International Journal of Electrical and Electronics Engineers
Vol. No.7 Issue 02, July-December 2015
www.arresearchpublication.com
IJEEE ISSN 2321 - 2055

APPRAISAL OFLOSS MINIMIZATIONS IN POWER TRANSMISSION SYSTEM USING SVC COMPENSATORS: AN ANALYTICAL CASE STUDY OF KUMBOTSO KANO, NIGERIA

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ABSTRACT

Electrical power plays a very significant role in all aspect of human development. Advancement in technology has made it a basic requirement for modern development the world over because most industries and other economic activities depend in continuous supply of power. The challenge facing the power Holding company today and similar utilities is the Transmission and distribution of Electric Energy to consumers efficiently and at affordable price. Part of the efforts put in place by utilities to cut down cost and guarantee consumer satisfaction is the strategy of minimizing losses. This study analyzed losses on power transmission system which are made of two components, technical and non-technical. The present strategies are to minimize them to meet the increasing demand of electricity and improve efficiency in delivery. The relevant data collected from the transmission sub region were used to develop a data base of electrical quantities for evaluation and analysis. The power system analysis toolbox (PSAT) was employed to simulate the network model and present the simulation results. The 33KV TR1 substation, Kumbotso was found to have the highest losses in the Network. The installation of SVC in the weak bus of the network model was however found to improve the voltage magnitude and minimize the losses. This study therefore recommends the employment of static Var compensator to minimize losses in the network. The SVC has a payback period typically ranging from one to two years.

Key Words: SVC, PSAT, Compensator

I INTRODUCTION

Electrical energy is the most popular form of energy, because it can be transported easily with high efficiency and reasonable cost. The electrical energy produced is transmitted over transmission lines and distributed by electrical networks to various consumers, Electrical Energy development in Nigeria started towards the end of the 19th century, when the first generating Plant was installed in the city of Lagos in 1898. Later, other Electricity undertakings were set up by the Native and Municipal Authorities in different parts of the country. In order to integrate power development in the Country and make it effective, the Federal Government passed the Electricity Corporation of Nigeria Ordinance No. 15 in the year 1950. This ordinance brought under one umbrella all the electricity undertakings owned and controlled by the native and Municipal Authorities under the Public Works department.The Electricity Corporation of Nigeria (E.C.N) thus became the statutory body responsible for Generation, transmission, Distribution and sale of Electricity to all electricity customers in Nigeria. The Niger Dams Authority was established in 1962 by an act of parliament. It was charged with the responsibility of construction and maintenance of dams and other works on the River Niger and elsewhere. Its function also included generating Electricity by means of the energy from water, improving navigation and promoting Fisheries and Irrigation. In 1972, the Electricity Corporation of Nigeria (ECN) and Niger dams Authority NDA were merged by the Federal Government to become the National Electric Power authority, a vertically integrated monopoly entity established by law to generate, transmit and distribute electricity across the country. Power generation in Nigeria started with only ijora, Delta, Egbin, Sapele and Afam thermal power stations, while kainji, jebba and Shiroro Hydro Power Stations, with the generation capacity increased from 20MW to over 6,000MW in the year 2002.Transmission Sector of the Authority is charged primarily with the new development plans, grid network operations, maintenance of 330KV and 132KV transmission lines, and maintenance of 330/132KV and 132/33kV substation equipment, reinforcement program and power system studies. The transmission voltage levels are 330kV and 132kV. 330kV transmission lines have a total length of 5,000Km while 132kV lines have a total length of 6,000Km. In summary, the sector acts as a middleman between the generation sector and the Distribution Sector, taking power from the generating stations to the distribution network, Electrical power plays a vital role in all human endeavors to the extent that it has become a basic requirement for modern living. Most industries, social and economic activities all over the world depend on availability of continuous power supply.

With the deregulation of electricity industries across the world, the emerging trend is the unbundling of Generation, transmission and distribution as independent business entities. In Nigeria's proposed structure, the independent system operators (Distribution business units and transmission companies) will function as business entities. The emerging issues facing utilities today include how to run Transmission and distribution systems at the lowest operating and maintenance cost, extend the life span of plants and equipments, manage with reduced manpower, execute deregulation of the electricity industry effectively and efficiently and meet these economic constraints while enhancing system reliability and efficiency. To deal with these technical and economic demands, electric utilities have focused on a number of Transmission and Distribution (T&D) strategies and advanced technology development aimed at reducing cost of energy, providing better services to customers and ensuring high environmental standard. Part of the strategies adopted by electric utilities and allied industries in power system operation includes the energy loss minimization strategies. These losses that are incurred in electrical power system are of two components: Technical losses and non-Technical losses.

