder = 1 x 15MVA

Hence;

15MVA x 0.83 = 12.45MW

Now substituting the data obtained into equation (3.42), we have;

$$Q_c = \frac{12.45}{0.83} sin\left[\left(cos^{-1}(0.83)\right) - \frac{12.45}{0.84}\left(sin[cos^{-1}(0.84)\right)\right]$$

Or

$$Q_c = 15\, sin(33.9012) - 14.8214\, sin(32.85)$$

or

$$Q_c = 15\ x\ 0.55776 - 14.821\ x\ 0.54244$$

$$Q_c = 8.3664 - 8.0395260$$

$$Q_c = 0.33MVAR$$

$$Q_c = 330KVAR$$

This mean that the capacity of static var required for compensation of the existing pf power factor of 0.83 to 0.84 proposed or defined evidently becomes 0.33MVAR (330KVAR).

3.8 Calculation of Voltage Rise

$$Voltage\ rise = \frac{static\ var\ compensatorfor\ \ improvement\ \ \times transformer\ \ reaction}{Transformer\ \ rating\ \ (KVA\ or\ MVA)}$$

Given the

Transformer reactance = 10.01%

Transformer rating = 15MVA

Static var compensation = 0.3MV_{ar} or 330 or KV_{ar} $= 330 \times 10^3 V_{ar}$

Voltage rise $= \frac{3.0MVar\ \times 10.01}{15MVar}$

Voltage rise $= \frac{0.3 \times 10.01}{15} = \frac{3.003}{15} = 0.2002$

% Voltage rise $= \frac{3003}{15} \times 100\%$

= 0.2002 x 100%

$\therefore$= 20.02% voltage increase

IV.RESULTS AND DISCUSSION

4.1 Case 1: Presentation of Results with the Penetration of Static Var Compensation

The integration of Facts device (power electronic controller), virtually to each Bus location may not be economically feasible in terms of cost. This means that the simulated results of the existing case study in Figure 4.2, 4.3, and 4.6 respectively will evidently indicate those buses/feeder that are either critically or marginally overloaded or stressed, that needs to be compensated with Static Var for purpose of improving the network of the study case essentially. It is also necessary to size the rating of the Static Var in order to accurately compensate for voltage reduction for better voltage profile increase.

Simple mathematical equation of active-power, apparent-power and reactive-power are considered to size capacity of the Static Var Compensation. The determined value of the Static Var controller is 0.3 MVAR (using the simple mathematical equation as recommended).

The stimulated results of the 11Kv Distribution network of one of the outgoing (Rumuola) feeder shows that (Bus 37 Obiwali, Bus 38 the Promise, Bus 39 Daniel Okocha Street, Bus 40 Daveages Hotel, Bus 41 Ejor Estate and Bus 42) are already over-stressed (or overloaded).

Importantly, the addition of 0.3 MVAR static compensation device to the affected buses/feeder will significantly improve the voltage-profile which are presented in Figure 4.9; thereby reduces the stress, overloaded and system instability. It is therefore evident that Rumuola 11Kv distribution feeder under study case shows that when plotted in terms % voltage profile existing case versus respective buses and % voltage profile versus respective buses with integration of Static Var Compensation after simulation are presented.

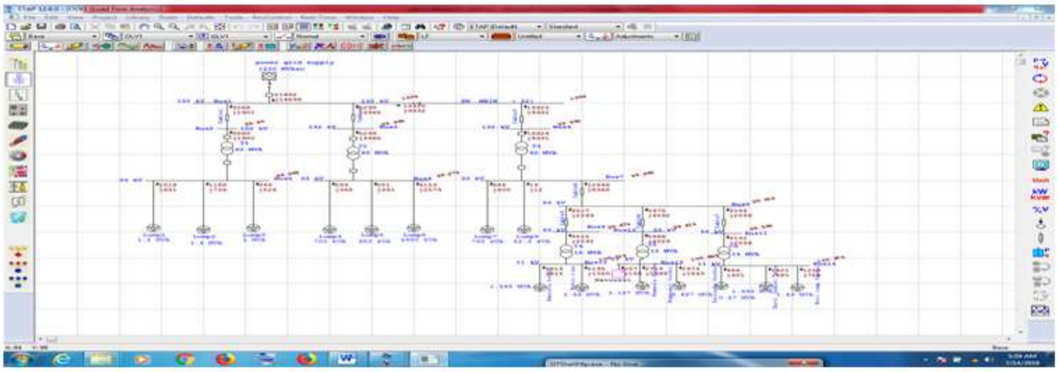

Figure 4.1: Presentation of Simulated Single Line Diagram of 132/33KV Network from Afam to Rumuola Injection Substation Golden Lilly

