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Evaluation of electric power Faults on11KV Distribution Network in NigeriaUsing Electrical Transient Analyzer Program

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ABSTRACT:-*The epileptic electricity power supply in Woji Village 11KV distribution network in Port Harcourt, Rivers State, Nigeria is never-ending following inadequate power distribution, human error fault, malfunctioning of power equipment and poor distribution infrastructure upgrade, etc. WojiVillage feeder is connected to Woji Injection substation. The Capacity, Voltage Ratio, Active Power, Reactive Power, Frequency, Power Factor, Complex Power, Transformer Percentage Loading, and Current Rating on each Transformerwere determined. The pre-upgrade and post-upgrade of the system was simulated using Electrical Transient analyser program (ETAP) software.Correction factor of 95% was usedfor the post-upgrade of the highly over loaded transformers in networksince it is verygood and economical for industrial purposes.Furthermore, 10Mvarcapacitor bank compensation was recommended for Woji Village 11KV distribution networkfor improved performance for the affected buses (B-9, B-14, B-20, B-45) with optimal placement capacity of B-9=2100KVAR, B-14=2500KVAR, B-20=2200KVAR, B-45=2200KVAR respectively. In conclusion, Port Harcourt Electricity Distribution (PHED) should do proper upgrading of their facility in WojiVillage feeders or develop another injection substation for Woji, Port Harcourt, Nigeria, for proper distribution of electricity to its customers.An effective monitoring of the network through load flow analysis should be activated to ensure that the connected load on the network is always equal to the capacity of the installed distribution transformer, thus conforming to IEE regulation of deviation not exceeding ±10% of the nominal voltage.*

Keywords:-*Capacitor bank, Complex Power, Pre-upgrade and Post-upgrade, Power world, System analysis*

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I. INTRODUCTION

Fault can be as a result of human error or due to malfunctioning of the equipment, electrical fault means an accidental electrical connection made between an energized component and something at a different potential leading to a short circuit.Faults occur when there is short circuit between phases, or phase to ground faults leading to unintended opening of fuses or circuit breakers used for protection within a power distribution system (Akintola, 2017). According to Elmir, et al., 2016), Single line-to-earth fault may become double line-to-earth faults. The inefficiency of Port Harcourt Electricity Distribution Company (PHEDC) accounts for why power interruption exists in our society. It is a well-known fact that PHEDC power supply has not been reliable for many years now and even till date, according to Okorie, 2016. Replacement or repair of any faulty electrical component such as transformer usually takes time, sometimes hours or days and as such may lead to longer hours of service interruption to the consumers. The transformers are electrical devices used for energy transfer by electromagnetic induction between two or more circuits, like all electrical devices faults also happen in the transformers which cause failures (Shayan, et al., 2015).

This research work identified fault as a result of active power, reactive power, Power Factor, Complex Power, Transformer Percentage Loading and the current rating on each Transformers in Woji Village11KV distribution feeder.

This research work isaimed at evaluating electric power faults on 11KV distribution feeder at Woji, Port Harcourt, Nigeria. This work deals with variables that are utilized in electrical power assessment, which includes: data collection on each transformerin WojiVillage 11KV distribution network from PHED, Port Harcourt, Rivers State, Nigeria, by determining the overloaded transformer on WojiVillage network, determine the active power, reactive power, frequency power factor, complex power, transformer percentage loading and current rating on each transformer in WojiVillage 11KV distribution Feeders, Newton-Raphson method was used for the power flow equation while Electrical Transient analyzer program (ETAP) simulation was used for the pre-upgrade and capacitor bank was used for the post- upgrade of Woji Existing Network.

II. MATERIALS AND METHODS

Direct patrol and inspection of the distribution network, as well as personal visits to the injection substations for on the spot assessment of the state of equipment. Three years (2015-2017) transformer load readings were gotten from the Port Harcourt Electricity Distribution Company of Nigeria (PHEDN) in Rivers State. Newton-Raphson method was used to determine the active power, reactive power, power factor, complex power, transformer percentage loading and the current rating on each transformer in Woji Village 11KV distribution feeder and line impedance while Microsoft Excel was used to justify the current and Electrical Transient analyzer program (ETAP) was used for the simulation.

Description of Woji, 33/11KV Distribution Network

Woji Injection substation receives electricity supply from Port-Harcourt Mains (Z_2), a garden city industrial Transmission station in Port-Harcourt Town and its capacity rating is 2x15MVA, 33/11KV which consists of one HV bus bars, two HV/MV transformers, two grounding transformers, one MV bus bars and two outgoing feeders (Woji Village Feeder and Woji Estate feeder), as shown in Figure 1 below, the distribution of electricity to the load centres within the network is through the respective 11KV feeders.

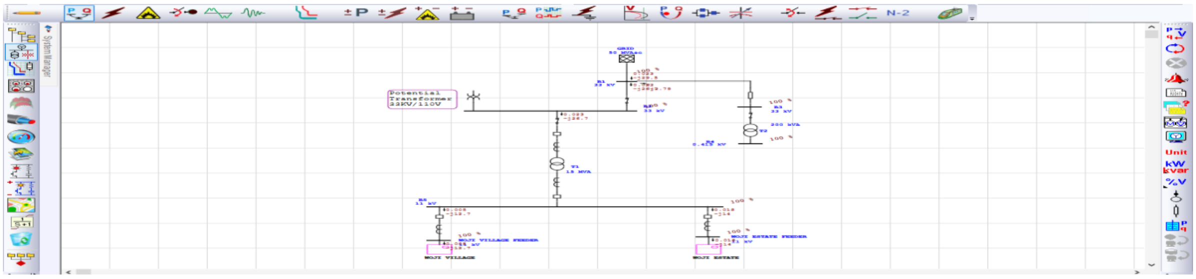

Figure 1: The Existing Network of Woji, 33/11KV Distribution Feeders

The 33 KV and 11 KV Woji, distribution networks in Rivers State are radial type system which is commonly used. It encompasses isolated feeders with, each feeder serving a given area, the circuits radiating out of the substation or source (Olusuyi, et al., 2014). Woji, distribution networks are large interconnected system with several buses and transformers connected through distribution lines, as shown in figure 2 below.

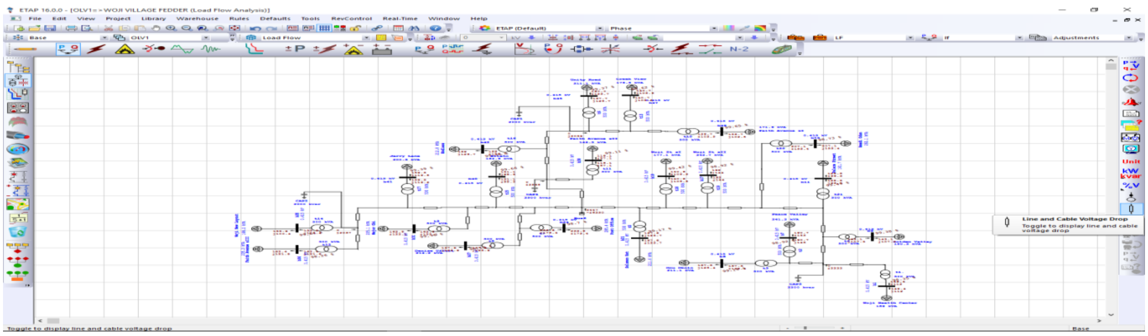

Figure 2: Post-Upgrade Single Line Diagram of Woji Village 11KV Network

There are links between HV/LV substations implemented by using link boxes. While some of these allow the maximum demand of the substation to be transferred, generally they are designed to assist maintenance and hence can only be used to transfer lower load levels. Modern LV fuse boards/cabinets have facilities for the connection of standby generation to assist maintenance and supply restoration following faults.

