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Optimal D-statcom Placement for Loss Minimization in Distribution System Using Loss Sensitivity Technique

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ABSTRACT-This study examines reactive power compensation in Choba 33kV distribution network using D-STATCOM. The network consists of thirteen (13) 33/0.415kV distribution transformers. The network experiences unavoidable power losses, under voltage and irregular power supply, which affect the overall efficiency of the network. This work aims atenhancing the availability of electrical supply to Choba 33kV network that will in turn boost the revenue of business owners in that location. MATLAB/Simulink software is used to model the network and power flow analysis is performed to determine the steady state condition of the network and candidate buses and then, sensitivity analysis is carried out to ascertain the most sensitive bus for D-STATCOM placement. Synchronous reference frame (SRF) method is employed to generate PWM switching signal for D-STATCOM control. The result obtained from power flow analysis shows that (Bus7, Bus8, Bus9, Bus10, Bus11, Bus12 and Bus13) violatethe statutory limit condition of 0.95-1.05pu and are selected as candidate buses. Furthermore, the result of the sensitive analysis shows that the least ranked is Bus 13 and hence, is selected as the most sensitive bus for D-STACOM placement. The total real and reactive Power loss in the line is calculated as 129.886kW and 66.92kvar respectively. After optimization of the network using D-STATCOM, there is no bus voltage violation and the total active and reactive power losses from the network under consideration is 129.886kW and 66.92KVA and the total real and reactive power loss in the line is reduced from 129.886kW to 521.018kW and 66.92KVAR to 117KVar respectively. Based on the findings, it is therefore concluded that D-STATCOM is effective in improving voltage profile as well as minimizing real and reactive power loss.

KEYWORDS:D-statcom, Loss minimization, Loss Sensitivity, Distribution Network, Choba

1. INTRODUCTION

Power distribution infrastructure is designed to deliver electric power from generating stations or transmission stations to end consumers in an efficient and cost-effective manner [1]. The first component of the electrical distribution system is the injection substation, which is a place where the transmission line voltage (132kV) or Sub-transmission line voltage (33kV) is lowered by step down transformer to obtain primary distribution line voltage (11kV) and this primary distribution line called feeder takes the energy to the load centre and the distribution transformer at the load centre further steps down the voltage to secondary distribution line voltage, which are: 415V for three phase supply while 240V for single phase supply and neutral [2]. Primary voltage is commonly used in industries, factories and also to feed small substations where secondary distribution takes place [3].Electrical energy among the various types of energy, has a significant impact on how a society operates. As a result, it is crucial for a government to provide among other things, power to meet the growing demand of it's inhabitants [4]. In underdeveloped countries such as Nigeria, the amount of power lost in the distribution system is enormous and this is partly due to inductive nature of electric loads utilized in residential, commercial and industrial settings that necessitates the usage of lagging reactive power [5].

1.2. STATEMENT OF THE PROBLEM

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Overloading and overdependence of the distribution station which causes mismatch between the amount of energy generated and the amount of energy required at the receiving end which results to power outages most times and thus, system breakdown in Choba distribution area is a major problem which this work aims to address.

1.3.OBJECTIVES OF THE STUDY

The Objectives of this research are:

i. To model and simulate Choba 33kV distribution network in Matlab software application

ii. To determine the optimal location for D-STATCOM placement in Choba 33kV distribution network using loss sensitivity analysis