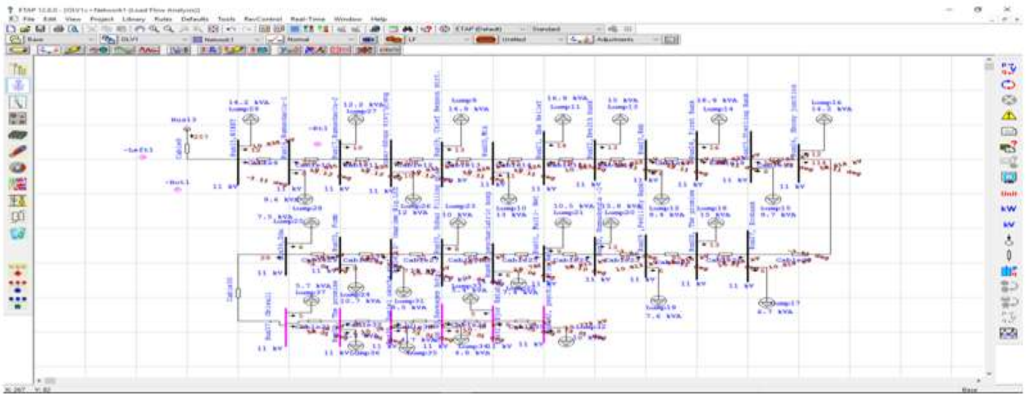

Figure 4.2: Presentation of Simulated Single Line Diagram of One of the Outgoing 11KV Distribution Feeder; Rumuola Injection Substation Golden Lilly

Table 4.1: The Results of Existing Case Study of Voltage Profile, at each Bus without Penetration of Static Var Compensation.

S/No	Existing Case Study at each Bus	Percentage % Voltage at each Bus	Voltage Angle
	Bus Number (No.)	% Voltage at each Bus	Deg (^{0})
1	Bus 1	74.80	- 8.6
2	Bus 2	72.42	- 10.25
3	Bus 3	70.72	- 10.02
4	Bus 4	69.88	- 10.52
5	Bus 5	68.25	- 10.33
6	Bus 6	67.20	- 10.48
7	Bus 7	66.26	- 10.76
8	Bus 8	66.24	- 11.20
9	Bus 9	66.28	- 11.16
10	Bus 10	65.43	- 11.50
11	Bus 11	64.88	- 11.42
12	Bus 12	63.33	- 11.66
13	Bus 13	63.20	- 11.36
14	Bus 14	63.17	- 11.72
15	Bus 15	62.44	- 11.22
16	Bus 16	62.21	- 11.66
17	Bus 17	61.28	- 11.28
18	Bus 18	61.46	- 11.86
19	Bus 19	61.21	- 12.07

Table 4.2: Presentation of Improved Voltage profile with the penetration of Static Var Compensation, after simulation of the network study case

S/No	Voltage at each Bus after Penetration of Static Var Compensation	
	Bus Number (No.)	% Voltage at each Bus
1	Bus 1	100.00
2	Bus 2	99.803
3	Bus 3	99.993
4	Bus 4	99.992
5	Bus 5	99.584
6	Bus 6	99.273
7	Bus 7	99.986
8	Bus 8	99.912
9	Bus 9	99.874
10	Bus 10	99.815
11	Bus 11	99.589
12	Bus 12	100.220
13	Bus 13	100.888
14	Bus 14	100.971
15	Bus 15	98.534
16	Bus 16	98.506
17	Bus 17	98.493
18	Bus 18	98.472
19	Bus 19	98.440

Table 4.3: Presentation of the comparison existing case study ad improved study case for voltage profile versus Bus number

Bus Number (No.)	Existing Case Study at each Bus	Improved study case of each Bus
Bus 1	74.80	100.00
Bus 2	72.42	99.803
Bus 3	70.72	99.993
Bus 4	69.88	99.992
Bus 5	68.25	99.584
Bus 6	67.20	99.273
Bus 7	66.26	99.986
Bus 8	66.24	99.912
Bus 9	66.28	99.874
Bus 10	66.43	99.815
Bus 11	64.88	99.589
Bus 12	63.33	100.220
Bus 13	63.20	100.971
Bus 14	63.17	98.534
Bus 15	62.44	98.506
Bus 16	62.21	98.493
Bus 17	61.28	98.493
Bus 18	61.46	98.472
Bus 19	61.21	98.440