Current Data Collected on 33 KV Primary and Secondary Transformer in Woji Substation

The data used in this research work were collected from Port Harcourt Electricity Distribution Company (PHED) substations visited. The data collected includes; line impedance, bus voltage ratings, transformer data and transformer load readings:

Product of C. T=ABB

C.T Ratio=400:1

RHSV 36KV

Type =outdoor

Frequency =50 Hz

Burden =50VA core

Core 1=400/1A=10P10
Core 2=10P10 400-1A
Core 3=10P10 400-1A

Calculation of Load Current in Woji Feeder

Power Triangle was used in analyzing the reactive power, apparent power and power factor.

Transformer load in SVA= $\sqrt{3}$IV (1)

Active power in watts or kW= $\sqrt{3}$IV $\cos\theta$ (2)

Reactive power in VAR or kVAR= $\sqrt{3}$VI $\sin\theta$ (3)

Apparent power in VA or kVA= $\sqrt{\text{kW}^2 + \text{kVAR}^2}$ (4)

Power factor, $\cos\theta = \frac{\text{Active power}}{\text{Apparent power}} = \frac{\text{kW}}{\text{kVA}}$ (5)

Complex power, S = P + JQ (6)

Current $I = \frac{P(KVA)}{\sqrt{3}IV}$ (7)

Where, I, represent Current. V, represent Voltage and $\cos\theta$ represent the power factor at primary and secondary of transformers respectively.

Using the above equation (1 -7) to determine the transformer connection in Delta/Star since the system, consists of 15MVA, 33/11KV transformer and a 200KVA, 33/0.415KV transformer to explain the above formula deductions.

(i) The 15MVA, 33/11KV transformer is connected in Delta/Star,

Equation (5) above was used in determining the primary and secondary current of the 15MVA, 33/11KV transformer, we have

Power (P) in KVA = $\sqrt{3}IV$ (8)

Hence, $I = \frac{P(KVA)}{\sqrt{3}IV}$

Primary Load current$I_p = \frac{P(KVA)}{\sqrt{3}IV}$ (9)

While,

Secondary load current $I_s = \frac{P(KVA)}{\sqrt{3}IV}$ (10)

(ii) 200KVA, 33/0.415KV Transformer

Equation (9 and 10) above was used in determining the primary and secondary current of the 200KVA, 33/0.415KV transformer, we have

Primary Load current$I_p = \frac{P(KVA)}{\sqrt{3}IV}$

While,

Secondary load current $I_s = \frac{P(KVA)}{\sqrt{3}IV}$

Table 1 below, shows the 15MVA, 33/11KV transformer load current rating in the primary and the load current rating on 200KVA, 33/0.415KV secondary transformer in Woji Substation.

The Table 1: The Transformer Load Current Rating in the Primary and Secondary Transformer in Woji Injection Substation (Source: Port-Harcourt Electricty Distribution Company)

Base Transformer Rating	Transformer Load Current	Current Connected in Delta/Star
15MVA, 33/11KV transformer	Primary Load currentI_p	$262.4A$
	Secondary load current I_s	$2.858A$
200KVA, 33/0.415KV transformer	Primary Load currentI_p	$109.6A$
	Secondary load current I_s	$10.5A$

CT Ratio on the Secondary Side of 15 MVA Transformer in Woji Substation

Product Of $C.T = Abb\ 400{:}\,5$

C.T ratio $= 400{:}\,5$

(i) C.T Ratio for the H.V side of the Transformer $= 400{:}\,1A$

Equation (7) above was used in determining the primary and secondary current of the 15MVA, 33/11KV transformer, we have

Secondary full load current $I = \frac{P(KVA)}{\sqrt{3}IV}$

Name plate reading $= 789A$

Secondary full load current in primary $C.T = \frac{262.4*1}{400} = 0.656A$

Secondary full load in secondary $C.T = \frac{787.3*5}{400} = 9.841A$

On the low voltage side of the main transformer winding are connected in star, so equation (8) below was used in determining the phase voltage, we have

$$Phasevoltage = \frac{linevoltage}{\sqrt{3}} \quad (11)$$

$$Phasevoltage = \frac{11}{\sqrt{3}} = 6.351KV$$

On the high voltage side of the transformer, the main transformer windings are connected in Delta, hence

$$Phasevoltage = linevoltage = 33KV$$

Current transformer on 11KV side are connected in delta and the turn ratio = 400/5 = 80

Distribution Line Parameters in Woji Injection Substation Feeders

Resistance of line per kilometer

$$R_o = \frac{\rho\ell}{A}\Omega/\text{km} \quad (12)$$

Where;

ℓ Is the resistivity of aluminum $= 2.65 \times 10^{-8}\Omega$m

A = Area of conductor $= 200mm^2$

Reactance of line per kilometer

$$X_o = 0.1445 log_{10}\frac{D_{GMD}}{r} + \frac{0.0157}{n}\Omega/km \quad (13)$$

Where n=3 (number of phases on the line)

$$GMD = \sqrt[3]{D_{aa} \times D_{ab} \times D_{ac}} = 1.26D$$

(14)

$$r = \sqrt{\frac{A}{\pi}} \quad (15)$$

Where:

A, represent the conductor cross sectional area of the aluminium conductor steel reinforced with galvanized, (A = 182mm2ACSR/GZ). GMD, represent the geometric mean distance of conductor in m. r represent the radius of conductor in metre (m). While D is the distance between adjacent conductor (D=0.88m).

Impedance of line per kilometer

$$Z_o = R_o + JX_o \quad (16)$$

Admittance of line per kilometer

$$Y_o = G_o + JB_o \quad (17)$$

Where; G_o represent the conductance of the line in Siemens while B_o is the susceptance of the line in Siemens.

Determination of Distribution Line parameters in Woji Village Feeder

Data on Woji Village Feeder:

L = 9.88km (the route length of Woji Village feeder), converting the value to metre, we have

L = 9.88×10^3m, while A = $150mm^2$ (cross sectional area of Woji Village feeder),

$\therefore$ A = $150 \times 10^{-6}m^2$ and $\rho = 2.8 \times 10^{-8}$ohm/m

Equation (12) above was used in Calculating the value of the resistance of WojiVillageFeeder, we have

$$R = \frac{\rho L}{A}$$

Equation (13) above was used in calculating for per kilometre inductive reactance X of the Woji Village feeder, we have;

$$X_o = 0.1445 log_{10}\frac{D_{GMD}}{r} + \frac{0.0157}{n}$$

Note that

$D_{GMD} = 1.26$D, and the value of $D = 880$mm, $D = 0.88$m (horizontal space)

Since $D_{GMD} = 1.26$D, hence the value of D above was used to determine the geometric mean distance of conductor, has shown below