iii. To improve the voltage profile of Choba 33kV distribution network

II LITERATURE REVIEW

2.1 EXTENT OF PAST WORKS

Electric power distribution system is the final stage of power supply system, as well as the part of the electrical power system that is most visible to the end users. It is also the most expensive component of power system. [6] say that optimal delivery of uninterrupted power supply to the end users is a huge task and this is because there is a high demand for electricity on a regular basis that makes the distribution network more vulnerable to system instability such as overloading. The fundamental purpose of electrical power system is to provide an adequate electric power supply to all points of utilization at an economically acceptable rate with reasonable level of reliability [7]. Nigerians are faced with acute electricity problems, which are hindering its development notwithstanding the availability of vast natural resources in the country [8]. Distribution network is an integral and vital component of power system assessment for improved power quality and reliable electric power supply [9]. [10] say that loss minimization can be achieved by incorporating D-STATCOM into load flow studies. Mathematical model known as UPFC injection model is used which is easier to incorporate into Newton-Raphson power flow model, allowing researchers to investigate its impact on loss minimization in the power system. The study also show that D-STATCOM has the potential to manage power flow while also minimizing loss at the same time. D-STATCOM can be installed in a distribution network in order to optimize the voltage profile of the feeder and reduce power loss. It is critical, however, that D-STATCOM be put in the most optimal location possible inside the distribution network [11].Real power loss (I^2R) affect the efficiency of the power transfer and lead to poor voltage profile. The studies indicates that 10-13% of the total power generation is consumed as real power loss at the distribution system hence, there is need to place a compensating device in the distribution system to reduce power losses[12]. [13] conducted a research in order to achieve optimal D-STATCOM allocation in distribution system planning. The limitations of the technique, such as D-STATCOM switching transients, are thoroughly studied, and a solution for a system of feeders is successfully produced. The studyshows that the system capacity has beenenhanced, and that losses have reduced as a result. [14] describean approach that can be utilized to increase the voltage profile while also reducing the amount of loss. In the study, loss sensitivity factor is employed in order to choose the bus that is most suitable for D-STATCOM installation. The benefits of D-STATCOM deployment in distribution systems include power factor correction, voltage regulation, voltage profile, and power quality. [15] employ particle swarm optimization technique to optimize the loss of voltage stability enhancement including D-STATCOM in order to improve voltage stability. To determine the appropriate location of D-STATCOM, the implementation of loss reduction is evaluated with the IEEE-14 and IEEE-57 bus systems.[16] Looks at the ideal location of a unified power flow controller in the Nigerian Grid system. MATLAB/Simulink computer program is utilized in this study to analyze the voltage stability of the system and to select the most optimum location for the D-STATCOM. This work takes into account the sensitivity of the overall system active power loss with regards to the control variables of D-STATCOM. [17] create an improved UPFC steady-state mathematical model for the implementation of the device in the conventional Newton Raphson (NR) power flow method, which is more efficient. The proposed approach is tested using the IEEE-14 bus test system, which is available online and is found that by utilizing optimal positioning and ideal settings of D-STATCOM, system line losses decreases greatly.

2.2. FACT DEVICES

Reactive power compensation devices are devices installed into existing power line in orderto improve power quality. It is possible to provide reactive power assistance in series, shunt or a combination of the two configurations depending on the configuration and limitations. These power devices alter the electrical impedance of the line

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and so, increasing the amount of power that can be sent across the line. Among the several loss minimization strategies available, FACT device method is the most effective, affordable and most ecologically friendly [18].

III MATERIALS AND METHOD

3.1. MATERIALS USED

The materials used for this work are :

i. Single line diagram of the existing Choba 33kV distribution network
ii. Matrix Laboratory Software
iii. Line parameters such as resistance and reactance
iv. D-STATCOM components

3.2. METHOD

This research employs a quantitative approach and priority given to identify existing Choba 33KVA distribution network consisting of thirteen (13) 33/0.415kV. The thirteen (13) 33/0.415kV distribution network is modelled using Newton-Raphson power flow method to ascertain the candidate buses be owing to its fast quadratic convergence. The collected primary data serve as an input source to the activities of the distribution feeders which are simulated using MATLAB Simulink 2018 version to find the optimum size and most suitable location of STATCOM controller that will reduce the loss of the network and minimize voltage magnitude deviation on the line.

3.2.1 **Simulation of Choba 33KV distribution in Network MATLAB Software Using Newton Raphson load flow Analysis method.**

The Newton-Raphson Power Flow Solution is used to determine the steady state condition of the network and identify candidate buses which help in the reduction of search space for D-STATCOM placement.

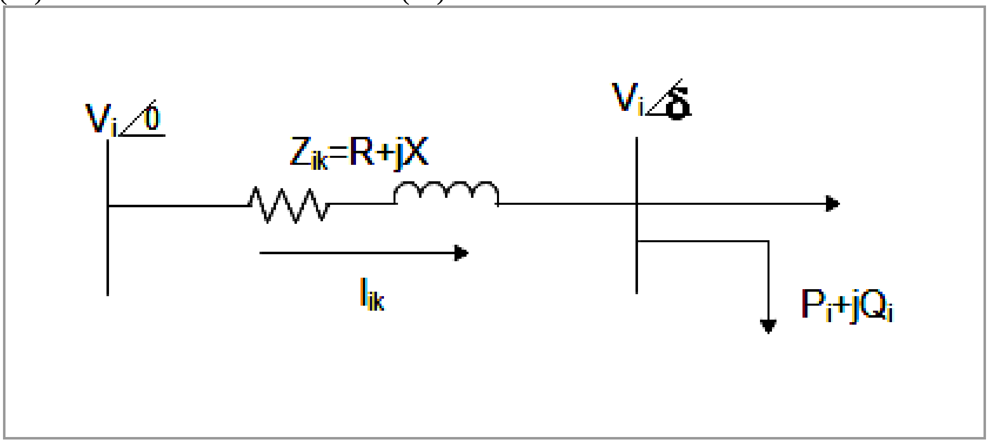

Figure 3.1 Distribution line with connected between two buses

From Figure 3.1 the complex power at the ith node on the distribution line is given

