Optimization Of 132/33kv Transmission Network Using Static Var Compensators (A Case Study of Owerri 132/33kv Network)

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Abstract- Effective and efficient electric power transmission is a major concern in Nigeria. Electric power transmission is the link between the generating companies and the distribution companies in Nigeria. This research work is to ascertain the status of Owerri 132kV/33kV Transmission Network for better performance with Newton Raphson method using Static VAR Compensators to solve the problem of under voltage, optimize the system for better power delivery by placing Static VAR Compensators to minimize Power System losses and maximize power transfer by its equivalent model using ETAP 7.0. The data used for this research work were obtained from the Transmission Company of Nigeria TCN (Owerri 132kV/33kV T/S) in Imo State. The Network consist of 132kV lines, ALAOJI I and ALAOJI 2 with the Six (6) 33kV Feeders: Mbaise 33kV, Owerri main 33kV, Owerri line 2, 332kV, Oguta 33kV, Okigwe 33kV and Orlu 33kV with a total load 152.42 MVA; The 132kV Substation has two (2) 60MVA transformers and one (1) 45MVA transformer called Mobitra.. The result of the simulation showed that transformers buses were over loaded beyond their capacities. The introduction of Static VAR Compensators at the 132kV Buses showed that there was an increase of Load MW by 3% and a reduction of Load MVAR by 49.37% when a capacity 52.9MVAR from the VAR Compensator was introduced at the 132kV buses. The simulated result showed an optimization of existing Network from the enhanced voltage, adequate power supply and a reduction of the total power loss from 22.0MW to 21.181MW representing a 4% reduction in load MW as seen from the simulation of the modeled 132kV/33kV Network.

Indexed Terms- ETAP, Optimization, SVC Compensation

I. INTRODUCTION

Efficient and reliable power supply systems must be maintained by the power supply companies. The increasing amount of electrical load and the location of the substations away from the power plants bring about a significant drop in voltage and power losses along the transmission lines. The voltage drop greatly affects the quality of power provided, and may cause the damage of connected electrical equipment if the voltage drop is not compensated or optimized.

There is an issue of power quality for developing nations where the load keeps increasing rapidly more than the generated power which is not up to the level of load demand. Electrical transient analyzer program (ETAP 7.0) was used to carry out load flow analyses and also ascertain the effect of Static VAR Compensators for voltage optimization of the 132/33kV transmission network under review

The Aim of this research work is to use a FACT Controller (Static VAR Controllers) in load flow analysis of a 15 Bus Owerri 132kV/33kV Network to better utilized the Network, reduce power system under voltages, Line loses and increase the voltage profile of the existing Network.

The objective seeks to achieve detailed analyses by using modern software ETAP Version 7.0, to perform Load flow calculations showing voltage magnitudes at various buses, real and reactive power in each line of the transmission line when its equivalent single line diagram is modeled in ETAP for optimal power transfer.

This scope of this work is limited to the 67km Owerri 132/33kV Transmission network from Alaoji to

Owerri. The single line diagram of Owerri 132/33kV Transmission Station is Modeled and simulated in ETAP based upon actual data of the 132kV and 33kV bus/feeders loads. Static VAR Compensators was used to maintain System Stability and improve voltage profile.

Thus, load flow problem provide insight into the calculations of real and reactive power in the buses and its voltage and phase angle and load flow across each line and the solution provides the ability of the system to Operate within its static stability limits from one Transmission Station to the other without over loading lines and by the using VAR Compensators and correct tapping of transformers.

II. RELATED WORKS

Ademola, A. E. (2014). Analysis of Abule-Egba 33-kV Distribution Grid System using real network Simulation's software this is to ascertain that an electric power is economically transferred over the grid system of Abule Egba 33/11kV 0.415kV feeders with maximum efficiency and reliability at minimum cost at fixed voltage and frequency to consumers, it becomes important to carry out power flow studies using the model as a case study. This study presents a model of al distribution grid on a computer system for simulation. Hence the research work models and simulates a distribution grid using the "ETAPS" software.