$D_{GMD} = 1.26$D, then $D_{GMD} = 1.26 \times 0.88 = 1.108$m

Equation (15) above was used in ccalculating the radius of the conductor, we have

$$r = \sqrt{\frac{A}{\pi}}$$

Calculating for per kilometre inductive reactance X of the Woji Village feeder, using equation (13), we have

$$X_o = 0.1445\ log_{10}\frac{1.108}{0.0069} + \frac{0.0157}{n}\Omega/k$$

Multiplying the route length of Woji Village feeder with the inductive reactance of the WojiVillage feeder, we have

$$X_o = 0.3239\Omega/km \times 9.88km$$

Equation (16) above was used to determine for the impedance of the Woji Village feeder, we have

$$Z_o = R_o + JX_o$$

Equation (18) below was used in calculating the per kilometre capacitive susceptance B, we have

$$B = \frac{7.5}{log_{10}\left(\frac{D_{GMD}}{r}\right)} \times 10^{-6} \qquad (18)$$

Multiplying the route length of Woji Village feeder with the capacitive susceptance of the WojiVillage feeder, we have

$$B = 3.4 \times 10^{-6}\Omega/km \times 9.88km$$

Using equation (17) above to determine the admittance (Y_o) of Woji Village feeder, we have

$$Y_o = G_o + JB_o$$

Determination of Overloaded Transformers on Woji Feeders

The apparent power performance index is used to determine the percentage loading of transformers in the network. Based on the principle of loading of distribution transformers being 60% on rating for design purpose, transformers with loadings in excess of this figure are considered overloaded.

$$\%Loading = \sum_{i=1}^{N_T}\left(\frac{S_{MVA}}{S_{MAX}}\right) \times 100 \qquad (19)$$

Where;

S_{MAX} Represent the MVA rating of the transformer

S_{MVA} Represent the operating MVA from power flow calculation

N_T Represent the number of transformers

Table 2 below, shows the transformer current reading in Woji Village.

Table 2: The Location of Transformers and its rating on 11KV Feeder in Woji Village (Source: Port-Harcourt Electricity Distribution Company)

LOAD READING FOR WOJI VILLAGE 11KV FEEDER

S/N	NAME, CAPACITY AND VOLTAGE RATIO	LOAD READING (Amps) R	Y	B	N
1	WOJI HEALTH CENTER, 300KVA, 11/0.415KV	234	217	301	36
2	PEACE VALLEY, 500KVA, 11/0.415KV	325	276	309	97
3	ONU OKOLO, 500KVA, 11/0.415KV	281	278	289	78
4	GOLDEN VALLEY, 500KVA, 11/0.415KV	231	178	276	67
5	KING SOLOMON EST., 500KVA, 11/0.415KV	267	256	289	71
6	UNITY ROAD, 500KVA, 11/0.415KV	231	278	273	99
7	POST OFFICE, 500KVA, 11/0.415KV	342	367	401	123
8	DENISE UFOT, 300KVA, 11/0.415KV	267	231	267	129
9	MAJOR OBI, 500KVA, 11/0.415KV	231	342	245	38
10	FAITH AVENUE S/S I, 500KVA, 11/0.415KV	231	215	230	40
11	FAITH AVENUE S/S II, 300KVA, 11/0.415KV	134	201	198	78
12	FAITH AVENUE S/S III, 300KVA, 11/0.415KV	235	255	321	32
13	CREEK VIEW, 500KVA, 11/0.415KV	231	198	241	68
14	WOJI NEW LAYOUT, 500KVA, 11/0.415KV	186	203	187	126
15	ELITOR S/S III, 500KVA, 11/0.415KV	234	198	213	42
16	ENDLESS S/S, 500KVA, 11/0.415KV	198	245	278	167
17	JERRY LANE, 500KVA, 11/0.415KV	189	267	261	121
18	WOJI STREET S/S I, 500KVA, 11/0.415KV	195	245	231	68
19	WOJI STREET S/S II, 500KVA, 11/0.415KV	324	271	287	131
20	AMADI ODUM, 500KVA, 11/0.415KV	325	289	267	213
21	PALACE STREET, 500KVA, 11/0.415KV	200	189	201	85

Determining each Transformer loading and its percentage load in Woji Village 11KV Feeder.

The loading reading data collected in table 3.4 above on each transformer in Woji Village Feeder was determined as follows,

1. Woji Health Center, 300KVA, 11/0.415KV

Equation (7) with the load reading data collected in table 2 above, was used in calculatingthe total current that flows through this transformer, we have

$$\text{Current, } I = \frac{Currentloadreading}{3} = \frac{234+217+301+36}{3} = \frac{788}{3} = 262.6666667 \cong 263A$$

Equation (1) above was used in calculating transformer-loading SVA:
$SVA = \sqrt{3} \times V \times I = \sqrt{3} \times 0.415 \times 263 = 1.7320 \times 0.415 \times 263 = 189$KVA
Since 60% rating was used for design purpose, calculating for overloaded transformer using equation (1) above, we have% $loading = \frac{SVA}{S_{MAX}} \times 100\% = \frac{188.81}{300} \times 100\% = 63\%$
Equation (3) above was used in calculating for the reactive power (kVAR), we have
The reactive power, kVAR= $\sqrt{3}VIsin\theta$; Note that $\sqrt{3} \times V \times I = 189$KVA,
Since$sin\theta = 0.6$; Hence, $kVAR = 189 \times 0.6 = 113.4KVA_r$
Equation (2) above was used in calculating for the active power (kW), we have
The active power, $kW = \sqrt{3} \times V \times Icos\phi$; Note that $\sqrt{3} \times V \times I = 189$KVA,
since $cos\phi = 0.8$; Hence,$kW = 189 \times 0.8 = 151.048 \cong 151.2$kW
Using equation (5) above in determining for the value of Complex power S, we have
Complex power, $\mathrm{S = kW + jkVAR = 151.2 + j113.4}$
Using equation (4) above in determining for the value of apparent power kVA, we have
Apparent power in VA or kVA= $\sqrt{\mathrm{kW}^2 + \mathrm{kVAR}^2} = \sqrt{151.2^2 + 113.4^2} = 189\mathrm{kVA}$
Using equation (5) above in determining for the value of Power factor (cos θ), we have
Power factor, $\cos\theta = \frac{\text{Active power}}{\text{Apparent power}} = \frac{\mathrm{kW}}{\mathrm{kVA}} = \frac{151.2}{189} = 0.8$
This same method was used in determining the active power, reactive power, frequency power factor, complex power and transformer percentage loading on each transformer in Woji Village 11kv Feeder.

III. RESULTS AND DISCUSSION

Result on Transformers in Woji Village 11KV Feeder

The Active Power, Reactive Power, Frequency Power Factor, Complex Power and Transformer Percentage Loading on each Transformer in Woji Village 11KV Feeder that was determination in Chapter 3 was put into table 3a and b.

Table 3a: The Name, Capacity, Voltage Ratio, Active Power, Reactive Power andFrequency on each Transformer in Woji Village 11KV Feeder.

