A Review on Load Balancing on Distribution System

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Abstract— If unbalancing load occurs in distribution system due to excessive overloading system and fault in the system take places, that depending on the types of customer connecting to system and seasons of environment. If this unbalancing load on distribution system occurs, it may cause excessive power loss to the distribution system and instability of the interconnected system. Hence balancing load on distribution system as early as possible after the occurrence of a overloading. Balancing load on distribution system is most important part of power system involve finding load balancing index and proper switching throughout the system during overloading condition. In this paper, recent work and future scope in balancing load on distribution system for loss minimizing is described. Here, different new methods for balancing load on distribution system are mentioned. Effect of renewable energy sources on balancing load on distribution system is also considered in this paper.

Keywords- Load ; Network Reconfiguration; Switching

I. INTRODUCTION

The balancing load on distribution system is the switching operation that eliminates overloading on distribution system. Load balancing can he obtained by reconfiguring the distribution feeders and reallocating load currents among the feeders and transformers. By properly performing the switching operation, the power demand of the service zones can be transferred from the heavily loaded transformers/feeders to the lightly loaded ones so that the distribution system will become more balanced and the risk of overloading can be reduced. The balancing load on distribution system required for

• It reduces demand during critical load period.
• It must have an acceptable cost ratio.
• It must operate an acceptable reliability level.
• It must provide benefit to the consumer by reducing cost.

The balancing load on distribution feeder is explained with the help of branching exchanging method [1]. In fuzzy reasoning approach membership function for feeder, transformer, lateral and switches is given for balancing load on feeder and transformer together [2]. Qin zhon have studied two feeder reconfiguration algorithms for the purpose of service restoration and load balancing in a real-time operation environment. The developed methodologies combine optimization techniques with heuristic rules and fuzzy logic for efficiency and robust performance [3]. chao-shun chen [6] [7] have studied load balancing of distribution feeder is do by loop power controller, which maintain active and reactive power.

II. LOADS ON DISTRIBUTION SYSTEM

Generally three types of load on distribution system classified according to customer types is residential commercial and industrial. These loads are varied according to seasons, the residential customer demand increase at evening and morning where commercial load demand increase at 6pm to 12am and industrial load demand is varied according to shift as shown in figures given below. The proper load forecasting required because population growth and energy requirement do not grow linearly but follows non linear power law the usual function that fits is

\[ y = k \cdot a^x \]  

Then increase in load demand is

\[ P_n = P_0 \cdot (1+g)^n \]  

Where,

- \( y \) = New value after growth period, \( x, k \) is initial value
- \( a \) = the rate at which \( y \) increases logarithmically

Where,

- \( P_0 \) = initial power demand,
- \( g \) =growth rate and \( n \)=period,

Thus to balancing load on distribution system require proper load forecasting.

Fig.1 Load pattern for residential customer
A. Load Models:
The loads on distribution feeder can be modeled as star or delta connected. The loads can be single phase or three phases these modeled. The load model for star and delta is same only difference between them is in star connected load phase-neutral voltage is find out and for delta phase-phase voltage magnitude. Different load models are
- Constant real power and reactive power
- Constant current
- Constant impedance

B. Star Connected Constant Real power and Reactive Power Model:
The line current is finding out by using star connected load, when know the complex power and voltage magnitude.
\[ \text{ILk} = \frac{(S_k V_{kn})}{V_{kn}} \quad (3) \]
Where,
K= particular phase
ILk= (ILk/δ-θ) \quad (4)

C. Star Connected Constant current
In this model constant current is calculated as by using equation 1, then angle of voltage is changes then angle of current is change so that power factor of the loads remains constant.
\[ \text{ILk} = \frac{(ILk/δ-θ)}{V_{kn}} \quad (4) \]
Where,
δ= The line to neutral voltage angle
θ= power factor angle

D. Star connected Constant impedance load model:
In this model first calculate impedance from complex power and phase-neutral voltage magnitude, and then find out line current.

III. METHODS OF BALANCING LOAD

A. Network reconfigurations for load balancing:
The network reconfiguration involving loss reduction and load balancing in same manner but there is slightly difference their objective. In the network reconfiguration status of sectional switches is changed for loss minimization and balancing load on distribution system [6]. The optimization technology is used to finding out objective (minimum non-linear) function and constraint such as voltage level, feeder capacity and reliability.

1) Network Reconfigurations By Branch Exchange:

The branch exchange method used to find out relevant rotating tree from base rotating tree, fig 1 show that when close open branch b and open old branch m than new loop is form[1]. The branch exchange method improves objective function without violation constrain. The loss on a branches is calculated by using two power flow solution method.