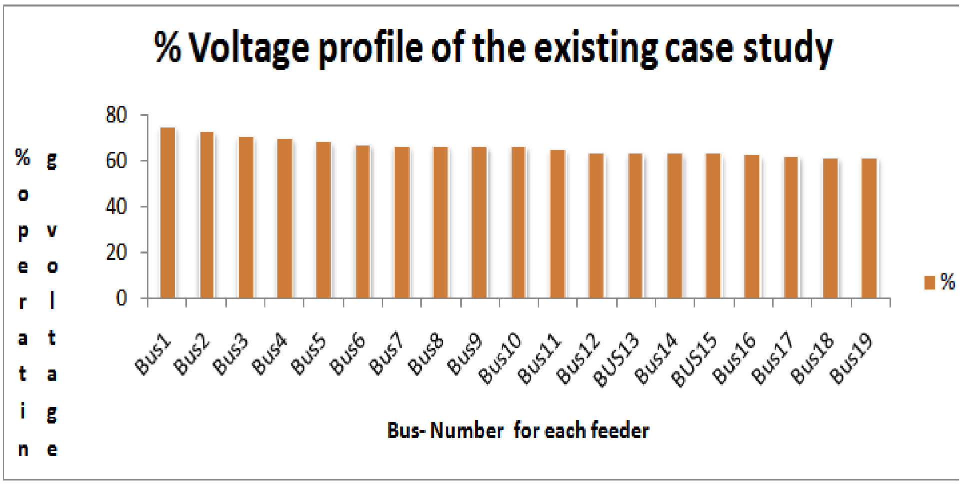

Figure 4.3: The Bar plot showing the % voltage profile of the existing case study with respect to Bus Number

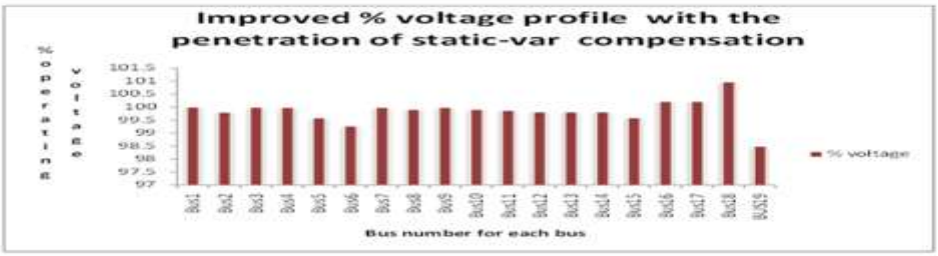

Figure 4.4: The Bar plot showing the % voltage profile of the compensated case study with respect to Bus Number

Case 2: Voltage Profile and Bus Location/Number

The result obtained in the composite bar chart showing the % voltage profile of existing and improved network with respect to Bus Number and the graph in figure 4.9 shows that the existing voltage profile against but location which are below the statutory limits, but by the penetration of power electronics controller (Static Var with capacity of 0.3MVA) which significantly improved the system stability with 20.02 % voltage rise on the view to enhance performance in the study case ; In one of the outgoing 11kv feeder at Rumuola, the composite bar chart of the existing / improved voltage magnitude versus bus number / location are plotted .

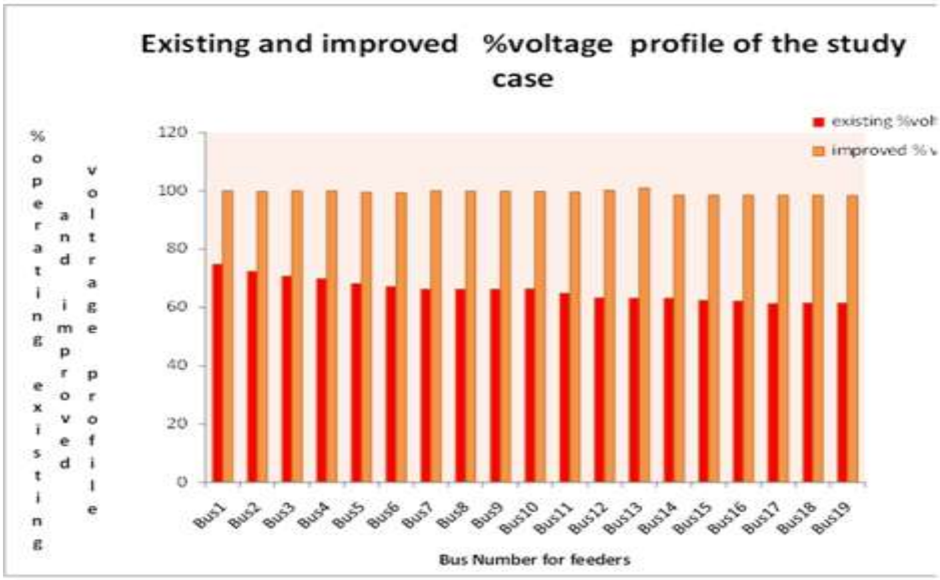

Figure 4.5: The composite Bar-chart showing the % voltage profile of existing and improved network with respect to Bus Number