$S_i = V_i I_i^* = P_i + jQ_i$ (3.1)

$I_i = \left(\frac{S_i}{V_i}\right)^* = \frac{P_i - jQ_i}{V_i^*}$(3.2)

$I_i = \frac{P_i - jQ_i}{V_i^*} = \sum_{k=1}^{n} Y_{ik} V_k$ (3.3)

$P_i - jQ_i = V_i^* (\sum_{k=1}^{n} Y_{ik} V_k)$ (3.4)

Let $V_i^* = V_i \angle -\delta_i, V_k = V_k \angle \delta_k$ and $Y_{ik} = Y_{ik} \angle \theta_{ik}$

$P_i - jQ_i = V_i^* (\sum_{k=1}^{n} Y_{ik} V_k \angle \delta_k + \theta_{ik} - \delta_i)$ (3.5)

$P_i - jQ_i = \sum_{k=1}^{n} |Y_{ik}||V_i||V_k| [cos(\delta_k + \theta_{ik} - \delta_i) + j\, sin(\delta_k + \theta_{ik} - \delta_i)]$ (3.6)

Separating (3.6) into real and imaginary parts we have,

$P_i = \sum_{k=1}^{n} |Y_{ik}||V_i||V_k| \, cos(\delta_k + \theta_{ik} - \delta_i)$ (3.7)

$Q_i = -\sum_{k=1}^{n} |Y_{ik}||V_i||V_k| \, sin(\delta_k + \theta_{ik} - \delta_i)$ (3.8)

Where;

Y_{ik} = the admittance matrix
P_i = the injected real power
Q_i = the injected reactive power
δ_i = phase angle

Expanding (3.7) and (3.8) in Taylors series neglecting higher order terms we have

$$\begin{bmatrix} \Delta P_2^{(k)} \\ \vdots \\ \Delta P_n^{(k)} \\ \Delta Q_2^{(k)} \\ \vdots \\ \Delta Q_n^{(k)} \end{bmatrix} = \begin{bmatrix} \begin{vmatrix} \frac{\partial P_2^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial P_2^{(k)}}{\partial \delta_n} \\ \vdots & \ddots & \vdots \\ \frac{\partial P_n^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial P_n^{(k)}}{\partial \delta_n} \end{vmatrix} & \begin{vmatrix} \frac{\partial P_2^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial P_2^{(k)}}{\partial |V_n|} \\ \vdots & \ddots & \vdots \\ \frac{\partial P_n^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial P_n^{(k)}}{\partial |V_n|} \end{vmatrix} \\ \begin{vmatrix} \frac{\partial Q_2^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial Q_2^{(k)}}{\partial \delta_n} \\ \vdots & \ddots & \vdots \\ \frac{\partial Q_n^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial Q_n^{(k)}}{\partial \delta_n} \end{vmatrix} & \begin{vmatrix} \frac{\partial Q_2^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial Q_2^{(k)}}{\partial |V_n|} \\ \vdots & \ddots & \vdots \\ \frac{\partial Q_n^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial Q_n^{(k)}}{\partial |V_n|} \end{vmatrix} \end{bmatrix} \begin{bmatrix} \Delta \delta_2^{(k)} \\ \vdots \\ \Delta \delta_n^{(k)} \\ \Delta |V_2^{(k)}| \\ \vdots \\ \Delta |V_n^{(k)}| \end{bmatrix} \quad (3.9)$$

The Jacobian matrix gives the linearized relationship between mall changes in voltage angle $\Delta\delta_i^{(k)}$ and magnitude $\Delta|V_i^{(k)}|$ with small change in real $\Delta P_i^{(k)}$ and reactive power $\Delta Q_i^{(k)}$ respectively.

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_3 \\ J_2 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} \quad (3.10)$$

Where;

J_1, J_2, J_3, J_4 are the elements of the Jacobian matrix, in which;

$$J_1 = \frac{\partial P_i}{\partial \delta_i} \& \frac{\partial P_i}{\partial \delta_K}, \quad J_2 = \frac{\partial P_i}{\partial V_i}, \& \frac{\partial P_i}{\partial V_K}, \quad J_3 = \frac{\partial PQ_i}{\partial \delta_i} \& \frac{\partial Q_i}{\partial \delta_K}, \quad J_4 = \frac{\partial P_i}{\partial V_i} \& \frac{\partial P_i}{\partial V_K} \quad (3.11)$$

The diagonal and the off-diagonal elements of J_1 are

$$\frac{\partial P_i}{\partial \delta_i} = \sum_{k \neq k} |Y_{ik}||V_i||V_k| \cos(\delta_k + \theta_{ik} - \delta_i) \quad (3.12)$$

$$\frac{\partial P_i}{\partial \delta_i} = -|Y_{ik}||V_i||V_k| \sin(\delta_k + \theta_{ik} - \delta_i) \quad (3.13)$$

Similarly, the diagonal and off diagonal element of J_2, J_3, J_4 can be computed

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{(k)} \quad (3.14)$$

$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{(k)} \quad (3.15)$$

3.2.2. Determination of Optimal D-STATCOM Placement

Loss Sensitivity Factor is used to identify the most sensitive bus for D-STATCOM placement. This method is used because of its fast prediction and requires less computation. Figure 3.1 shows a line with impedance between two buses 1 and 2 respectively. The real and reactive power loss on the line can be obtained using the following equations.