- Simplified Dist Flow Method
Dist flow branch exchange method [2] calculates active power, reactive power and voltage then finding out power loss according to that calculates load balancing index and balancing load on distribution system. The formula for calculation of loss by transfer power and balancing load on PQ plan is
\[ \Delta L_{pbm} (P_{m} Q_{m}) = 2drp.pm + 2drq.Qm - tr (P_{m}^{2} + Q_{m}^{2}) \quad (5) \]
If branch is changed that is close switch b and open switch m shown in fig.5 then loss estimated using P-Q plan defined by \( \Delta L_{p}>0 \) then loss is reduced as shown in fig.6, and \( \Delta L_{p}<0 \) then loss is increased.
To obtain optimal network reconfiguration by switching operation each one hour required to find out cost function of distribution feeder. The cost function required to find out cost of switching during the operation. Generally optimal switching operation required to balancing load on feeder and transformer, but when feeder and transformer phases unbalance then ground relay trip that happen due to unbalancing load. The cost function consists of load cost and unbalance cost function [2].

2) **Network Configuration by Switching Operation:** To obtain optimal network reconfiguration by switching operation each one hour required to find out cost function of distribution feeder. The cost function required to find out cost of switching during the operation. Generally optimal switching operation required to balancing load on feeder and transformer, but when feeder and transformer phases unbalance then ground relay trip that happen due to unbalancing load. The cost function consists of load cost and unbalance cost function [2].

- **Load cost is expressed as,**

\[
C_L = \left( \frac{I_{max}}{0.95*RL} \right)^{**10}
\]  

(6)

Where,
RL = Rated capacity of phase feeder
Imax = Maximum phase current

Here exponential function with order of **10 will imply a dramatically increase of cost function when the current loading of the feeder is larger than 95% of the rated value [2].

Thus when proper switching used than load is balancing on distribution feeder and avoids increasing cost function.

- **Unbalance cost CU**

The unbalance phase causes ground relay should be trip, this is due that load on distribution feeder is unbalance so that unbalance cost function is defined.

\[
C_U = \left( \frac{U_{max}}{0.95*RB} \right)^{**10}
\]  

(7)

Where,
RB = ground relay setting value
Umax = the current difference between any two phase.

- **Flowchart of optimal switching operation**

The flowchart of optimal switching required for balancing load on distribution feeder by transferring load from heavily loaded feeder to lightly loaded feeder. The switching operation done for each one hour [5].
\[ \mu_{DOS}(T) = \begin{cases} \frac{l}{T_{LTT}} & \text{For } l < T_{LTT} \\ 2 - \frac{l}{T_{LTT}} & \text{For } T_{LTT} < l < 2T_{LTT} \\ 0 & \text{For } l > 2T_{LTT} \end{cases} \] (8)

Where,

\( T_{LTT} = \text{Target Load Transfer for Transformers} \)

\( l = \text{Amount of load transferred by a switching Operation} \)

2) Measure of Satisfaction for Feeder: Here same case of transformer, a load transfer by switching operation is equal to target load transfer on transformer than membership function is unity. The larger the deviation from the target, the lesser is the degree of satisfaction. For \( l > 2T_{LTT} \) the value is zero [3].

\[ \mu_{DOS}(T) = \begin{cases} \frac{l}{T_{LTF}} & \text{For } l < T_{LTF} \\ 2 - \frac{l}{T_{LTF}} & \text{For } T_{LTF} < l < 2T_{LTF} \end{cases} \] (9)

3) Measure of Satisfaction of Number of Switching Operation: In this approach membership function decreases as switching increases, it unity up-to two switching operation.

C. Loop power Flow controller

The loop power flow controller consists of series connected inductor and series connected voltage sources inverter [6]. It balancing load between two distribution feeders by transferring load. This system also helpful to connect renewable energy sources to distribution feeder at the time of peak load on system. The advantages of loop power flow controller is 1) Aims for free access to a distributed power supply. 2) System responds flexibly to unbalanced load between feeders, and makes effective use of equipment. 3) To enable this, the system is constructed in the shape of a loop from a radial. 4) A loop distribution system is provided without altering existing systems such as the protection system, except for loop points.

IV. CONCLUSION

In this paper focuses on loss reduction on distribution system due to overloading. This losses are reduced by balancing load on distribution system. Load on distribution system balanced by proper switching operation for that different algorithm and methods required. Loop power flow controller also one type method used to balancing load on distribution feeder and also it helpful for renewable energy sources connected in distribution system.

V. REFERENCES


