DISTRIBUTION NETWORK RECONFIGURATION TO IMPROVE SYSTEM PERFORMANCE AND REDUCE POWER LOSSES

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ABSTRACT

Optimal Reconfiguration of Radial Distribution System. Which can be obtained by closing switches (tie- switch normal open) and opening closed switches (sectionalizing switch – normal close) to satisfy Radial Distribution System for getting improvement system voltage, and power losses. This can be made by The Proposed Method which consists of two Parts:

1-Determining the tie switches which their terminal voltage less than specified value by ± 5% from the rated value

2- Transferring load from lower voltage side of tie switch to higher voltage side after checking the power of transformer and all feeders to avoid over loading .

3-calculate system power losses before and after change the switch action we obtained improve system performance and improvement feeders end voltages and reducing power losses

If the problem (under voltage) is still found connect capacitor bank in the feeders which contain this problem.

By using ETAP software program on real time and the application by FORTRAN software, we can make the switches options, calculation of power flow of each transformer and feeder. So, This Paper Presents an Optimal Reconfiguration Of Radial Distribution System.

Keywords

Distribution System. Network Reconfiguration. Power Losses of Radial Network.

INTRODUCTION

In the reconfiguration strategy described here .it is assumed that the distribution system is radial. So, each load is served through only source. All loads in distribution system are served by substation transformers through distribution feeders. The loads are modeled at their peak value, and it is assumed that each line section contains switches, whose status may be opened or closed. The primary goal of heuristic strategy eliminate over-loading transformers, under voltages and thermal constraint violations by determining the open /closed status of all switches in the system [1].

The network reconfiguration problem in distribution system is to find a configuration with minimum losses while satisfying the operation constraints under a certain load pattern. The operating constraints are voltage drop, current capacity and radial operating structure of the system [2]. The voltage and power on/through both ends of a feeder are used to describe the load and its distribution pattern within the feeder line [3]. The optimal allocation of the reactive sources reduces the losses due to the reduction current in distribution system [4]. Balancing of load plays a key role in reducing losses in addition to enhancing stability and reliability of electrical power network. Distribution network is divided into subsystem of radial feeder equipped by numbers of sectionalizing switches and tie switches [5]. Methodology is reconfiguration of electrical power distribution network under normal operation condition. In order To reduce the active losses of network or to balance the load, based on the branch exchange where different radial configuration are generated [6]. The optimal flow pattern of network is the branch flow pattern that will cause minimum resistive line losses .The method starts by closing all network switches , thus forming a meshed distribution network , loops are open one after another in such away that the optimal flow pattern [7]. Network reconfiguration in distribution system is realized by changing the status of sectionalizing switches to reduce the power losses in the system [8]. Network reconfiguration in distribution system is realized by changing the status of sectionalizing switches, and usually done for losses reduction proposed by [9]. To improve the system reliability and operational efficiency, a distribution automation system. Feeder reconfiguration for fault restoration and load balancing. By changing the open / close status of the line switches along distribution feeders [10].

PROPOSED MODEL:

The network reconfiguration problem in a distribution system is to find a configuration with minimum losses while satisfying the operation constraints under a certain load pattern. The operation constraints are voltage drop, current capacity and radial operation of the system. The mathematical formulation for minimization of power loss reconfiguration problems is presented in literature in different ways.

The formulation is presented as:

Minimize f = min (P_{Tloss}) (1)

Subjected to $V_{min} \le |v_i| \le V_{max}$ (2)

$|I_i| \le |I_{imax}|$ (3)

Where, P_{Tloss} is the total real power loss of the system, |Vi| voltage magnitude of bus I

V_{max}. V_{min} are the maximum and minimum voltage limits respectively. I_i ,I_{max} are current magnitude and maximum current limit of branch I respectively A set of simplified feeder –line flow formulation is employed. Considering a single line diagram depicted in Fig 1.