S/NO	NAME, CAPACITY AND VOLTAGE RATIO	Active Power (kW)	Reactive Power (kVAR)	Apparent Power (KVA)	Frequency (Hz)
1	WOJI HEALTH CENTER, 300KVA, 11/0.415KV	151.2	113.4	189	50
2	PEACE VALLEY, 500KVA, 11/0.415KV	193.02	144.77	241.3	50
3	ONU OKOLO, 500KVA, 11/0.415KV	177.5	133.12	221.9	50
4	GOLDEN VALLEY, 500KVA, 11/0.415KV	144.144	180.11	180.27	50
5	KING SOLOMON EST., 500KVA, 11/0.415KV	169.266	126.94	211.6	50
6	UNITY ROAD, 500KVA, 11/0.415KV	168.86	126.65	211.1	50
7	POST OFFICE, 500KVA, 11/0.415KV	236.344	177.26	295.4	50
8	DENISE UFOT, 300KVA, 11/0.415KV	171.36	128.52	214.2	50
9	MAJOR OBI, 500KVA, 11/0.415KV	164.08	123.06	205.1	50
10	FAITH AVENUE S/S I, 500KVA, 11/0.415KV	137.24	102.93	171.6	50
11	FAITH AVENUE S/S II, 300KVA, 11/0.415KV	117.12	87.84	146.5	50
12	FAITH AVENUE S/S III, 300KVA, 11/0.415KV	161.58	126.59	205.3	50
13	CREEK VIEW, 500KVA, 11/0.415KV	141.464	106.1	176.8	50
14	WOJI NEW LAYOUT, 500KVA, 11/0.415KV	134.56	100.92	168.2	50
15	ELITOR S/S III, 500KVA, 11/0.415KV	131.69	98.77	164.6	50
16	ENDLESS S/S, 500KVA, 11/0.415KV	170.22	127.66	212.8	50
17	JERRY LANE, 500KVA, 11/0.415KV	160.632	120.47	200.8	50
18	WOJI STREET S/S I, 500KVA, 11/0.415KV	141.65	106.24	177.1	50
19	WOJI STREET S/S II, 500KVA, 11/0.415KV	194.18	145.63	242.7	50
20	AMADI ODUM, 500KVA, 11/0.415KV	209.7	157.27	262.1	50
21	PALACE STREET, 500KVA, 11/0.415KV	129.38	97.04	161.7	50

Table 3b: The Name, Capacity, Voltage Ratio, Power Factor, Complex Power, Transformer Percentage Loading and Current Rating on each Transformer in Woji Village 11KV Feeder

S/NO	NAME, CAPACITY AND VOLTAGE RATIO	Power factor Cos Ø	Complex power S	Transformer %Loading	Current (A) Rating
1	WOJI HEALTH CENTER, 300KVA, 11/0.415KV	0.8	151.2 + j113.4	63%	263
2	PEACE VALLEY, 500KVA, 11/0.415KV	0.8	193.02 + j144.77	48%	336
3	ONU OKOLO, 500KVA, 11/0.415KV	0.8	177.5 + j133.12	44%	308.67
4	GOLDEN VALLEY, 500KVA, 11/0.415KV	0.8	144.14 + j180.11	36%	250.67
5	KING SOLOMON EST., 500KVA, 11/0.415KV	0.8	169.26 + j126.65	42%	2943
6	UNITY ROAD, 500KVA, 11/0.415KV	0.8	168.86 + j126.65	42%	293.67
7	POST OFFICE, 500KVA, 11/0.415KV	0.8	236.34 + j177.26	59%	411
8	DENISE UFOT, 300KVA, 11/0.415KV	0.8	171.36 + j128.52	43%	298
9	MAJOR OBI, 500KVA, 11/0.415KV	0.8	164.08 + j123.06	41%	285.33
10	FAITH AVENUE S/S I, 500KVA, 11/0.415KV	0.8	137.24 + j102.93	34%	238.67
11	FAITH AVENUE S/S II, 300KVA, 11/0.415KV	0.8	117.12 + j87.84	49%	203.67
12	FAITH AVENUE S/S III, 300KVA, 11/0.415KV	0.8	161.58 +j126.59	67%	281
13	CREEK VIEW, 500KVA, 11/0.415KV	0.8	141.46 + j106.10	35%	246
14	WOJI NEW LAYOUT, 500KVA, 11/0.415KV	0.8	134.56 + j100.92	34%	234
15	ELITOR S/S III, 500KVA, 11/0.415KV	0.8	131.69 + j98.77	33%	229
16	ENDLESS S/S, 500KVA, 11/0.415KV	0.8	170.22 + j127.66	43%	296
17	JERRY LANE, 500KVA, 11/0.415KV	0.8	160.63 + j120.47	40%	279
18	WOJI STREET S/S I, 500KVA, 11/0.415KV	0.8	141.65 + j106.24	35%	246
19	WOJI STREET S/S II, 500KVA, 11/0.415KV	0.8	194.18 + j145.63	49%	37.67
20	AMADI ODUM, 500KVA, 11/0.415KV	0.8	209.7 + j157.27	52%	364.67
21	PALACE STREET, 500KVA, 11/0.415KV	0.8	129.38 + j97.04	32%	225

The result in Figure 3 shows that the active power (KW) on each Transformer in Woji Village 11KV Distribution Network, were in Table 3a, No. 7, the active power (KW) on transformer located at Post Office was very high while the active power on transformer located in Table 4.2, No. 11 (Faith Avenue S/S II) has the lowest.

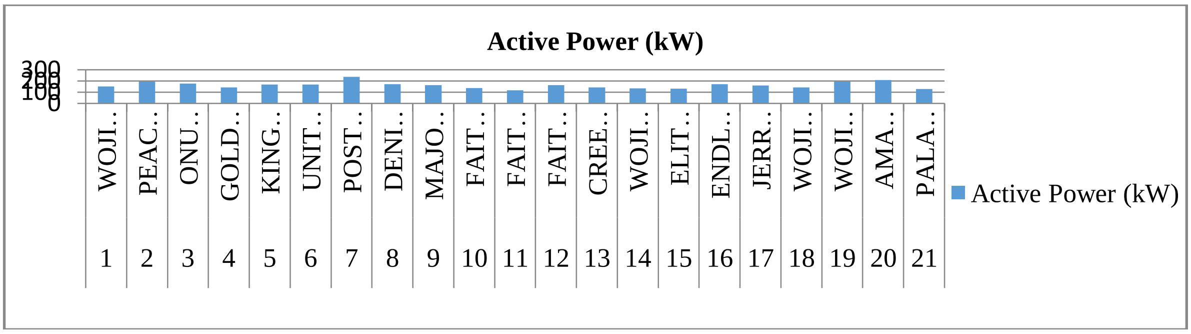

Figure 3: The Active Power (KW) Chart on each Transformer in Woji Village 11KV Network

The result in Figure 4, shows that the reactive power (KVAR) on each Transformers in Woji Village 11KV Distribution Network, were in Table 3a, No. 4 above the active power (KW) on transformer located at Golden Valley was very high while the reactive power on transformer located in table 3a, No. 11 (Faith Avenue S/S II) has the lowest.

