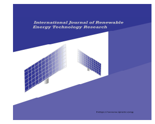
International Journal of Renewable Energy Technology Research
Vol. 6, No. 1, January 2017, pp. 1-5, ISSN: 2325-3924 (Online)
Available online at http://ijretr.org



Research article

DEVELOPMENT OF A B-LOSS COEFFICIENT MODEL FOR ANALYSIS OF NON- TECHNICAL LOSSES ON NIGERIAN TRANSMISSION NETWORK

GaniyuAdedayo Ajenikoko[1], Olakunle ElijahOlabode[2]

[1,2.] Department of Electronic & Electrical Engineering, LadokeAkintola University of Technology, P.M.B. 4000, Ogbomoso, Nigeria.
Corresponding Email: ajeedollar@gmail.com

Abstract

Non-technical losses are caused by actions external to the power system or are caused by loads and condition that the technical losses computation failed to take into account. This paper develops a B-loss coefficient model for analysis of non-technical losses on Nigerian 330kV transmission network. B-loss coefficients which are used to calculate the incremental losses express transmission losses as a function of the output of all generating plants.Non Technical losses, by contrast, relate mainly to power theft in one form or another. They are related to the customer management process and can include a number of means of consciously defrauding the utility concerned. By default, the electrical energy generated should equal the energy registered as consumer. However, in reality, the situation is different because losses occur as an integral result of energy transmission and distribution. The information about the power source and loads are needed to determine expected losses in the power system using load-flow analysis software. The actual losses are the difference between outgoing energy recorded by the source (e.g., at a substation) and energy consumed by the consumers, which is shown on the bills. The discrepancy between expected losses and actual losses would yield the extent of nontechnical losses in the system. So firstly technical losses have been calculated using load flow studies. The various specifications of different parameters of transmission line, transmission line resistance and reactance values were taken from 11kV transmission lines datasheet. The conductor size and line length were chosen arbitrarily.

The B-loss coefficient model is developed using the power loss analysis of a simple radial transmission to establish the mathematical relationship between the Nigerian 330kV transmission lines. The losses were then approximated as second order function of generation to establish the effect of a second power generation supplying the load. The B-losscoefficients are not truly constant but vary with unit loading.Transmission losses become a major factor to be considered when it is needed to transmit electric energy over long distances. The result of the B-loss coefficient model developed shows that the power losses vary linearly as the generated power on the Nigerian 330kV transmission network. The power losses increase progressively from 2.5kW to 4.5kW with a corresponding decrease in the generated power from 170kW to 150kW until when 5kW of power was lost when a power of 140kW was generated which might be due to the i^2R loss of the transmission line. It might then be necessary to transport power over a very long distance to minimize losses along the transmission line. The B-loss coefficient model developed will form a basis for stressing the correlation between the power loss and power generated along the transmission line.

Keywords: Non-Technical Losses, B-Loss, Coefficient, Transmission Network, Power Factor Technical Losses, Power Theft, Voltage regulation

---

I. Introduction

Non-technical losses represent an avoidable financial loss for the utility. They are also called commercial losses which are caused by pilferage, defective meters, errors in meter reading and in estimating unmetered supply of energy, divergence of generated income to useless purposes, natural disasters, terrorism, errors in accounting and record keeping [[1], [4], [6]].

Factors Affecting Power System Losses
The following are some of the factors influencing system losses [[5], [8], [9]].

i. **Voltage Regulation:** Maintaining and / or increasing the nominal operating voltage of the system will reduce both the maximum demand and energy losses because the line losses increase with the square of load current
ii. **Phase Balancing:** When dealing with heavily loaded lines, phase balancing is so significant. The reason is to balance the phase load so that the maximum deviation from the average is below 10%
iii. **Power Factor:** Any reactive component will cause an increase in current with a resultant increase in real power losses because the current is minimum at unity power factor. For large inductive load, losses due to Volt ampere reactive (VAR) becomes significant and demand side compensation becomes necessary. Due to the increase in current in the system, the voltage drop due to live resistance is greater than it would be at unity power factor.
iv. **Circulating Current**: Failure to maintain a flat voltage profile across a network will result in the flow of circulating current in highly interconnected networks.

Reduction of Non-Technical Losses[[2], [3], [7]]

i. Government Policy:Government should formulate better policy such as encouraging the industries in rural communities, which will reduce the migration of people to the major urban areas, such as Lagos and Abiawhich are already overpopulated.
ii. There should be reduction of tax or tariffs paid by some small and medium scale citizens to encourage them to stay out of crime.
iii. An enforceable capital law should be put in place for case of electricity theft; and utility technicians should be trained to carry out effective metering of a particular community as well as regular auditing of the company utility account, at least on monthly or quarterly basis.

