

Network Reconfiguration for Loss Minimization by Optimal Switching Operation in Distribution System

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Abstract- There are three functional areas of electrical utility namely Generation, Transmission and Distribution. Out of three functional areas of Electrical utility, the distribution sector needs more attentions and difficult to standardize due to its complexity. Aggregated Technical & Commercial (AT&C) Loss i.e. T&D loss in India has been consistently on the higher in the range of 28-30 per cents. Out of these losses major share are at Distribution level. This is due to inadequate investments for system improvement works. In this paper to reduce the technical losses and analysis is carried out for the distribution network on the measurement of unbalanced current, reactive power, active power, and voltage profile of every network in distribution feeders using MAT LAB software and results are simulated.

Indexing Terms- Network Reconfiguration, optimal Switching Operation, Distribution system, Loss minimization.

I. INTRODUCTION

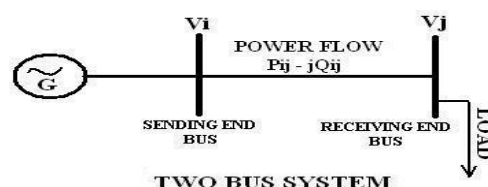
Electricity is modern society's most convenient and useful form of energy. Without it, the present social infra-structure would not at all be feasible. The increasing per capita consumption of electricity throughout the world reflects the standard of living of the people. The optimized utilization by society of this form of energy can be ensured by an effective distribution system. Electrical power distribution system is an important part of electrical power systems in delivery of electricity to consumers.

In this paper to obtain the best solution for feeder reconfiguration problem with minimal loss for various loading condition of the given system and design the optimal switching

operation of distribution network and to predict the solution for an unseen loading pattern.

II. DEVELOPMENT OF FEEDER RECONFIGURATION

The new criterion is developed on the basis of the value of the slope of the line. If the slope of the value are more in comparison with another value of slope then the rate at which the value increases or decreases is more than the compared value. This is the basic mathematics involved in the development of the criterion. The criterion is based on the slope obtained by differentiating the loss equation with respect to the receiving end voltage. To develop the criteria a simple two bus system is taken into consideration. The two bus system is as shown in figure.



Let i and j be the buses under consideration, where i is the bus connected to the generator and j is the bus connected to the load. The line resistance is taken as R_{ij} and the inductance is taken as X_{ij} . The power of the line section between i and j be

$P_{ij} - jQ_{ij}$ so the basic current equation of the system is given by equation 1

$$I_{ij} = (P_{ij} - jQ_{ij}) / V_i < \theta_i - V_j < \theta_j \quad (1)$$

This gives us the basic step involved in deriving the criterion, to get the loss of the system we require the current flowing in the system in each line section. The loss of the system is given by equation 2

$$LOSS_{ij} = I_{ij}^2 * R_{ij} \quad (2)$$

So we now have the loss equation of a line section and the equation of current in terms of the line power flow and the line sectional voltages of the sending end and the receiving end bus. So now by substituting the value of current in the loss equation we get the following equation

$$LOSS_{ij} = (P_{ij} - jQ_{ij})^2 / (V_i < \theta_i - V_j < \theta_j)^2 * R_{ij} \quad (3)$$

So, from the above equation we have an equation for loss of the line section in terms of the power flowing in that line and the values of the sending and receiving end voltages. So in order to eliminate the terms which represent the power flow from the above equation, the equation which gives us the flow of power in a line section in made use of which is given by equation 4

$$(P_{ij} - jQ_{ij}) = (V_i < \theta_i) * (V_i < \theta_i - V_j < \theta_j) / (R_{ij} + jX_{ij}) \quad (4)$$

So substituting 4 in 3 we have equation 5

$$LOSS_{ij} = V_j^2 (Cos\theta_j - j Sin\theta_j)^2 * R_{ij} / (R_{ij} + jX_{ij})^2 \quad (5)$$

So now we have a term, loss of the line section in terms of its receiving end voltage, line resistance, line reactance and the angle of the receiving end voltage. From the literature survey done it was found that none of the papers the criterion involved the angle of the voltage, so this criterion will give us more accurate results than others because of the fact that the angles of the voltages also pay an important role in deciding the loss of the particular line section. So now expanding equation 5 we have

$$= \frac{V_j^2 * R_{ij} (Cos^2\theta_j - Sin^2\theta_j - 2*j*Cos\theta_j*Sin\theta_j)}{(R_{ij}^2 - X_{ij}^2 + 2*j*R_{ij}*X_{ij})}$$

In order to eliminate the imaginary term of the loss we take conjugate, hence neglecting the imaginary losses of the line section of the system. On taking conjugate and multiplying with numerator and denominator we get

$$LOSS_{ij} = \frac{V_j^2 * R_{ij} ((R_{ij}^2 + jX_{ij}^2) * (Cos^2\theta_j - Sin^2\theta_j) - A)}{(R_{ij}^2 - X_{ij}^2 + 2 * R_{ij}^2 * X_{ij}^2)}$$

$$\text{Where } A = (4 * R_{ij} * X_{ij} * Cos\theta_j * Sin\theta_j)$$

So now we have an equation which gives us the real loss of a particular line section in terms of receiving end voltage, line resistance, line inductance and the angle of voltage in degree. Upon simplification we get the following equation no 6

$$\frac{(Cos^2\theta_j - Sin^2\theta_j) = Cos(2*\theta_j)}{LOSS_{ij} = \frac{V_j^2 * R_{ij} ((R_{ij}^2 + jX_{ij}^2) * (Cos^2\theta_j - Sin^2\theta_j) - A)}{(R_{ij}^2 + X_{ij}^2)^2}} \quad (6)$$

In order to get the slope of the line section in terms of losses vs. receiving end voltage we will have to get the first derivative of loss in equation 6 in terms of its receiving end voltage. So differentiating the above equation 6 w.r.t. Vj we have

$$\frac{LOSS_{ij}}{(V_j)} = \frac{V_j^2 * R_{ij} ((R_{ij}^2 + jX_{ij}^2) * (Cos(2*\theta_j) - A)}{(R_{ij}^2 + X_{ij}^2)^2} \quad (7)$$

This is the slope for a given particular line section involving the real line losses and its receiving end voltage. Where, $LOSS_{ij}$ - Loss in the particular line section; V_j - Receiving end Voltage; R_{ij} - Sectional Resistance; X_{ij} - Sectional inductance; θ_{ij} - Angle in degrees; P_{ij} - Sectional Real Power; Q_{ij} - Sectional Reactive Power.

III. RESULTS AND CONCLUSION

This paper has proposed a systematic methodology to derive the optimal switching criterion to reduce the energy loss for the short term and long term operation of distribution systems. The short term optimal switching criterion can efficiently relief the system contingency such as overloading of main transformers or the occurrence of faults in distribution systems. The seasonal optimal switching criterion can increase the operation efficiency of distribution systems by minimizing the energy loss. The load profile of distribution feeders and the load patterns of each type of load customer are used to evaluate the loading condition of each service section so that the feeder load behavior is simulated more accurately. By using the proposed methodology, a computer simulation of a practical tie-power

distribution system is performed and the critical switches are solved. It is concluded that significant energy loss reduction can be easily obtained by operating the critical switches with the change in seasons.

The MATLAB software is used for carrying out the load flow analysis using Newton-Raphson Method. The result of off-line simulations of load flow calculation is made and the best switching option for the given loading condition using the implementation of the distribution system. Thus the proposed method can provide the information about the status of the switch for the loading condition in order to obtain the minimum loss configuration network.

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