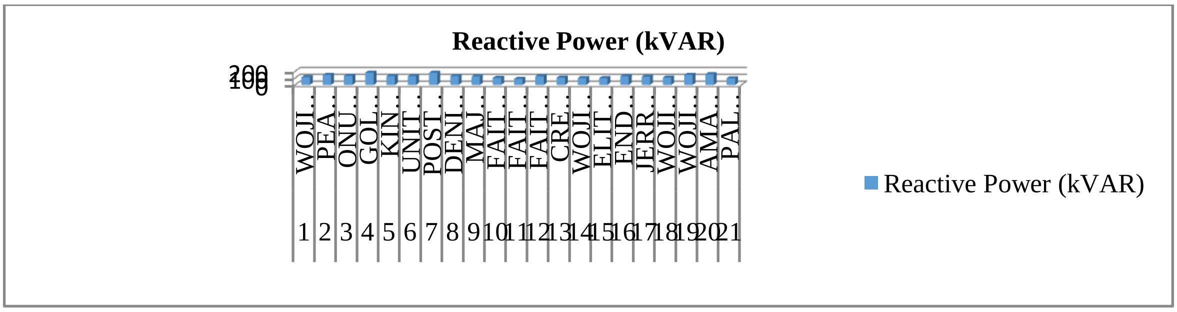

Figure 4: The Reactive Power (KVAR) Chart on each Transformer in Woji Village 11KV Network

The result in Figure 5 shows that the apparent power (KVAR) on each Transformer in Woji Village 11KV Distribution Network, were in Table 3a, No. 7 above the apparent power (KW) on transformer located at Post Office was very high while the apparent power on transformer located in Table 3a, No. 11 (Faith Avenue S/S II) has the lowest.

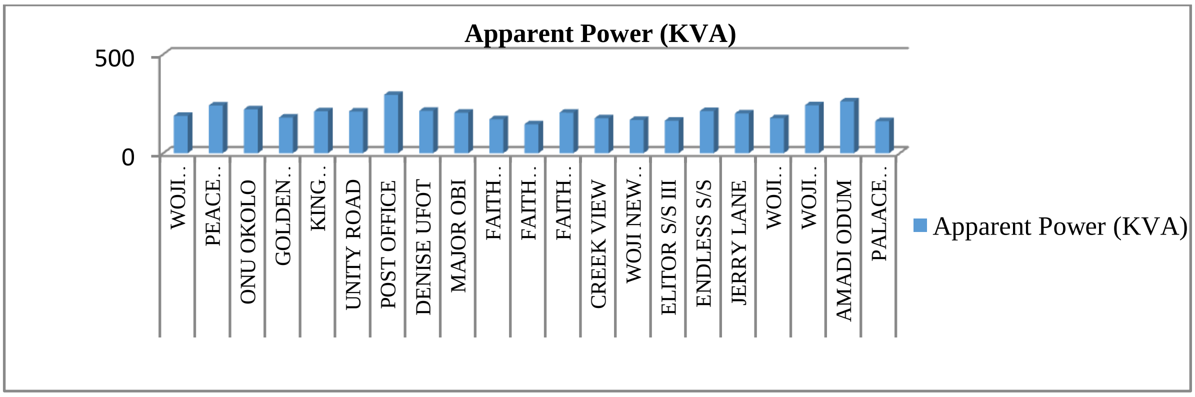

Figure 5: The Apparent Power (KVA) Chart on each Transformer in Woji Village 11KV Network

The result in Figure 6, shows that the Frequency (H_Z) on each Transformer in Woji Village 11KV Distribution Network, which is gotten from Table 3a were all equal.

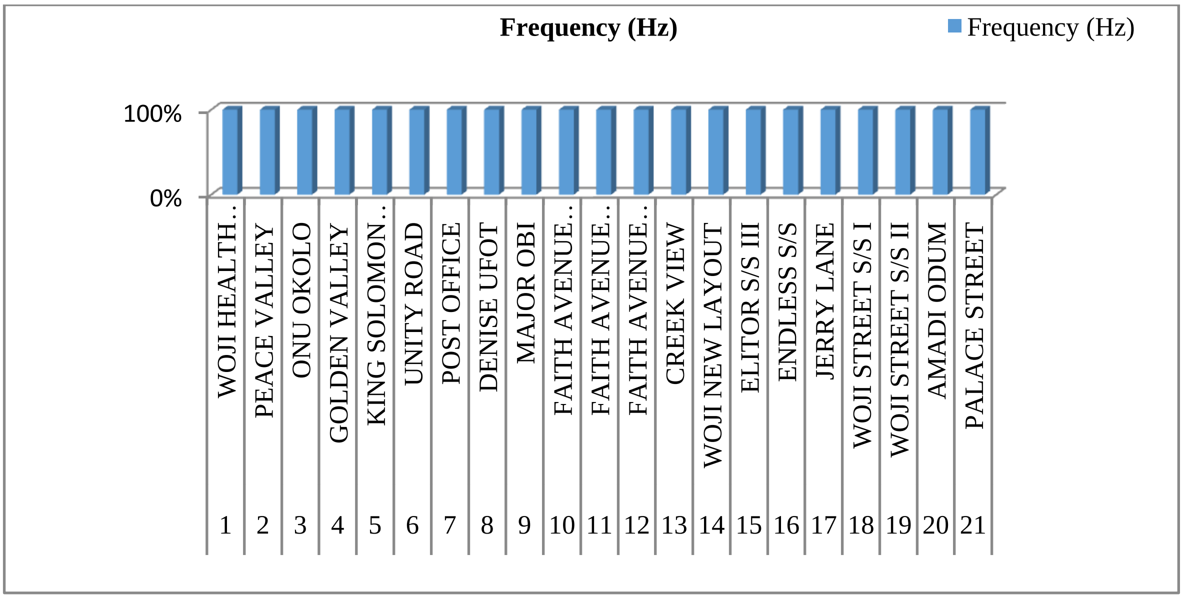

Figure 6: The Frequency (Hz) Chart on each Transformer in Woji Village 11KV Network

The result in Figure 7 shows that, the Power Factor (Cos Ø)on each Transformer in Woji Village 11KV Distribution Network, which is gotten from Table 3b were all equal.