The active power loss in the line is specified by $I^2_{ik}R$, which can be given by:

$$PL_{(2)} = \frac{[P_{(2)}^2 + Q_{(2)}^2] * R}{V_{(2)}^2} \quad (3.16)$$

Also, the reactive power loss in this line is obtained below:

$$QL_{(2)} = \frac{[P_{(2)}^2 + Q_{(2)}^2] * X}{V_{(2)}^2} \quad (3.17)$$

Th LSF of active and reactive power can be computed by taken the partial derivative of equation (3.16&3.17) to obtain:

$$\frac{\partial P_{ikloss}}{\partial Q_k} = \frac{2Q_K \times R_{ik}}{V_{(k)}^2} \quad (3.18)$$

$$\frac{\partial Q_{ikloss}}{\partial Q_k} = \frac{2Q_K \times X_{ik}}{V_{(k)}^2} \quad (3.19)$$

$$V_{norm\,[2]} = \frac{V_{(2)}}{0.95} \quad (3.20)$$

Where;

I_{ik}: is the current flowing through line
R: is the resistance of line k
X: is the reactance of line k
$V_{(k)}$: is the voltage at the bus k
$P_{(k)}$: is the real power loss at bus k
$Q_{(k)}$: is the reactive power loss at bus k

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3.2.3 Modeling of D-STATCOM Control Scheme

The basic function of D-STATCOM controller is to detect fault, voltage sag, voltage swell etc. AC current is rapidly injected into the grid to maintain constant voltage magnitude at load points under system disturbances by adjusting the phase and magnitude of the output voltage thereby permitting the control of active and reactive power between the D-STATCOM and the AC system. For this work, the synchronous reference frame (SRF) method is used as the control scheme for DSTATCOM. This method was used because of its fast action and high accuracy.