III. DESIGN METHODOLOGY

$$\sum_{n=1}^{N} |\,|V_i||\,|V_n||\,|Y_{in}||\,\cos(\theta_{in} + \delta_n - \delta_i) = PI_i$$

$$-\sum_{n=1}^{N} |\,|V_i||\,|V_n||\,|Y_{in}||\,\sin(\theta_{in} + \delta_n - \delta_i) = QI_i$$

Separating the term with n = i we get

$$\|V_i|^2 G_{ii} + \sum_{\substack{n=1\\ n=i}}^{N} |\,|V_i||\,|V_n|\,||Y_{in}||\,\cos(\theta_{in} + \delta_n - \delta_i) = PI_i$$

$$-|V_i|^2 B_{ii} - \sum_{\substack{n=1\\ n=i}}^{N} |\,|V_i||\,|V_n||\,|Y_{in}||\,\sin(\theta_{in} + \delta_n - \delta_i) = QI_i$$

in symbolic form, the above equation can be writter as

$$\begin{bmatrix} H & N \\ M & L \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \dfrac{\Delta|\,|V|}{|\,|V|} \end{bmatrix} = \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}$$

The matrix

$\begin{bmatrix} H & N \\ M & L \end{bmatrix}$ is konwn as JACOBIAN matrix.

SINGLE LINE DIADRAM OF OWERRI 132/33Kv SUB STATION

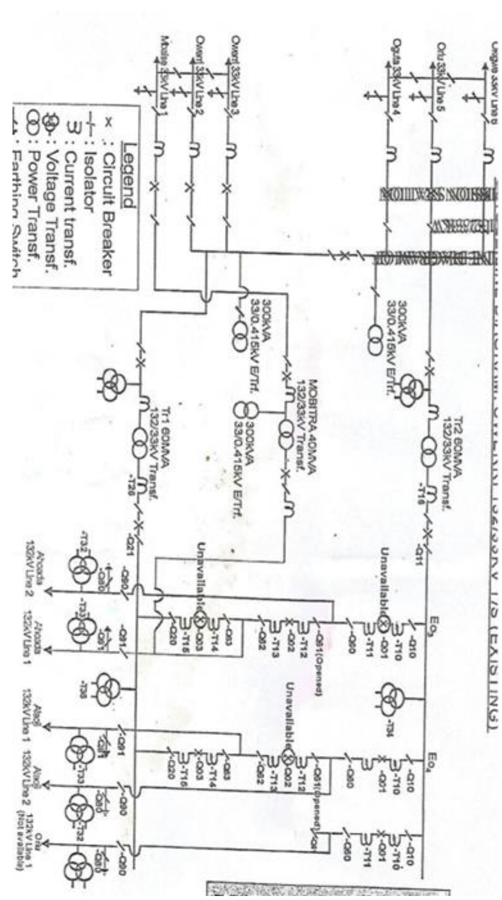


Fig 1

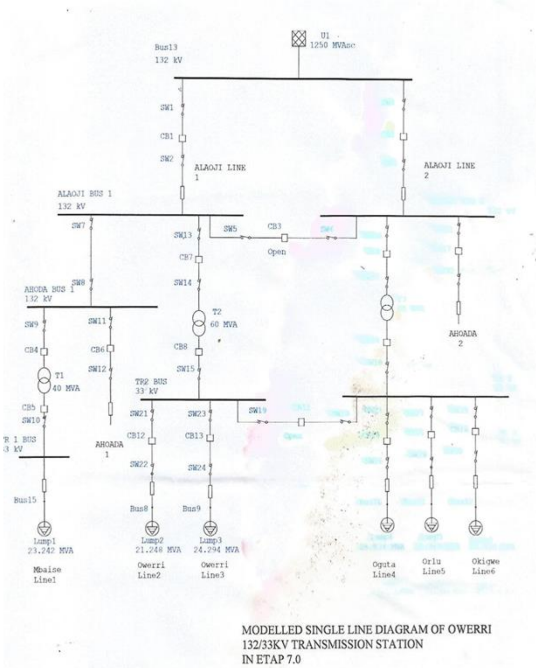
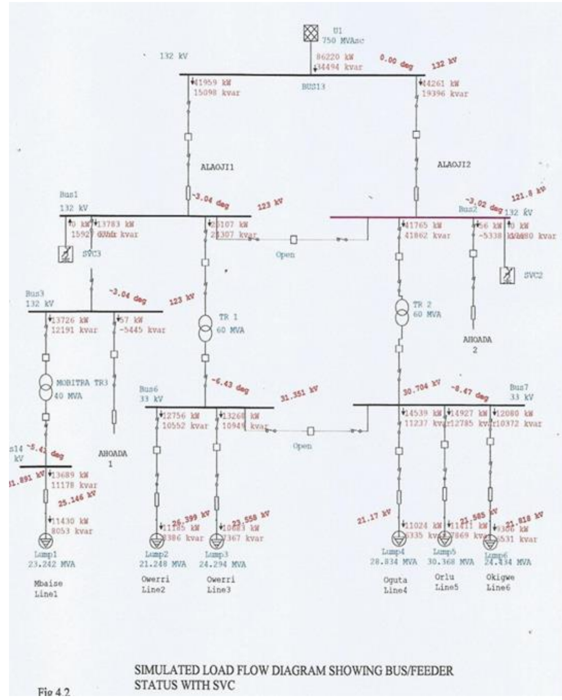