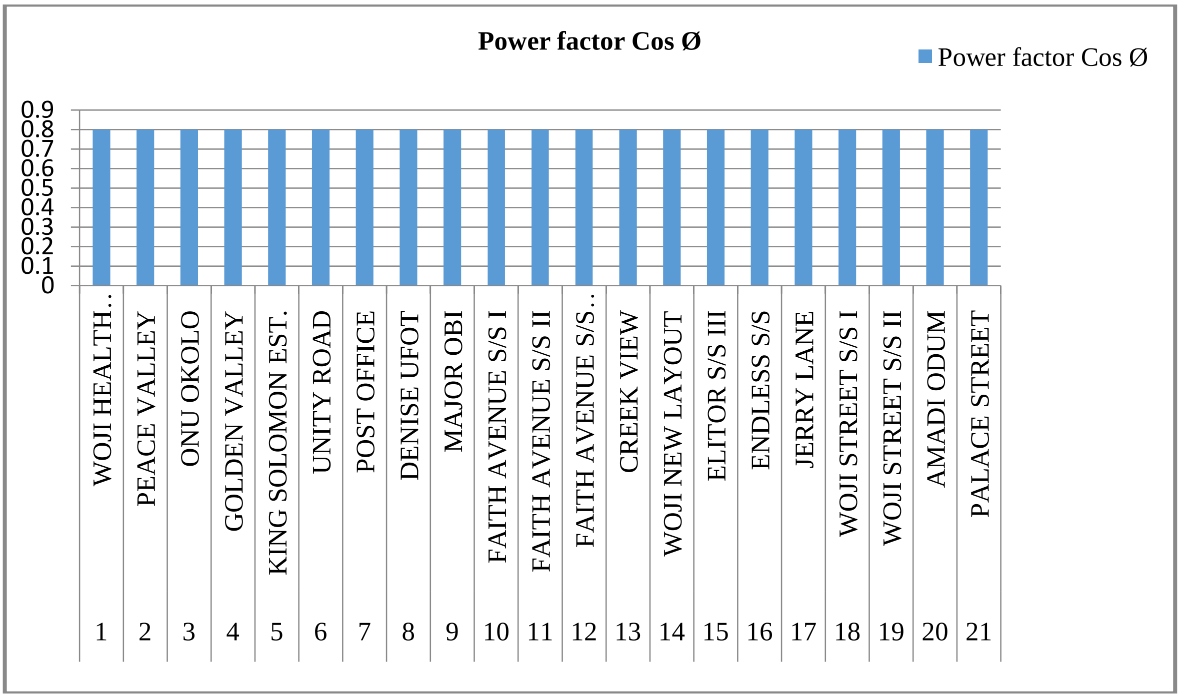

Figure 7: The Power Factor Chart on each Transformer in Woji Village 11KV Network

The result in Figure 8 shows that the transformer percentage loading in table 3b, No. 1, Faith Avenue S/S III and andWoji Health Center has 67% and 63% transformer loadings respectively, representing the highest transformer percentage loading on the network. While the transformer on Post Office Street has 59% and the one at AmadiOdumis52% showing that the transformers are high, while the transformer loading of Palace Street has 32%, representing the lowest transformer percentage loading on the network.

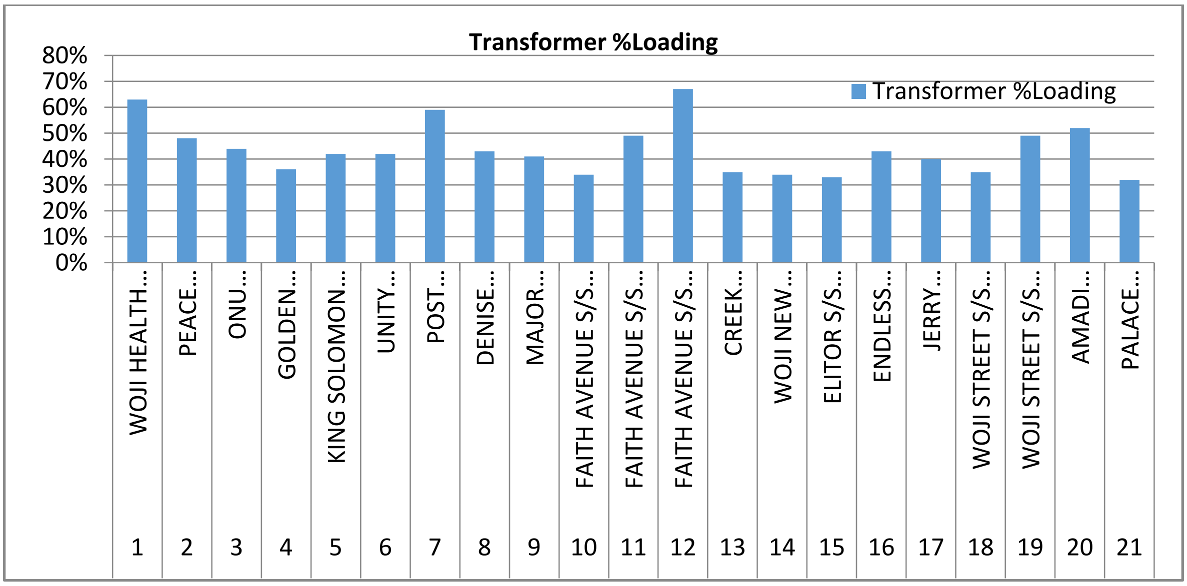

Figure 8: The Transformer Percentage Loading Chart on each Transformer in Woji Village 11KVDistribution Network

The result in Figure 9represents the current (A) rating on each Transformer in Woji Village 11KV distribution network in table 3b, No. 5, which shows that the current (A) rating on the transformer in King Solomon EST, was very high, while the current (A) rating on Woji Street S/S II, was the lowest in Woji Village 11KV Feeder.

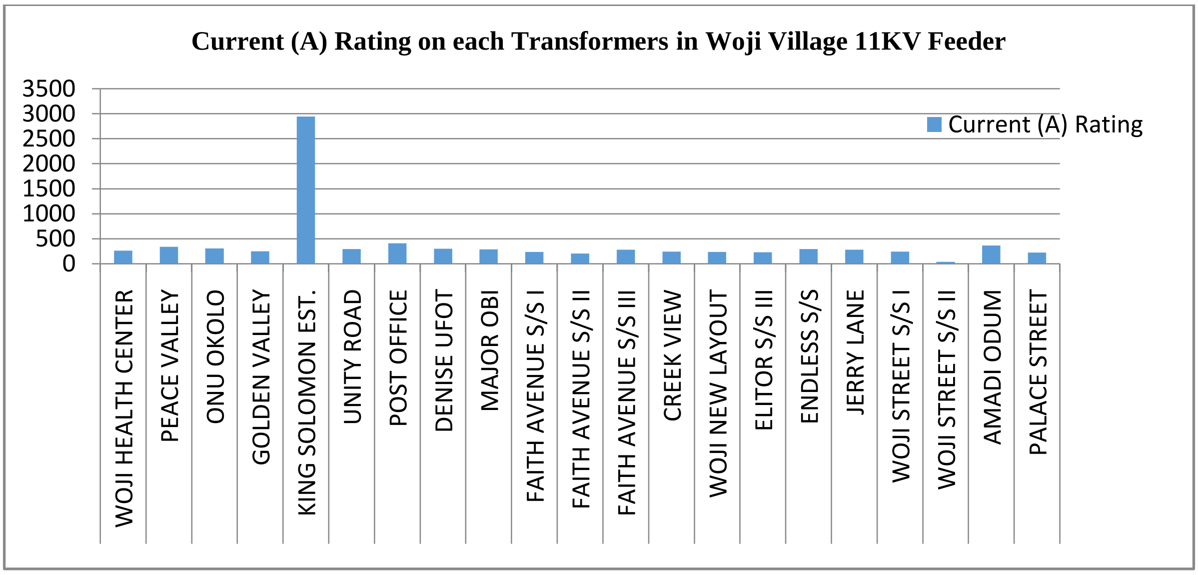

Figure 9: The Current (A) Rating on each Transformer in Woji Village 11KV Distribution Network

The Determination of Post Upgrade Bus Voltage Operating Condition for Woji Village Feeder
The result in Figure 10 represents the post-upgrade of each transformer in Woji Village 11KV distribution network, which was corrected using 10 MVAR capacitor bank.