Technical loss in Transmission and distribution sector of power industry deals with the losses that happen because of the physical nature of the equipment and infrastructure of the power systems, example of this is the copper loss. Loads are not included in the losses because they are actually intended to receive as much energy as possible. Technical losses can be calculated based on the natural properties of components in the power system such as resistance, reactance, capacitance, voltage, current and power. Non-technical losses on the other hand, are caused by actions external to the power system, or are caused by loads and conditions that the technical losses computation failed to take into account. Non-technical losses are more difficult to measure because these losses are often unaccounted for by the system operators and thus have no recorded information

II MATERIAL AND METHODOLOGY

Technology shows that analysis in engineering sciences starts with the formulation of appropriate models. In these modern years, more attention has been devoted to computer modeling and analysis of power systems. The approach used here was to collect relevant data which include voltage profile, Load current recorded, Conductor sizing, Feeder route length and Line reactance from the relevant authority, which are used to develop a data base of electrical quantities, The 330kV is fed to the Kano transmission sub-region from Kaduna transmission region. 2Nos. 150 MVA transformers are used to step down the power to 132kV which is used by the transmission lines under the sub-region.

2.1 Data Source and Data Collection:

The instruments used for data collections are the daily summary log books in the Kumbotso sub-station Kano and personal observations on the existing infrastructure and facilities in the sub-station. The summary of data extracted for the first 6 months of the year 2015 is presented in tabular form as shown in appendix, and is made up of the following: Bus Voltages, Load current, Route length, Resistance/km and Line reactance/ km. Each of the data on the transmission line is presented with its own corresponding data. The data for the months January, February, March, April, May and June for the year 2015 is given, and an annual average for the year is also presented and used for all the computations.

Table 1.0: Simulated and Non-Simulated Line Losses

Bus No.	Analysis Techniques	Voltage,V (P.U)	Angle	Power Injected		Power Losses	
				MW	MVAR	MW	MVAR
Bus-1	Simulated	1.0600	0.0000	-223.498	101.599	0.000	0.000
	Recorded	1.0600	0.0000	232.593	-15.233	0.000	0.000
Bus-2	Simulated	1.0450	5.3722	3.400	-38.394	21.700	12.700
	Recorded	1.0450	-4.9891	40	47.928	21.7	12.7
Bus-3	Simulated	1.600	13.2156	193.063	-3.176	94.200	19.000
	Recorded	1.010	-12.749	0	27.758	94.2	19
Bus-4	Simulated	1.0694	10.6870	98.915	-8.075	47.800	-3.900
	Recorded	1.0132	-10.242	0.000	0.000	47.8	-3.9

Bus-5	Simulated	1.0624	9.2723	15.674	3.300	7.600	1.600
	Recorded	1.0166	-8.7601	0.000	0	7.6	1.6
Bus-6	Simulated	1.1100	14.7538	22.819	-18.507	11.200	7.500
	Recorded	1.070	-14.447	0.000	23.026	11.2	7.5
Bus-7	Simulated	1.1116	13.7908	-0.000	-0.000	0.000	0.000
	Recorded	1.0457	-13.237	0.000	0.000	0.000	0.000
Bus-8	Simulated	1.1000	13.7908	0.000	-7.246	0.000	0.000
	Recorded	1.0800	-13.237	0.000	21.03	0.000	0.000
Bus-9	Simulated	1.1297	15.3706	62.826	35.353	29.500	16.600
	Recorded	1.0305	-14.820	0.000	0	29.5	16.6
Bus-10	Simulated	1.1340	15.5435	19.206	12.377	9.000	5.800
	Recorded	1.0299	-15.036	0.000	0	9.000	5.800
Bus-11	Simulated	1.1258	15.2848	7.440	3.826	3.500	1.800
	Recorded	1.0461	-14.858	0.000	0.000	3.500	1.800
Bus-12	Simulated	1.1256	15.6171	12.965	3.402	6.100	1.600
	Recorded	1.0533	-15.297	0.000	0.000	6.100	1.600
Bus-13	Simulated	1.3090	15.6862	28.767	12.358	13.500	5.800
	Recorded	1.0466	-15.331	0.000	0.000	13.500	5.800
Bus-14	Simulated	1.1485	16.4730	32.012	10.742	14.900	5.000
	Recorded	1.0193	-16.072	0.000	0.000	14.900	5.0

III RESULT ANALYSIS AND DISCUSSION

From the simulation result above, the total contribution of the generator to load are reasonable since it is less than its total production. For example, the total contribution of generator at bus 1 total loads is 1.859 p.u real power and 0.74366 p.u reactive power and these values do not exceed its generation. The total real power generated at bus is 1.9413 p.u while that of reactive power is 2.3787 p.u the total real power supplied to the load is 1.8593 p.u and a total of 0.74366 p.u reactive power is supplied to the load respectively.