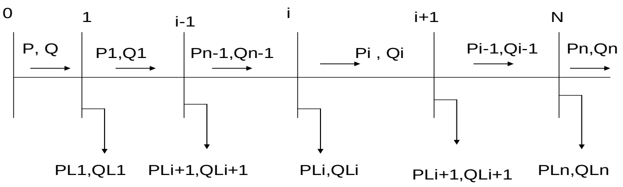


Fig .1 Single line diagram of main feeder

Network reconfiguration problem is normally assumed as symmetrical system and constant load. Therefore, the distribution line are represented as series impedances of value ($Z_{ij+1}=R_{ij+1}+jX_{ij+1}$) and load demand as constant and balanced power sinks $S_L=P_L+jQ_L$. The real and reactive power flows at the receiving end of branch i+1, Pi_{+1}, Qi_{+1} and voltage magnitude at the receiving end.

| V_{i+1}| is expressed by the following set of recursive equation (4)

$$P_{i+1}=P_i-P_{Li+1}-R_{i,i+1}*\frac{P_i^2+Q_i^2}{|V_i|^2} \quad (4)$$

$$Q_{i+1}=Q_i-Q_{Li+1}-X_{i,i+1}*\frac{P_i^2+Q_i^2}{|V_i|^2} \quad (5)$$

$$|V_{i+1}|^2=|V_i|^2-2*(R_{i,i+1}*P_i+X_{i,i+1}*Q_i)+(R_{i,i+1}^2+X_{i,i+1}^2)*\frac{P_i^2+Q_i^2}{|V_i|^2} \quad (6)$$

Eq 4, 6 are known as distflow equation hence if P… Q…V. at the first node of the network is known or estimated then the same quantities at the other nodes can be calculated by applying the above branch equations successively. This procedure is referred to as a forward update

Similar to forward update. Backward update is expressed by the following equation

$$P_{i-1}=P_i+P_{Li}+R_{i,i+1}*\frac{P'^2_i+Q'^2_i}{|V_i|^2} \quad (7)$$

$$Q_{i-1}=Q_i+Q_{Li}+X_{i,i+1}*\frac{P'^2_i+Q'^2_i}{|V_i|^2} \quad (8)$$

$$|V_{i-1}|^2=|V_i|^2+2*(R_{i,i-1}*P_i+X_{i,i-1}*Q_i)+(R_{i,i-1}^2+X_{i,i-1}^2)*\frac{P'^2_i+Q'^2_i}{|V_i|^2} \quad (9)$$

Where $P'_i=P_i+P_{Li}$ and $Q'_i=Q'_i+Q_{Li}$

The power loss of the line section connecting between buses (i) and (i+1) is computed as

$$P_{losses\ (i,\ i+1)}=R_{i,i+1}*\frac{P_i^2+Q_i^2}{|V_i|^2} \quad (10)$$

The total power losses of the feeder $P_{F\ losses}$ is determined by summing up the losses of all line sections of the feeder, which given by:

$$P_{F\ losses}=\sum_{i=0}^{n-1} P_{loss}(i,i+1) \quad (11)$$

Where the total system power losses $P_{T\ losses}$ is the sum of power losses of all feeders in the system.

PROPOSED METHOD

In fig2. Explain flow chart of program to improve system performance and reduce system power losses.