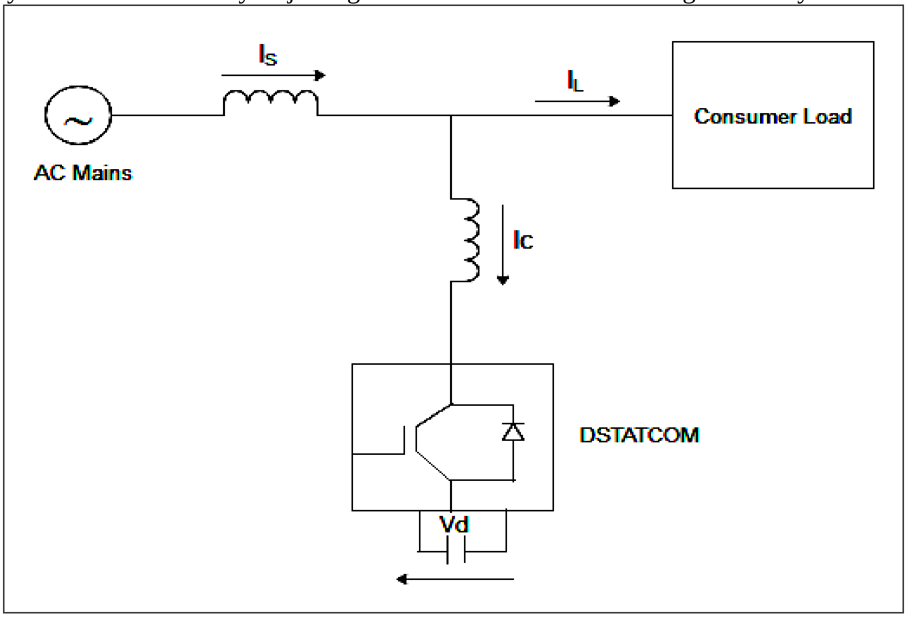

Figure 3.2: Single Line Diagram of D-STATCOM System

Table 3.1: Load and Bus Data

Substation				I_R	I_Y	I_B	I_N	**Total**
Bus No	**Bus Name**	**KVA**	**kV**	**(A)**	**(A)**	**(A)**	**(A)**	I_L **(A)**
1	Chukwu Street	500	0.415	250	208	200	40	232.667
2	Oriji Street	500	0.415	198	118	208	70	198.000
3	School Road	500	0.415	265	352	414	128	386.333
4	First Mechanic Rd	500	0.415	415	360	450	102	442.333
5	NDDC Road	500	0.415	410	384	512	150	485.333
6	Meabagas Street	500	0.415	472	420	464	48	468.000
7	Choosen Street	500	0.415	304	310	308	50	324.000
8	Omaro Street	500	0.415	290	280	275	35	293.333
9	Basket Ball Court	500	0.415	270	285	265	20	280.000
10	Abuja Street	500	0.415	280	274	270	32	285.333
11	Ideogu Street	500	0.415	290	280	275	55	300.000
12	Omunakwa Street	500	0.415	270	285	265	50	290.000
13	Okabie Street	500	0.415	280	274	270	62	295.333

Source: Port Harcourt Electricity Distribution Company (PHEDC)

From the above table, the average load current (I_L) of the distribution transformer was calculated using

$$I_L = 1 + \frac{I_R + I_Y + I_B + I_N}{3}$$

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2029-2039www.ijaem.net ISSN: 2395-5252

Where;

I_R = current in the red phase
I_Y = current in the yellow phase
I_B = current in the blue phase
I_N = current in the neutral line

Table 3.2: Line Data

Line ID	From Bus	To Bus	Impedance (Z)
1-2	Chukwu Street	Oriji Street	0.35+j0.037
2-3	Oriji Street	School Road	0.37+j0.039
3-4	School Road	First Mechanic Road	0.36+j0.038
4-5	First Mechanic Road	NDDC Road	0.39+j0.041
5-6	NDDC Road	Meabagas Street	0.33+j0.035
6-7	Meabagas Street	Choosen Street	0.30+j0.031
7-8	Choosen Street	Omaro Street	0.38+j0.040
8-9	Omaro Street	Basket Ball Court	0.37+j0.039
9-10	Basket Ball Court	Abuja Street	0.32+j0.033
10-11	Abuja Street	Ideogu Street	0.35+j0.037
11-12	Ideogu Street	Omunakwa Street	0.38+j0.040
12-13	Omunakwa Street	Okabie Street	0.33+j0.035

Source: Port Harcourt Electricity Distribution Company (PHEDC)

IV. RESULTS AND DISCUSSION

4.1: Resultof Simulation of Choba 33KV feeder distribution Network without D-STATCOM

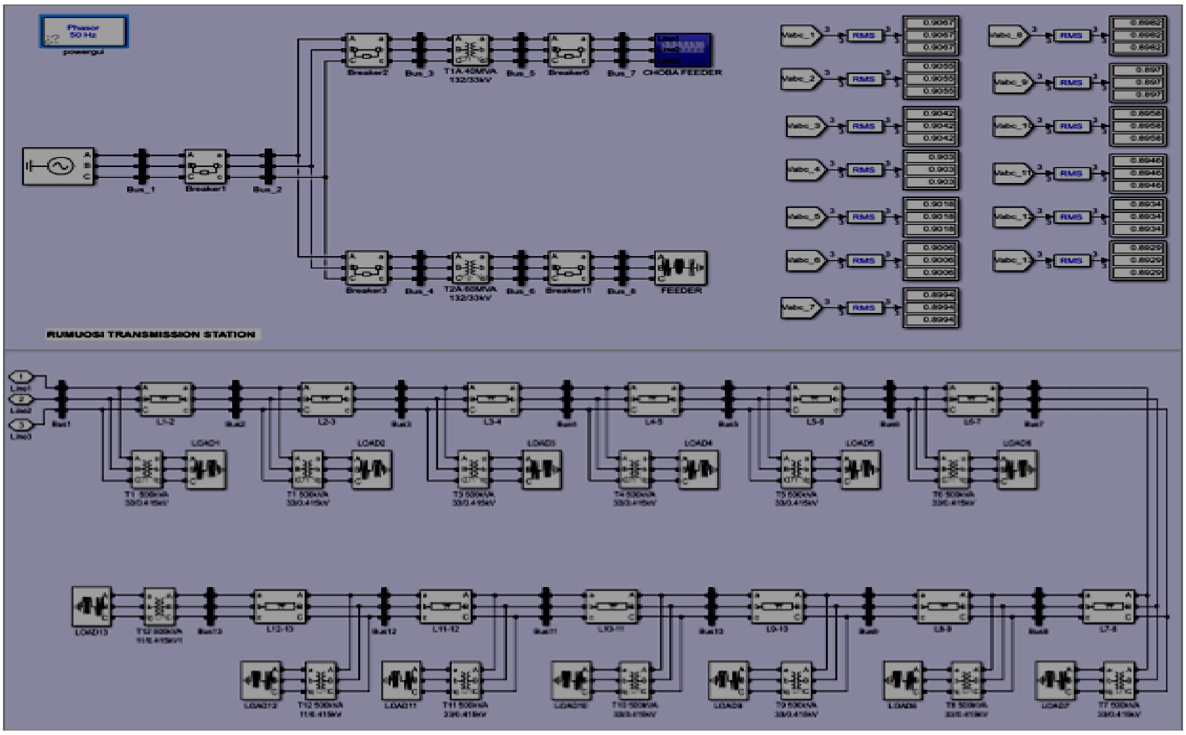

Figure 4.1: Simulation of Choba 33KV Feeder Distribution Network without D-STATCOM