II. Materials and Method

Model Development:

B-loss coefficients are widely used to calculate the incremental losses. The coefficient expresses transmission losses as a function of the output of all generating plants.
For a simple radial transmission line, the power loss

$$\mathrm{P_L} = \mathrm{I}^2\mathrm{R} \qquad 1$$

$$I = \frac{p}{v} \qquad 2$$

Where $\mathrm{P_L}$ = Power loss
R = Resistance
I = Current

International Journal of Renewable Energy Technology Research
Vol. 6, No. 1, January 2017, pp. 1-5, ISSN: 2325-3924 (Online)
Available online at http://ijretr.org

The power loss $P_L = I^2 R = \left(\frac{P}{V}\right)^2 R = \frac{RP^2}{V^2}$

$$P_L = \frac{RP^2}{V^2} \qquad 3$$

From equation (3), the power loss is proportional to the resistance and inversely proportional to the square of the voltage. With this, energy can be transmitted at high voltage which reduces the current and power loss during transmission.

For a simple three phase radial; transmission lines between two points of generating / source and receiving / load is shown in Figure1

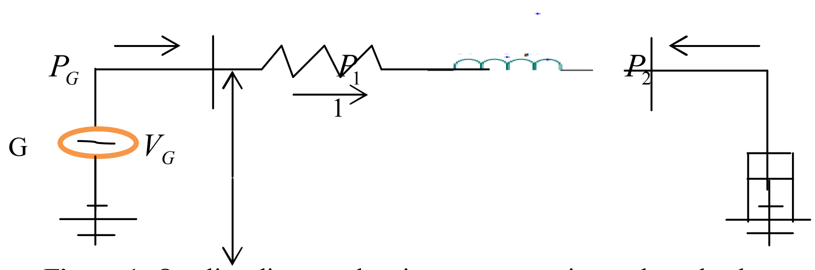


Figure 1: One line diagram showing one generation and one load

The line loss is derived thus: $P_{Loss} = 3I^2 R$ 4

$$|I| = \frac{P_G}{(\sqrt{3})V_G Cos\phi_G} \qquad 5$$

Where V_G = magnitude of the generated voltage (line - to- line)

$Cos\phi_G$ = Generator power factor

Combining equation (4) and (5),

$$P_{Loss} = \frac{R}{|V_G|^2\ Cos^2\phi_G}(P_G)^2 \qquad 6$$

Assuming fixed generator voltage and power factor, the losses can be written as;

$$P_{Loss} = BP_G^2 \qquad 7$$

where $B = \frac{R}{|V_G|^2 \cos^2\phi_G}$

Losses are approximated as second order function of generation. If a second power generation is present to supply the load as in the Figure 2 below, then the transmission loss can be expressed as a function of the two plants loading.

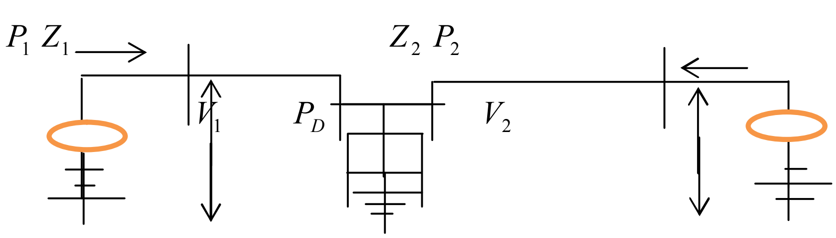


Figure 2: Radial system with one additional generation to load bus

International Journal of Renewable Energy Technology Research
Vol. 6, No. 1, January 2017, pp. 1-5, ISSN: 2325-3924 (Online)
Available online at http://ijretr.org

Thus, $P_L = P_1B_{11} + 2P_1P_2B_{12} + P_2B_{22}$

Where B; is the loss coefficient.

The B- coefficients are not truly constant but vary with unit loading. Transmission loss becomes a major factor to be considered when it is needed to transmit electric energy over long distances.The developed B-loss coefficient model is applied to the Nigerian 330kV transmission network to establish the relationship between the power loss and generated power with a view to analyzing the non-technical losses on the network.