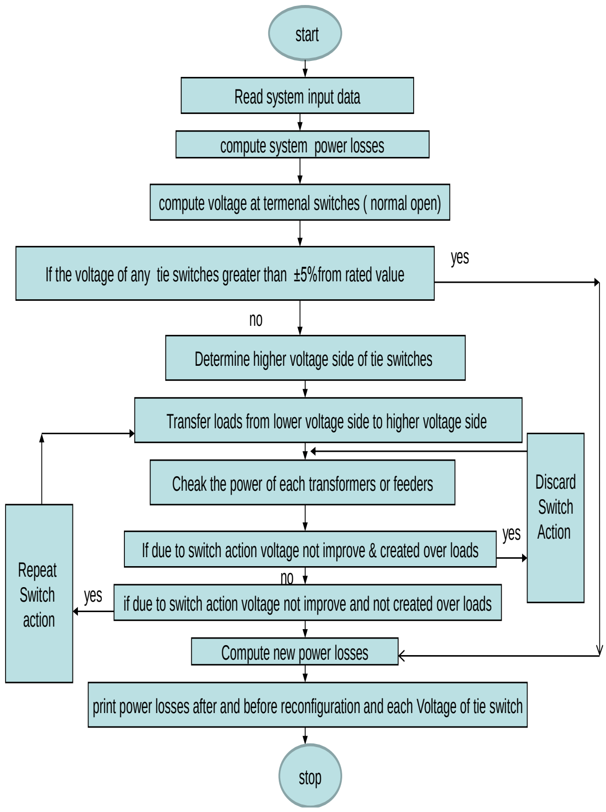
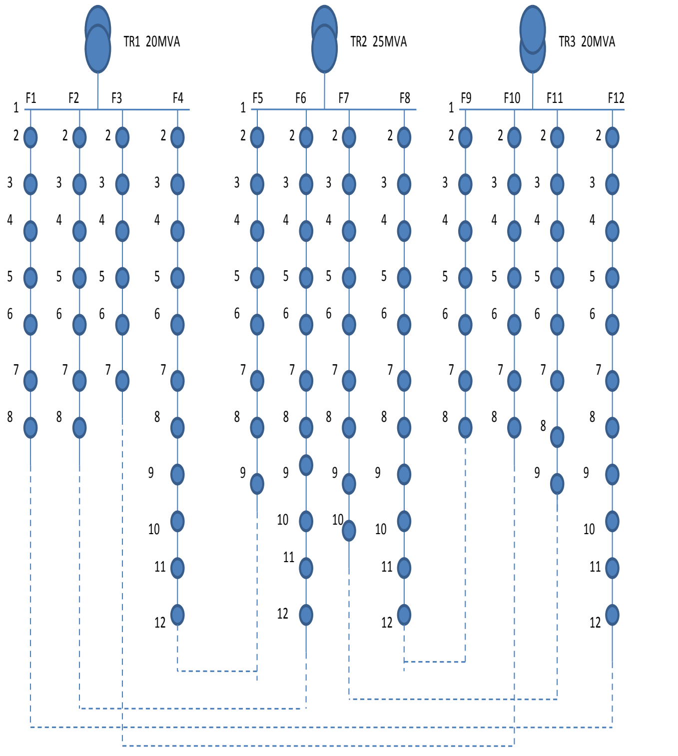


Fig .2 flow chart



● Loads center

——— sectionalizing switches (normally closed)

. . . . Tie switches (normally open)

Fig 3. Egyptian distribution Network (kafr elshekh Network)

Fig 3 describes the network that consists of three transformers and each transformer consist of four feeders. The first and third are 20MVA and the second is 25MVA, table 1 describes the network data and load data of transformer 2 under case study.

Table 1 describe the network and load of transformer 2.

Feeder name	From bus	To bus	R (Ω)	X (Ω)	Active Power (KW)	Reactive Power (KVAR)
Feeder 5	1	2	0.161	0.09	718	445
	2	3	0.096	0.054	623	319
	3	4	0.080	0.045	554	387
	4	5	0.064	0.036	576	279
	5	6	0.051	0.028	642	311
	6	7	0.045	0.025	549	250
	7	8	0.128	0.072	387	198
	8	9	0.136	0.076	391	283
Feeder 6	1	2	0.096	0.054	733	312
	2	3	0.072	0.040	637	290
	3	4	0.020	0.011	418	178
	4	5	0.032	0.018	473	242
	5	6	0.096	0.054	606	376
	6	7	0.080	0.045	626	285
Feeder 6	7	8	0.032	0.018	435	211
	8	9	0.136	0.076	474	187
	9	10	0.056	0.031	406	173
	10	11	0.096	0.054	308	140
	11	12	0.080	0.045	298	98
Feeder 7	1	2	0.088	0.049	1160	338
	2	3	0.096	0.054	764	302
	3	4	0.072	0.040	595	415
	4	5	0.048	0.027	794	288
	5	6	0.080	0.045	707	381
	6	7	0.064	0.036	747	340
	7	8	0.241	0.135	483	362
	8	9	0.056	0.031	472	201
	9	10	0.241	0.135	307	112
Feeder 8	1	2	0.161	0.09	455	318
	2	3	0.064	0.036	355	182
	3	4	0.080	0.045	261	94
	4	5	0.262	0.146	323	138
	5	6	0.032	0.018	175	109
	6	7	0.064	0.036	517	235
	7	8	0.048	0.027	322	165
	8	9	0.072	0.040	482	158
	9	10	0.024	0.013	303	163
	10	11	0.056	0.031	227	82
	11	12	0.090	0.050	183	60

Table 1 describes network and load of transformer 2.