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2029-2039www.ijaem.net ISSN: 2395-5252

Figure 4.1 shows the existing Choba 33kV distribution system when simulated in MATLAB software without D-STATCOM. The single line diagram consists of thirteen (13) 33/0.415KV distribution transformers with electric power supply from Omoku generating station to Rumuosi Transmission substation.

Table4.1: Bus Voltage without D-STATCOM

Bus No	Bus Name	Nominal (kV)	Operating (p.u)
1	Chukwu Street	33	0.9746
2	Oriji Street	33	0.9692
3	School Road	33	0.9666
4	First Mechanic Road	33	0.9642
5	NDDC Road	33	0.9585
6	Meabagas Street	33	0.9549
7	**Choosen Street**	**33**	**0.9381**
8	**Omaro Street**	**33**	**0.9244**
9	**Basket Ball Court**	**33**	**0.9148**
10	**Abuja Street**	**33**	**0.9035**
11	**Ideogu Street**	**33**	**0.8912**
12	**Omunakwa Street**	**33**	**0.8811**
13	**Okabie Street**	**33**	**0.8702**

Table 4.1 shows the calculated values of the bus voltages, of which the voltage magnitude at Bus 7, 8,9,10, 11, 12, 13 violated the statutory limit condition of voltage declaration according to IEEE. This situation must be prevented to avoid cascading bus voltage violation which might lead to system collapse. Therefore, there is need to incorporate STATCOM to control this bus voltage deviation, hence, these buses whose terminal voltages are violated are the candidates for STATCOM controller placements.

Table 4.2 Power Loss in the lines without DSTATCOM

Line ID	From Bus	To Bus	kW Loss	Kvar Loss
1	Bus1	Bus2	28.104	12.807
2	Bus2	Bus3	15.403	10.141
3	Bus3	Bus4	13.675	8.951
4	Bus4	Bus5	12.687	7.787
5	Bus5	Bus6	11.636	6.55
6	Bus6	Bus7	10.582	5.309
7	Bus7	Bus8	9.78	4.235
8	Bus8	Bus9	8.545	3.564
9	Bus9	Bus10	7.425	3.004
10	Bus10	Bus11	6.208	2.514
11	Bus11	Bus12	5.821	2.058

Table 4.2shows active and reactive power losses without D-STATCOM placement. It is shown that Bus 1 to Bus 2 has the highest power loss. Also, it was review that the total real and reactive power loss in the line as calculated are 129.886kW and 66.92kvar respectively. These losses must also be minimized for optimal operation of the network.

Table 4.3: Sensitivity Analysis

Bus ID	R(j)	V(j)	Q(j)	LSF	Ranking
1	0.35	0.9746	2461	1813.66	2
2	0.37	0.9692	2347	1848.92	1
3	0.36	0.9666	2253	1726.20	4
4	0.39	0.9642	2095	1757.70	3
5	0.33	0.9585	1916	1376.43	6
6	0.30	0.9549	1722	1133.10	8
7	0.38	0.9381	1536	1326.50	5
8	0.37	0.9244	1408	1219.30	7
9	0.32	0.9148	1292	988.08	11
10	0.35	0.9035	1183	1014.44	10
11	0.38	0.8912	1072	1025.79	9
12	0.33	0.8811	901	765.98	12
13	**0.35**	**0.8702**	**789**	**729.35**	**13**

Table 4.3 shows the sensitivity analysis results using lose sensitivity factor (LSF). In this method, the normalized voltage and the loss sensitivity factors are used to determine the most sensitive bus for D-STATCOM placement while the loss sensitivity factor (LSF) decides the requirement for D-STATCOM placement, normalized voltage gives the order of priority. Bus with normalized voltage less than 1.0pu and highest LSF value ranked in ascending order is selected as the most sensitive bus. Based on the above condition, Bus 13 is selected as the most sensitive among other candidate buses that really need D-STATCOM placement for improved network performances.