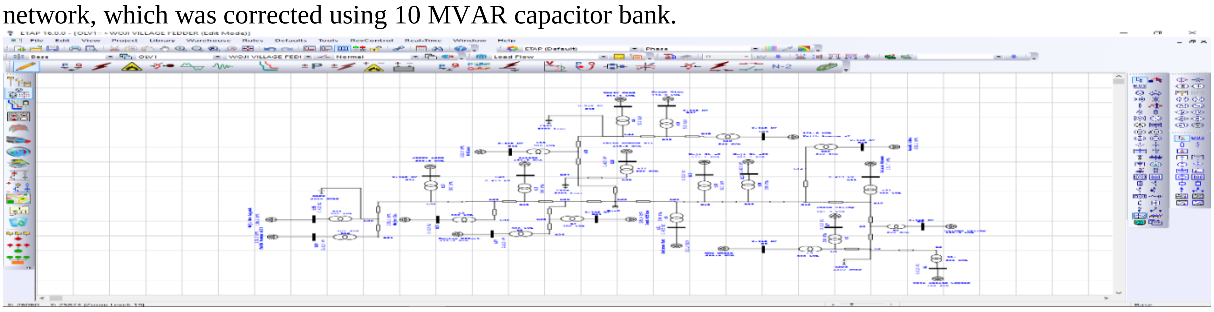

Figure 10: The Post Upgrade of each transformer in Woji Village 11KV distribution network.

The result in Figure 11 indicates that the highest value of 0.278MW load flow was on bus-9 while bus-10 was the least with the value of -0.446MW load flow before introduction of capacitor; hence it became zero (0) after capacitor bank was introduced respectively. Bus-9 has the highest value of 0.21Mvar while bus-10 was the lowest (-0.338Mvar) before the introduction of capacitor bank. Hence, bus-9 became 0.278Mvar and bus-10 became -0.338 after capacitor bank was introduced respectively in 11KV Distribution Network of Woji Village.

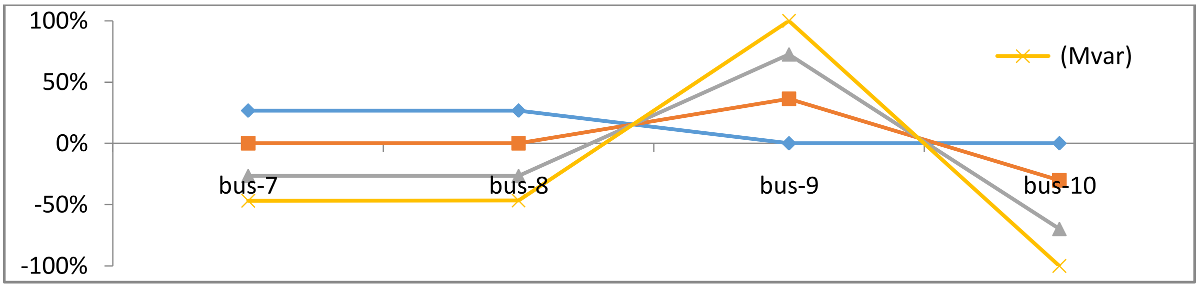

Figure 11: The vector sum of the active-power (MW) and reactive-power (MVAR) onbus-7 to bus10 in 11KV Distribution Network of Woji Village.

The result in Figure 12 indicates that bus-14 has the highest value of 0.17MW load flow before capacitor bank was introduced; hence it became 0.2MW after capacitor bank was introduced to it. Bus-14 has the highest value of 0.2Mvar while point 5 was zero 0Mvar before and after capacitor bank was introduced. The values of bus-11, bus-12 and bus-13 were almost equal before and after capacitor bank correction was applied on it respectively in 11KV Distribution Network of Woji Village.

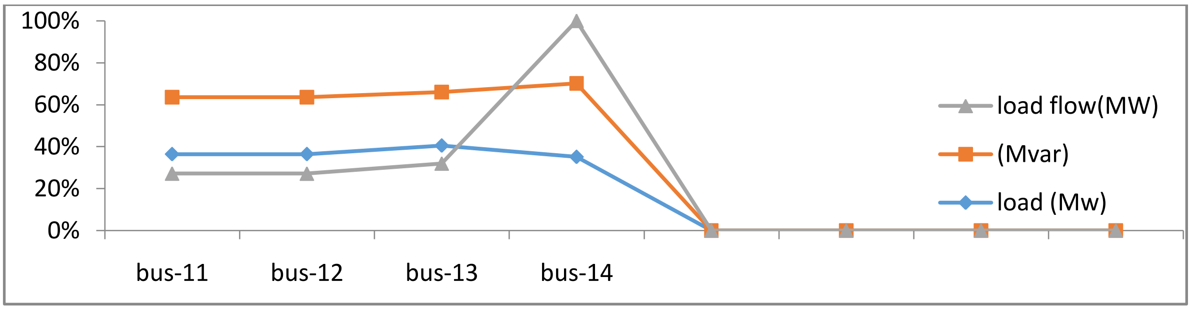

Figure 12: The Vector Sum of the Active-Power (MW) and Reactive-Power (MVAR) on Bus-11 toBus-14 in 11KV Distribution Network of Woji Village

The result in Figure 13 indicates that bus-15 was the least value (-0.205MW) of load flow while bus-16 was the highest (-0.117MW) before capacitor bank was introduced, hence it became 0.205MW and 0.104MW respectively after the introduction of capacitor bank. Bus-15 has the least value of -0.556Mvar while bus-17 was 0.089Mvar before capacitor bank was introduced. Hence, the vector sum of the reactive-power (MVAR) on bus-15 became 0.154Mvar and bus-17 became 0.143Mvar after capacitor bank was introduced in 11KV Distribution Network of Woji Village.

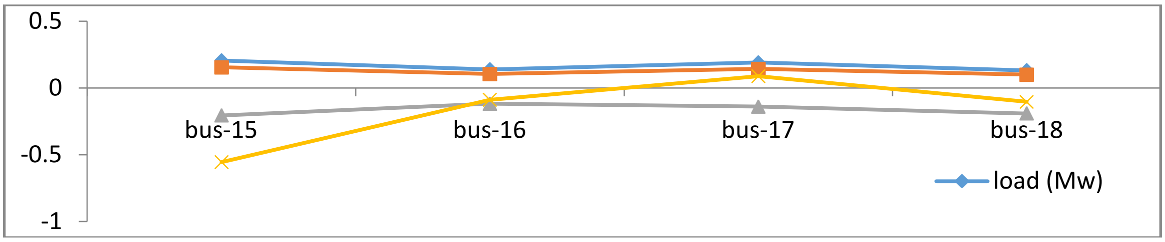

Figure 13: The Vector Sum of the Active-Power (MW) and Reactive-Power (MVAR) on Bus-15 to Bus-18 in 11KV Distribution Network of Woji Village

The result in Figure 14 indicates that bus-20 has the least value of -0.298MW load flow while bus-19 was the highest (-0.127MW) before capacitor bank was introduced, hence it became 0.2MW and 0.132MW after capacitor bank was introduced respectively. Bus-19 has the highest value of -0.095Mvar while bus-20 has -0.227Mvar value before capacitor bank was introduced. Hence, bus-19 became 0.095Mvar and bus-20 became 0.2Mvar after capacitor bank was introduced in 11KV Distribution Network of Woji Village.