The total losses incurred are 0.08201 p.u real powers, and 1,635 p.u reactive power respectively. Bus 1 is the reference bus, thus the 330KV generator bus. This bus has the highest voltage magnitude of 1V p.u. it generates a real power of 1.9413 p.u and a reactive power of 2.3787 p.u. the voltage magnitude begins at a peak value of

1V and reduces as time t, increases. The plot of the voltage magnitude against time is depicted in figure 4.1 below. Bus 18that is the 132KV T2A bus has the highest voltage among the buses. It has a voltage of 0.89374 p.u, this bus feeds a total of Nine buses including Katsina, Kankia and Dan Agundi transmission sub stations. The real power between the source and this bus is 0.60044 p.u and the reactive power is 0.53825 p.u. the graphical representation of this shown in figure 4.2 below. This bus is followed by bus 25 responding 132KV katsina with a voltage magnitude of 0.88232 p.u.From the power flow results obtained, it can be observed that the lowest voltage level is at bus 3 and bus 4 which area t at 0.51472V [p.u]. These are 33KV TR1 and 33KV TR2 respectively. Fed from 132 KV T1A (bus2). Generally power generation must meet load demands as well as losses but this is not the case with the voltage at bus 3 and bus 4 as the voltage is at a critical value of 0.51472V. These buses are the critical busses as they have voltage levels much lower than the reference voltage level. Tracing the real power and reactive power between the source to these loads its observed that line 20 which connects 132KV T1A(bus2) to bus 3 and line 21 connecting this source(bus2) to bus 4 have real powers of 0.20078p.u and reactive power of 0.22781p.u respectively. These buses have very high reactive power loss of 0.10362p.u each.It can be seen from above that bus 3 and bus 4 representing a substation (33KV buses fed by two 132/33KV transformers) at Kumbotso have the highest losses and therefore need a compensator to improve the losses. The plot of voltage magnitude against time is shown in figure 4.3 below. The installation of SVC on bus 3 shown in figure 3.3 above and resulted in improving the voltage profile on the substation from 0.51472 p.u to a p.u value of 1. The improvement is not only limited to the affected bus but also extended to most of the buses in the network. The voltage magnitude at bus 17 has improved from 0.66146 p.u to 0.79355 p.u while that of bus 11 has risen to 0.79234 from a value of 0.66064 p.u and the voltage magnitude at bus 16 has improved from 0.66146 p.u to o.79355 p.uThe real power losses and reactive power losses also significantly reduced after the introduction of the SVC. The power loss in line 20(bus 2 to 3) has reduced to 0.0000690 p.u from 0.00207 p.u while the reactive power dropped to 0.00230 p.u from 0.10362 p.u similar Improvements were recorded in line 21 (bus 2 to 4) and others as shown on table 3.3.4.

3.1 Discussion of Results

The results of power flow and loss computations on the substation under the transmission sub region Kano, for the period being investigated, January to December 2009 were shown above. The total simulation results for the whole transmission lines were corrupted. A total real power loss of 0.08201 p.u was experienced while total loss due to reactive power [p.u] of 0.74366 was incurred.Bus 3, that is, the 33KV TR1 a substation in Kumbotso, has the highest power loss and percentage loss respectively while bus 18, thus the 132KV T1A recorded the highest voltage magnitude and least power losses during the period under study as shown above.The installation of SVC at bus 3 has the positive effect of improving the voltage profile and also minimizing the power losses not only on this bus but also other buses in the network.

IV CONCLUSION AND RECOMMENDATION

This chapter summarizes the main result obtained in the framework of this project by providing general conclusion and discussion on the key findings, which is followed by suggestions for possible extension of future work. The major aim of the study has been to analyze the nature of losses and their impact on power system;. To achieve this, extensive literature review on power system was discussed. Relevant literature review on power transmission and characteristics of transmission lines were also undertaken. An overview of Energy losses on power system also presented.

The main focus of the study is the 132KV transmission lines under the kano sub transmission region. Relevant data required for the analysis of power losses and other computations was collected from the sub transmission region of the power holding company. This was used to simulate the Network using PSAT and obtained the power flow results which are used to demonstrate the concept of the real and reactive power allocation method and determine the substation with the least losses and high voltage magnitude and also the substation that has the highest loss. The installation of SVC on the weak bus has improved its performance and that of the Network.

Recommendations:

The purpose of the research has been to study the losses associated with particularly transmission lines, with the intent of finding and proposing ways of minimizing them. From discussions and findings above, the following recommendation are proposed as ways of minimizing losses on the transmission lines.

- Use of high transmission voltage and conductors of adequate size for long rural feeders.
- Re conducting of poorly constructed or ill-maintained network.
- Power factor improvement on the network
- Training and re-training of workers to ensure that they maintain high skill level and maintain high skill level and reduce incidences of losses arising due to poor workmanship.

Finally the installation of static Var compensator is hereby recommended as a way of improving power factor, stabling voltage and minimizing losses on the transmission lines. Implementation of SVC will not only minimize losses in the transmission lines. But also improves the service delivery of the transmission sub-region. This will increase power quality. Stabilized voltage levels and reactive power compensation improve the overall system stability, increasing transmission line power transfer capabilities, thus providing seamless power flow to end-users and offering a quick return-on-investment. The SVC investment has a payback period ranging typically between one to two years. Finding from Spanish Engineering kano, and PHC revealed that the company saved an average of N8, 509,683 monthly as its monthly amount billed, after the installation of SVC worth N75, 000,000. This shows that the company would pay back the cost of the new compensator through this saving alone, in this period of Nine months.

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