4.2 Simulation Result of Choba 33KV Feeder Distribution Network with D-STATCOM

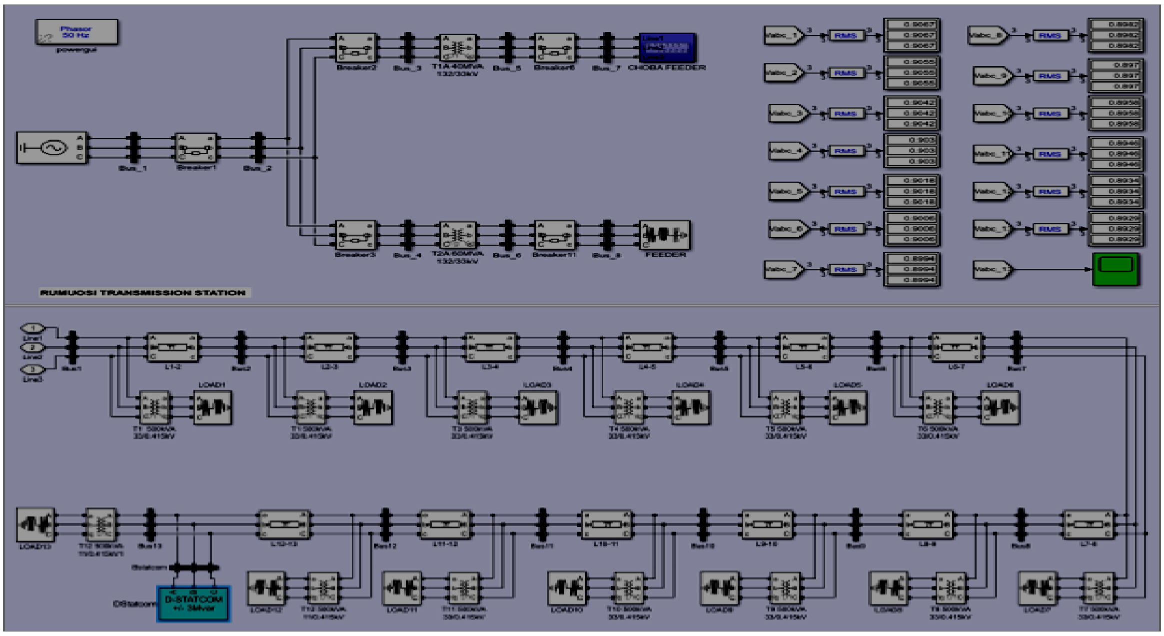

Figure 4.2: Simulation of Choba 33KV Feeder Distribution Network with D- STATCOM

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2029-2039www.ijaem.net ISSN: 2395-5252

Figure 4.2 shows the improved Choba 33kV distribution system when simulated in MATLAB software with D-STATCOM placement at bus thirteen (13). The results from the simulation are below.

Table 4.4: Bus Voltage with D-STATCOM

Bus No	Bus Name	Nominal (kV)	Operating (p.u)
1	Chukwu Street	33	0.9828
2	Oriji Street	33	0.9826
3	School Road	33	0.9824
4	First Mechanic Road	33	0.9821
5	NDDC Road	33	0.9819
6	Meabagas Street	33	0.9817
7	Choosen Street	33	0.9815
8	Omaro Street	33	0.9914
9	Basket Ball Court	33	0.9813
10	Abuja Street	33	0.9811
11	Ideogu Street	33	0.9809
12	Omunakwa Street	33	0.9807
13	Okabie Street	33	0.9805

Table 4.4 shows the nominal and operating voltage of Choba 33kV distribution network when D-STATCOM was placed on the network. It was noted that buses 12 and 13 were now regulated to 0.98 p.u. voltage magnitudes as aresult of STATCOM devices placement and the entire bus voltage magnitudes were improved which shows that D-STATCOM placement on bus network imparted positively on the voltage profile of the system.

Table 4.5 Power Loss in the lines with D-STATCOM

Line ID	From Bus	To Bus	kW Loss	Kvar Loss
1	Bus1	Bus2	15.442	8.974
2	Bus2	Bus3	11.404	6.621
3	Bus3	Bus4	5.317	3.084
4	Bus4	Bus5	4.609	2.667
5	Bus5	Bus6	3.879	2.238
6	Bus6	Bus7	3.177	1.824
7	Bus7	Bus8	2.601	1.485
8	Bus8	Bus9	2.258	1.283
9	Bus9	Bus10	1.988	1.124
10	Bus10	Bus11	1.767	0.994
11	Bus11	Bus12	1.576	0.882

There is an apparent impact of D-STATCOM on the network power loss as shown table. 4.5. Network power loss significantly reduced at almost all nodes, mainly at bus 7,8,9,10,11 and 12.The simulation results are presented to show the impact of the allocations of D-STATCOM placement in the network to minimize the active and reactive power losses in the line. It can be noted that a real power loss reduction of 54.018kW was achieved. This was as a result of incorporation of STATCOM controller in the system which generated required reactive power to control the load flow and loss minimization.