Fig 2 SINGLE LINE AND MODELED DIAGRAM OF 132/33k V

SIMULATION OF 132/33 kV SUBSTATION

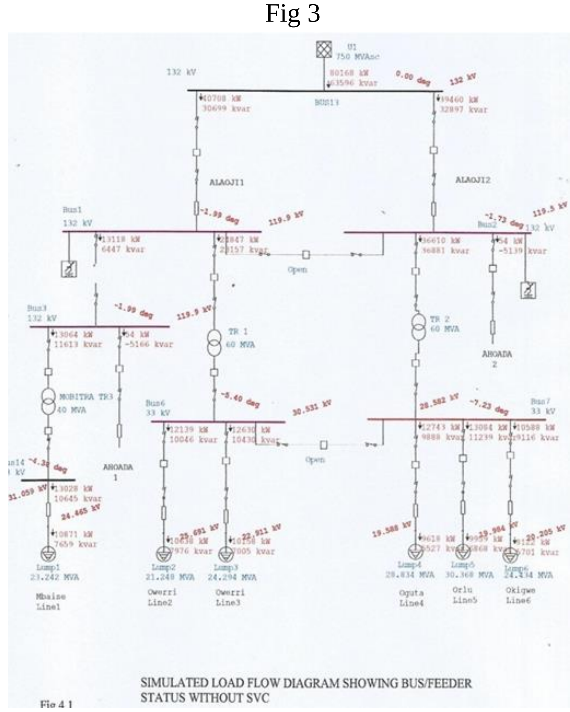
Fig. 2 The Power Grid which supplies power to the 132 kV Bus 13. Transformer 1, Transformer 2 and Transformer 3 are 45MVA, 60MMA and 60MVA respectively and supply power to the 33kV buses. One feeders is connected to Bus 1(MBAISE 33Kv) two feeders are connected to bus 3 (Owerri 1 and Owerri 2) and three feeders connected to Bus 4 (Oguta,Orlu and Okigwe).The 45MVA is connected to bus 1 while the other two 60MVA transformers are connected to bus 2 and 4 respectively

SIMULATED RESUILT WITH SVC



SIMULATED RESULT WITHOUT SVC

Fig 3



ID	STATUS
Buses	15
Branches	14
Generators	0

Power Grids	1
Loads	6
Load-MW	86.221
Load-Mvar	34.493
Generation-MW	0
Generation-Mvar	0
Loss-MW	21.181
Loss-Mvar	23.55
Mismatch-MW	0
Mismatch-Mvar	0

Table 1

Branches	14
Generators	0
Power Grids	1
Loads	6
Load-MW	83.638
Load-Mvar	67.428
Generation-MW	0
Generation-Mvar	0
Loss-MW	22
Loss-Mvar	25.20
Mismatch-MW	0
Mismatch-Mvar	0