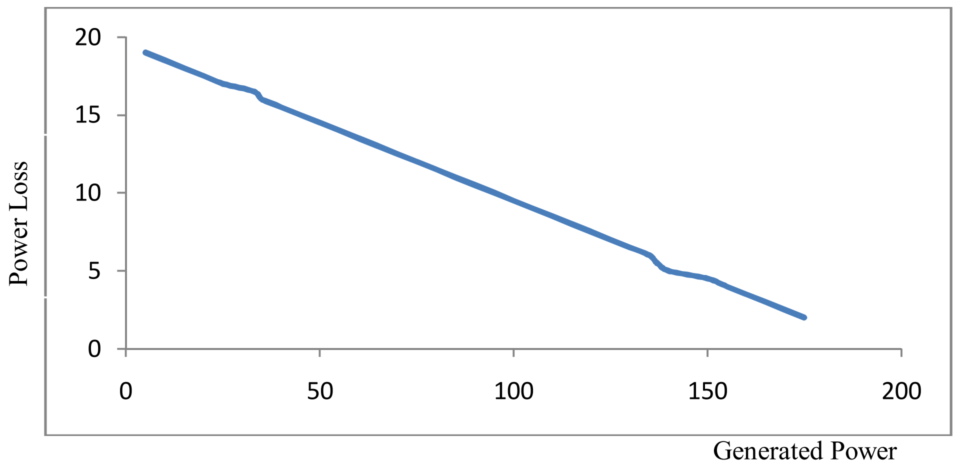


Figure 3: The graph of Power loss P_L versus square of Generated power P_G

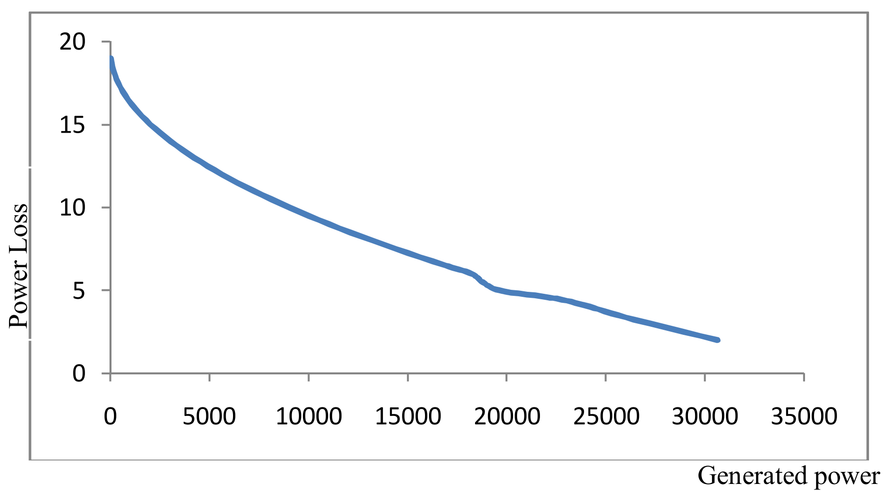


Figure 4: The graph of Power Loss P_L versus square of Generated power

III. Discussion of Results

The relationship between the power loss and generated power is shown in Figure 3. 175kW of power was generated with a loss of 2.0kW. At this instance, only about 1.1% of the total power generated was lost as a result of drop in the ohmic resistance of the transmission line.

The power losses increase progressively from 2.5kW to 4.5kW with a corresponding decrease in the generated power from 170kW to 150kW. This trend continues until when 5kW of power was lost when a power of

140kW was generated. A total of 120kW of power was generated with a power loss of 7.5kW. A generated power of 100kW and a total sum of 9.5kW was lost in the process which might be due to the I^2R loss of the transmission line. In this case, it might be necessary to transport power over a very long distance in order to minimize the loss along the transmission line.

The power generated decreases from 115kW to 35kW with corresponding power losses of 8kW and 16kW, suggesting as inverse relationship between the power loss and generated power. At a generated power of 33kW, 16.5kW of power was lostand at a power loss of 19.0kW, 25kW of power was also generated.

Figure 4 shows the variation of the power loss with the square of the generated power. From the graph, a model equation is obtained which represents a B-loss coefficient model for analysis of non-technical loss on Nigerian 330kV transmission network.

The model developed for B-loss coefficient is polynomial in naturewith R^2 = 97.95. R^2 is coefficient of determination which establishes the relationship between the power loss and power generated along the transmission lines.

IV. Conclusion

A polynomial B-loss coefficient model for the analysis of non-technical losses on Nigerian 330kV transmission network has been developed. The model development started with the computation of the power loss and the power generated using appropriate mathematical notations. From the model, the B-loss coefficient is 0.3934 with a constant term of 0.0073. This B-loss coefficient further stressed the correlation between the power loss and power generated along the transmission line with R^2 value of 97.95.

V. References

[1] Arai S, Abdelkader M. (2011): "Characterization of transmission losses", IEEE Transactions on Power System. Volume 26, Number 1, Pp. 1-10.

[2] Bhattacharyya A.B and Goswami B.S.K. (2014): "Optimal placement of FACTS devices by Genetic Algorithm for the increased loadability of a power system", World Academy of Science, Engineering and Technology. Volume 3, Number 5, Pp. 16-21.

[3] Gupta J.B (2010): "A course in power system", International Journal of Energy. Volume 3, Number 2, Pp. 65-73.

[4] Kakkar V and Agarwal N.K. (2010): "Recent Trends on FACTS and D-FACTS", Modern Electric Power Systems, Innovation System Design and Engineering. Volume 3, Number 3, Pp. 6-13.

[5] Lana W (2012): "A review of transmission losses in power systems", Current Research in Science, Engineering and Technology. Volume 3, Number 2, Pp.17-23.

[6] Narasimha K and Rao J. (2013): "Enhancement of available transfer capability with FACTS devices", Journal of Current Sciences. Volume 2, Number 3, Pp. 23-31.

[7] Onohaebi O.S and Kuale P.A. (2007): "Estimation of technical losses on the Nigerian 330kV transmission network" International Journal of Electrical Engineering. Volume 1 (4), Pp. 402-409.

[8] Sadat H. (2012): "Power system analysis and design" McGraw Hill, New Yale International Publisher Ltd Second Edition, Pp. 33-41.

[9] Vijayakumar K. (2011): "Optimal location of FACTS devices for congestion management in deregulation power systems", SRM University, Kattankulathur, Chennai, International Journal of Computer Applications. Volume 16, Number 6, Pp. 973-993.