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4.3 Chart Showing Voltage Profile of Choba Distribution Network with D-STATCOM and without D-STATCOM

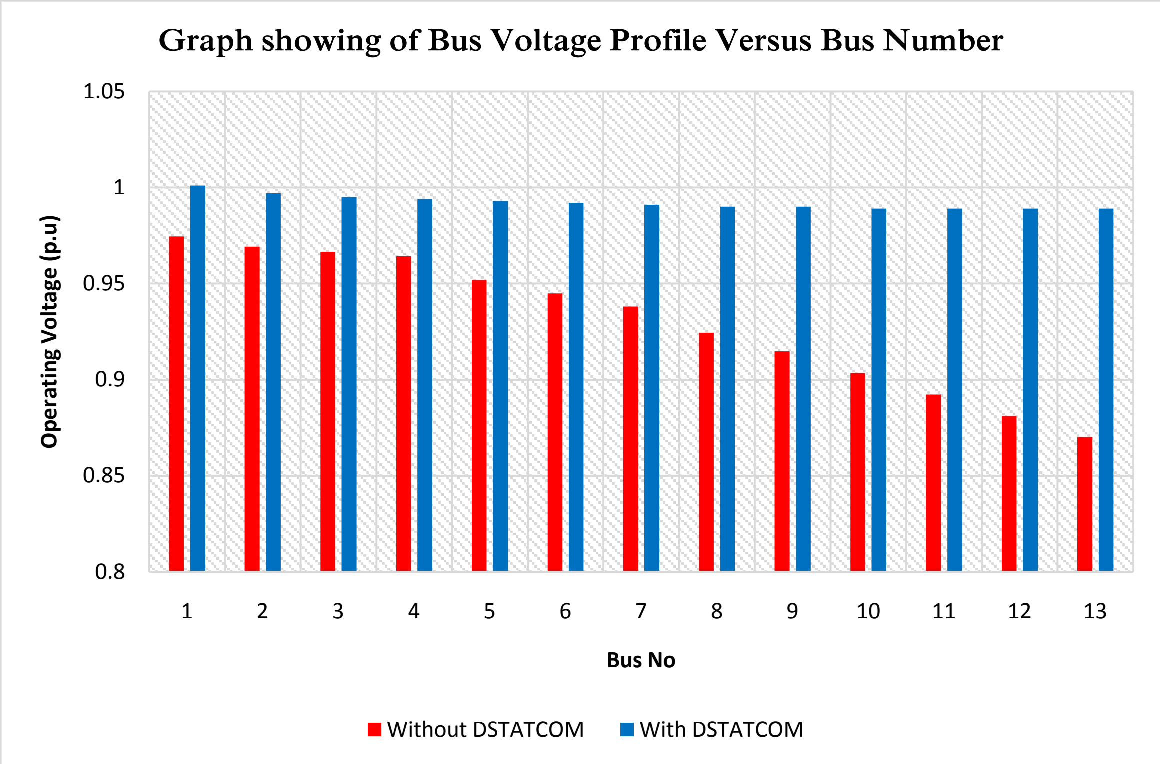

Figure 4.3: Voltage Profile of Choba 33kV Distribution Network

Figure 4.3 shows the combine plot of Choba 33kV distribution network voltage profile. The red bar indicates the existing network condition when D-STATCOM is not installed. Similarly, the blue bar shows the improved network condition when D-STATCOM is installed. A quick look at figure 4.3 shows that the voltage profile is improved significantly with D-STATCOM placement.

V. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The study examined the existing Choba 33KV distribution network consisting of thirteen (13) 33/0.415KV distribution transformers. The electric power supply to the distribution network is via Rumuosi Transmission stationduly link to Omuoku generating station. The network was modeled through MATLAB software, and was simulated based on two scenarios (without D-STATCOM and with D-STATCOM). The steady state condition of the network was evaluated and sensitivity analysis was performed to determine the most sensitive bus for D-STATCOM placement. Lastly, synchronous reference frame control scheme was used to generate PWM switching signal for D-STATCOM. The result obtained shows that D-STATCOM is effective in improving voltage profile as well as minimizing real and reactive power loss.

5.2 Recommendations

Based on the findings, the following recommendations are highlighted

i. Illegal connections should discourage and adequately monitored by the electricity power stakeholders.
ii. The loading of the distribution transformers should fall within acceptable limit on the view to operate at reliable and efficient power supply.
iii. The Port Harcourt Electricity Distribution Company (PHEDC), should put in place an improved mechanism for effective management strategies in minimizing losses on the power lines.
iv. There should be an integration of STATCOM on line 12 and 13 bus of Choba 33kv distribution network in order to improve the power factor and reactive power to be compensated.

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