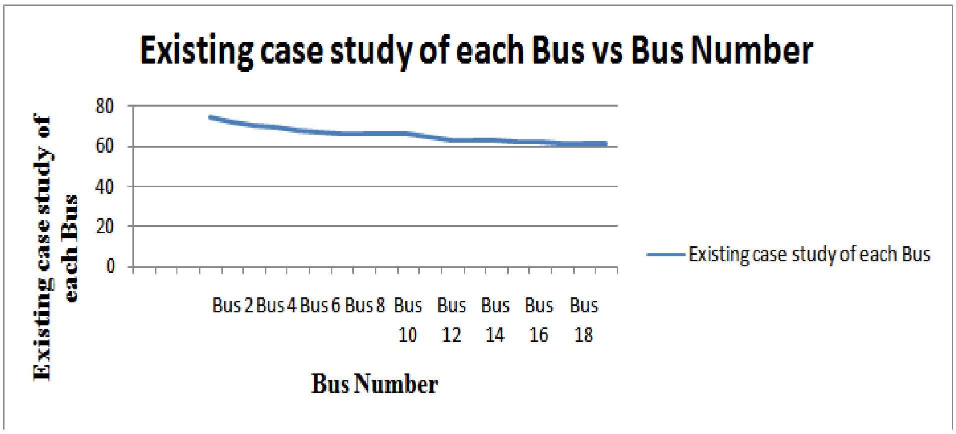

Fig. 4.6: Presentation of the graph showing the existing case study and versus bus number

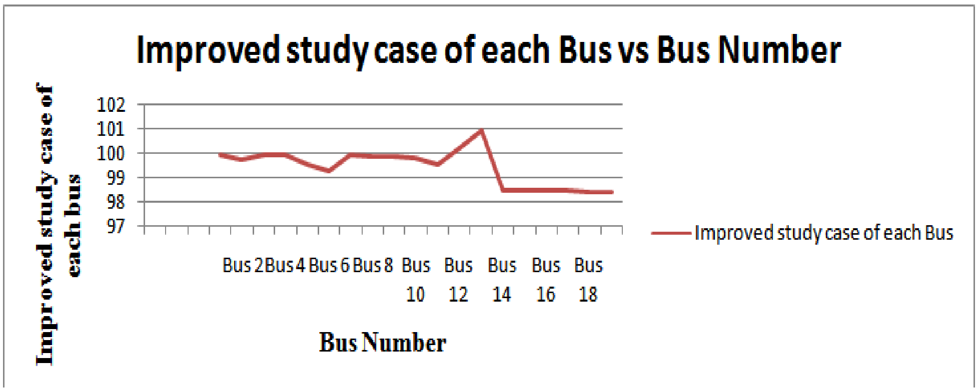

Fig. 4.7: Presentation of the graph showing the improved study case for voltage profile versus bus number

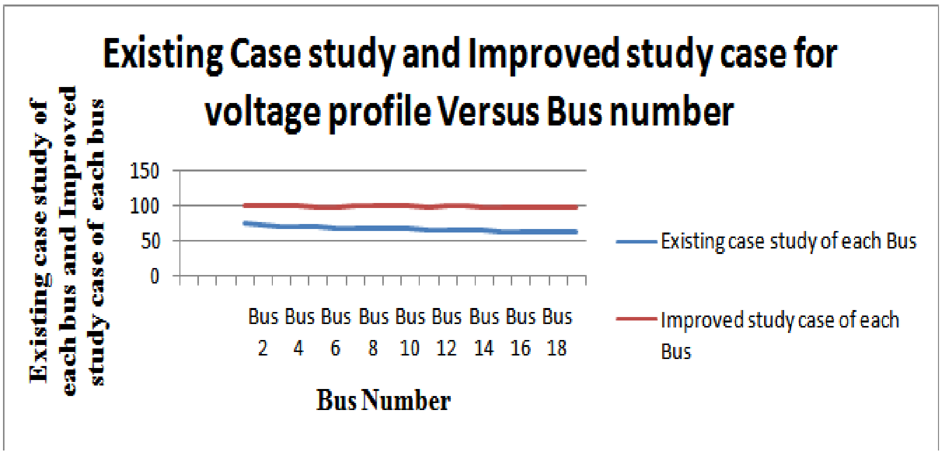

Figure 4.8: Graph showing the Percentage Voltage Profile of Existing and Improved Network with Respect to Bus Location