Table 2

ID	STATUS
Buses	15

LOAD FLOW REPORT															
Bus		Voltage		Generation		Load		Load Flow						XFMR	
ID	kV														
	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID			MW	Mvar	Amp	%PF	%Tap	
Bus1		132	93.217	-3	0	0	0	-15.927	BUS13			-39.89	-15.134	200.2	93.5
							Bus6			26.107	24.307	167.4	73.2	-2.5	
							Bus3			13.783	6.754	72	89.8		
Bus2		132	92.294	-3	0	0	0	-17.67	BUS13			-41.821	-18.854	217.4	91.2
							AHOADA 132KV LINE 2~			0.056	-5.338	25.3	-1.1		
							Bus7			41.765	41.862	280.2	70.6	-5	
Bus3		132	93.217	-3	0	0	0	0	AHODA 132KV LINE 1~			0.057	-5.445	25.6	-1.1
							Bus14			13.726	12.191	86.1	74.8	-2.5	
							Bus1			-13.783	-6.754	72	89.8		
Bus6		33	95.003	-6.4	0	0	0	0	Bus8			12.756	10.552	304.9	77.1
							Bus9			13.268	10.949	316.8	77.1		
							Bus1			-26.025	-21.501	621.7	77.1	5	
Bus7		33	93.042	-8.5	0	0	0	0	Bus10			14.539	11.237	345.5	79.1
							Bus12			12.08	10.372	299.4	75.9		
							Bus11			14.927	12.785	369.6	76		
							Bus2			-41.546	-34.394	1014.2	77	5	
Bus8		33	79.996	-9.4	0	0	11.185	8.386	Bus6			-11.185	-8.386	305.7	80
Bus9		33	71.388	-11.7	0	0	10.683	7.367	Bus6			-10.683	-7.367	318	82.3
Bus10		33	64.151	-16.6	0	0	11.024	6.335	Bus7			-11.024	-6.335	346.8	86.7
Bus11		33	65.41	-14.7	0	0	11.411	7.869	Bus7			-11.411	-7.869	370.8	82.3
Bus12		33	66.116	-14.4	0	0	9.306	6.531	Bus7			-9.306	-6.531	300.8	81.9
BUS13		132	100	0	86.22	34.494	0	0	Bus1			41.959	15.098	195	94.1
							Bus2			44.261	19.396	211.4	91.6		
Bus14		33	96.64	-5.4	0	0	0	0	Bus15			13.689	11.178	319.9	77.5
							Bus3			-13.689	-11.178	319.9	77.5	5	
Bus15		33	76.199	-9.7	0	0	11.43	8.053	Bus14			-11.43	-8.053	321	81.7
AHODA 132KV LINE 1		132	94.037	-4.2	0	0	0	0	Bus3			0	0	0	0
AHOADA 132KV LINE		132	93.105	-4.2	0	0	0	0	Bus2			0	0	0	0

Table 3

IV. STATIC VAR RATINGS

Inductive Rating

These are the ratings of the inductive component of the SVC. The relation between the ratings is governed by the following equations:

$QL = \sqrt{3}.V\ Rated.IL = V^2\ Rated\ .BL$

QL

The rated inductive reactive power in Mvar.

IL

The rated inductive current in kA.

BL

The rated inductive susceptance in Siemens.

BL is calculated by the following equation:

$$BL = \frac{QL_{max}}{\left(\frac{V_{max}}{100*KV}\right)^2}$$

Capacitive Rating

These are the ratings of the capacitive component of the SVC. The relation between the ratings are governed by the following equations:

$Qc = \sqrt{3}.V\ Rated.Ic =$
$V^2\ Rated\ .Bc$

Qc

This is the rated capacitive reactive power in Mvars

Ic

This is the rated capacitive current in kA.

Bc

This is the rated capacitive susceptance in Siemens.

BC is calculated by the following equation:

$$Bc = \frac{Qc_{max}}{\left(\frac{V_{min}}{100*KV}\right)^2}$$

V. DISCUSSIONS

The load flow analysis with an improvement to overcome the problem of under voltage The Simulation of the 132KV substation was carried out in ETAP 7.0 by placing the Static VAR Compensators in shunt at the 132KV bus Alaoji bus 1 and Alaoji bus 2. The load flow analysis of the Substation shows an improvement from 95.91% to 97.83% for Mbaise, 94.04% to 96.15% for Owerri 1 and Owerri 2 and 87.13% to 93.65% for Oguta ,orlu feeder and okigwe feeders

CONCLUSIONS

ETAP software is carried out with an approach to overcome the problem of an under voltage. Load Flow Studies using ETAP software is an excellent tool for system planning. A number of operating procedures can be analyzed such as the loss of generator, a transmission line, a transformer or a load. Load flow studies can be used to determine the optimum size and location of SVC to surmount the problem of an under voltage, system voltages under conditions of suddenly applied or disconnected loads. Load flow studies determine if system voltages remain within specified limits under various contingency conditions, and whether equipment such as transformers and conductors are overloaded. Load- flow studies are often used to identify the need for additional generation, capacitive, or inductive VAR support, or the placement of capacitors and /or reactors to maintain system voltages within specified limits.

The objective of the project has been fulfilled in the sense that a thorough analysis of the load flow study of the Owerri 132kv transmission and distribution network was carefully executed to show the distribution of VAR and MW in the thirteen (15) bus interconnected system.

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