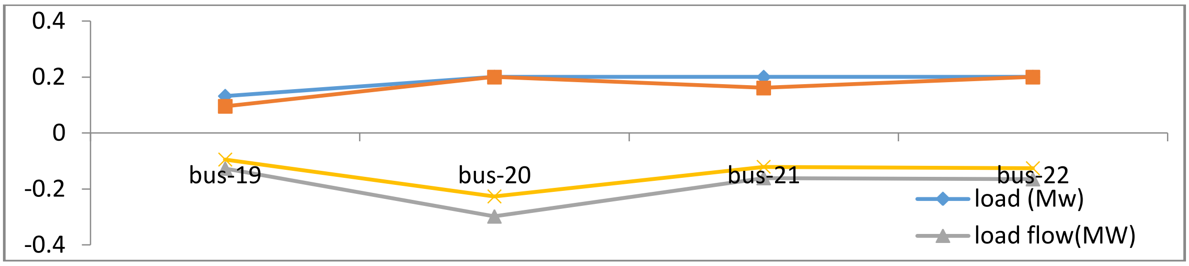

Figure 14: The Vector Sum of the Active-Power (MW) and Reactive-Power (MVAR) on Bus-19 to Bus-22 in 11KV Distribution Network of Woji Village

The result in Figure 15 indicates that bus-24 has the highest value of -0.163MW load flow and bus-26 has the lowest value of -0.752 before capacitor bank was introduced, hence it became 0.2MW and 0.2MW after capacitor bank was introduced to it respectively. Bus-23 has the value of 0.121Mvar and point 5 became zero (0) before and after capacitor bank was introduced.

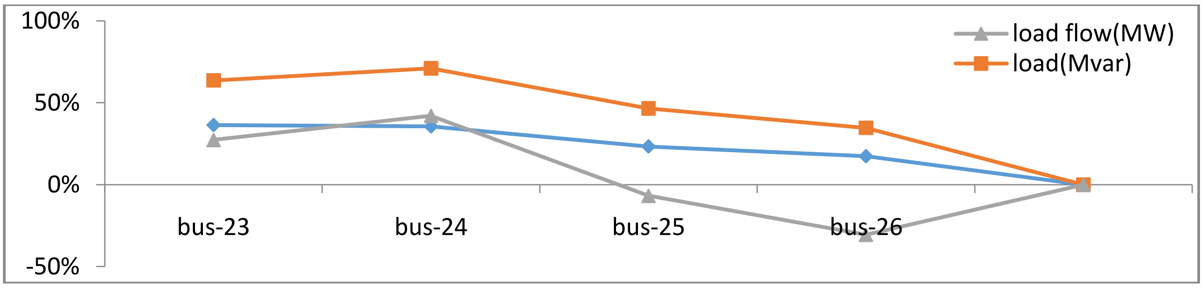

Figure 15: The Vector Sum of the Active-Power (MW) and Reactive-Power (MVAR) on Bus-23 to Bus-26 in 11KV Distribution Network of Woji Village

The result in Figure 16 indicates that the percentage voltage magnitude on bus-9 was the highest with the value of 100.288%, while Bus-7 and Bus-8 has a stabilized voltage angle of -0.6 respectively. More so, Bus-9 and Bus -10 has a stabilized voltage angle of -0.3 respectively in 11KV Distribution Network of Woji Village.

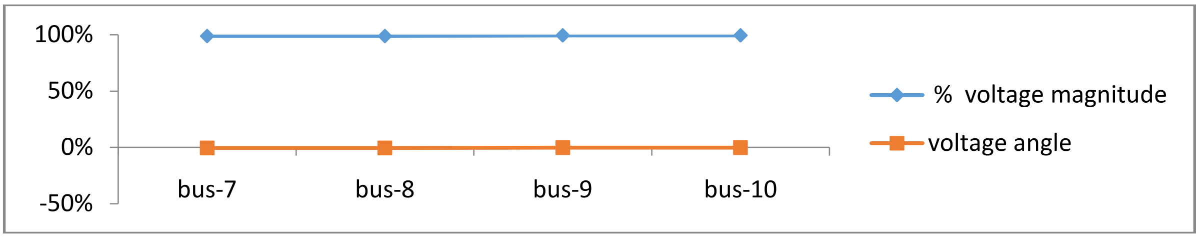

Figure 16: The Percentage Voltage Magnitude and Voltage magnitude on Bus-7 to Bus-10 in 11KV Distribution Network of Woji Village

The result in Figure 17 indicates that the load current on bus-13 was the value of 295.5A before the upgrade, but it became 96.3A after the upgrade. Furthermore, the load current before capacitor bank introduction on bus-20, bus-23, bus-25, bus-26 and bus-29 was 19.7A, 28.6A, 30.2A, 49.5A and 40.9A respectively, but it increased to 105.6A, 284.9A, 101A, 95A and 97.2A respectively when capacitor bank was introduced in 11KV Distribution Network of Woji Village.

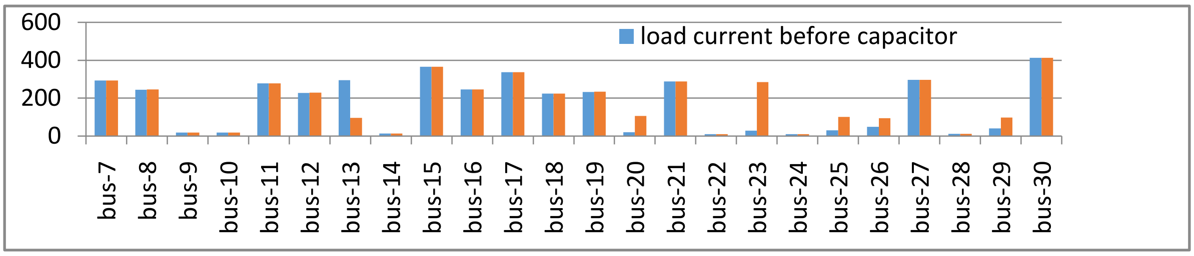

Figure 17: The Load Current before and after Capacitor Bank was Introduced on Bus-7 to Bus-30 in 11KV Distribution Network of Woji Village

V. CONCLUSION

The epileptic electricity power supply in Woji Village 11KV distribution network in Port Harcourt, Rivers State, Nigeria is never-ending following inadequate power distribution, human error fault, malfunctioning of power equipment and poor distribution infrastructure upgrade, etc. The active power, reactive power, frequency, power factor, complex power and transformer percentage loading on each transformer allocated to WojiVillage 11KV distribution network was determine. The pre-upgrade and post-upgrade of the system was simulated using Electrical Transient analyzer program (ETAP) software, the pre-upgrade of each transformers in Woji Village, 11KV distribution network, indicate that the transformer at location in Woji Health Center has 63%, Post Office has59% while Faith Avenue has 67% representing the pre-upgrade transformer in the single line diagram, Woji Village 11KV Network.

The post-upgrade of Village Woji was corrected using capacitor bank. 10MVAR was recommended for Woji Village 11KV distribution network for improved performance for the affected buses (B-9, B-14, B-20, B-45) with optimal placement capacity of B-9=2100KVAR, B-14=2500KVAR, B-20=2200KVAR and B-45=2200KVAR respectively.I recommend that Port Harcourt Electricity Distribution (PHED) should do proper upgrading of their facility in WojiVillage feeders or develop another injection substation for Woji, Port Harcourt, Nigeria, for proper distribution of electricity to its customers. More so, an effective monitoring of the network through load flow analysis should be activated to ensure that the connected load on the network is always equal to the capacity of the installed distribution transformer, thus conforming to IEE regulation of deviation not exceeding ±10% of the nominal voltage.

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