Fig. 4, 5, 6, 7 describe the voltage profile before and after reconfiguration along feeders 5,6,7,8 respectively. Table 2 describes the transformer loading before and after reconfiguration to show load balancing with using capacitor bank.

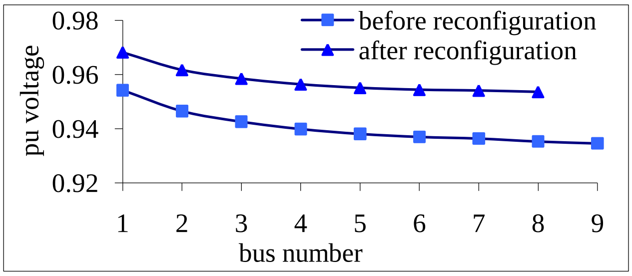


Fig 4 Pu voltage along feeder 5 of transformer 2

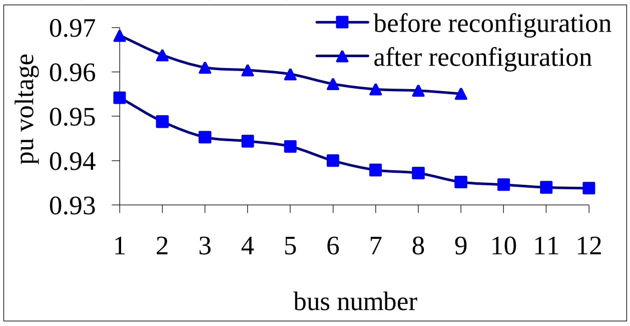


Fig 5 Pu voltage along feeder 6 of transformer 2

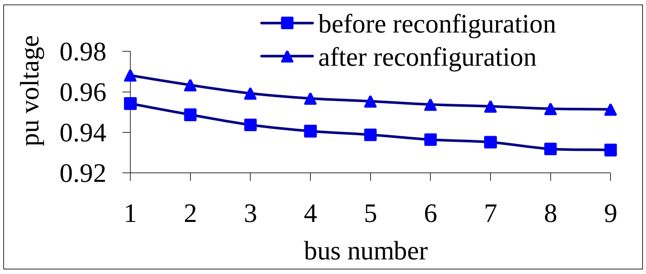


Fig 6 pu voltage along feeder 7 of transformer 2

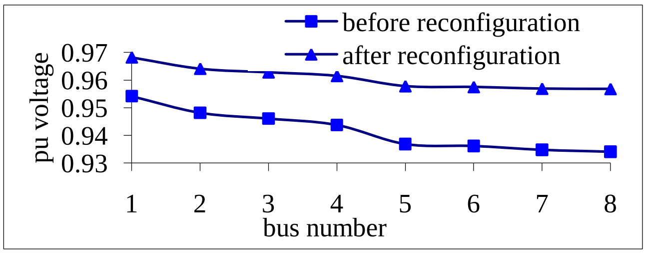


Fig 7 Pu voltage along feeder 8 of transformer 2

Transformer name	Loading before reconfiguration	Loading after reconfiguration
Transformer 1	70.8 %	79.1 %
Transformer 2	90 %	73.1 %
Transformer 3	70 %	78.7 %

Table 2 transformers loading before and after reconfiguration.

CONCLUSION

In this paper, a new method approach is developed to improve the system. This method gives the optimal solution with a few numbers of load flow runs and the CPU time needed is much less. Therefore, this method can be effectively used in real time application of the large distribution system under widely varying load conditions. Considering the cost of KWH (0.2 LE), and number of units (6*300 KVAR) with cost of one unit / year equal = 11000 LE / life time (20 year) = 3300 LE.

The remarkable results of this application are:

- The losses before reconfiguration = 540.6 KW
- The losses after reconfiguration without using capacitor bank = 468.9 KW (percentage reduction 13.2 %).
- The losses after reconfiguration with using capacitor bank = 445.3 KW (percentage reduction 17.6 %).
- The annual saving without using capacitor bank = 125618.4 LE (Egyptian pound).
- Annual saving with using capacitor bank=166965.6 LE
- Total annual saving with using capacitor bank equal : 166965.6 – 3300 = 163665.6 LE

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