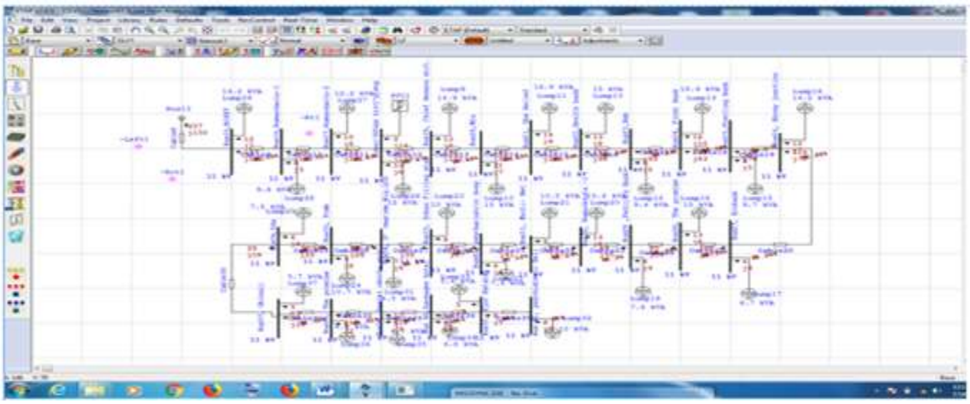

Figure 4.9: compensated single-line diagram of one of the outgoing 11kv distribution feeder; Rumuola Injection Substation Golden Lilly

V.CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The research work seriously examined the existing state of electrical power network for Rumuola injection substation, Golden Lilly (particularly one of the outgoing feeder, which consists 28-feeder points as the study

case, for purpose of analyzing the behaviour/voltage profile etc of the 11KV distribution network namely: (Bus 37 Obiwali, Bus 38 the Promise, Bus 39 Daniel Okocha Street, Bus 40 Daveages Hotel, Bus 41 Ejor Estate and Bus 42 Pyschiatric Road).

The existing case study is foundational and modeled in electrical transient analyzer programe/tool (E-Tap of verse 12.6) with the application of voltage drop/voltage-regulation and power flow equations in order to investigate the activities of the system. The results obtained are presented as an attachment in appendix B1, B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14 B15, B16, B17, B18, B19 and B20). The analysis and calculating were conducted and also simulated via e-tap-tool on the view to determine voltage drop, active and reactive power flow etc.

The results in the 11kv distribution network after simulation shows that buses: Bus 37, Bus 38, Bus 39, Bus 40, Bus 41 and Bus 42 respectively which are over stressed (overweighed) needed to be suppressed by facts device (Static Var Compensator) for purpose of system improvements. The size of static-var compensator capacity were formulated and determined in order to accurately take care of the affected buses, this will go along way to enhance effective operation and performance in the network. This is because it's a requirement that the distribution network shall not be deviated within the standard value of (±5 – ±10%) or (0.95pn – 1.05pn) in order to satisfy the statutory regulation practice.

Therefore, having identified the mismatch in the power flow, voltage-drop etc resulting into outage (black-out) in the network, the power factor need to be improved by making the power factor close to unity; in order to improve electrical supply available and increase efficiency of the system; thereby reducing the line losses.

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ABUT THE AUTHORS

Briggs, Kelly Cronuel Benibo holds [ND] in Electronics Telecommunication, Elechi Amadi polytechnics Port Harcourt and B – Tech in Electrical Engineering (power option), Department of Electrical Engineering, Rivers State University. Currently at the peak of Master's Degree, Rivers State University Port Harcourt, Rivers State and Member Nigeria Society of Engineers (MNSE)

Idoniboyeobu, Dikio Clifford is a Professor in the Department of Electrical Engineering, Rivers State University, Port Harcourt. He holds B.Eng degree in Electrical Engineering, Ahmadu Bello University, Zaria; M.Sc and Ph.D degrees in Electrical Engineering, University of Manchester, UK. He is COREN registered and a member of several Professional Organizations.

Braide, Sepiribo Lucky holds B – Tech in Electrical Engineering, M – Tech Electrical Engineering, Department of Electrical Engineering, Rivers State University Port Harcourt and Ph.D Electrical Engineering, Federal Technology Owerri and he is COREN registered and member of several professional organizations.

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