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Restructuring of Distribution System for Voltage Profile Improvement and Loss Reduction using BPSO

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Abstract: This paper mainly focuses on finding the best restructuring of IEEE-69 bus distribution system network by changing the status of tie and sectionalizing switches without endangering the radiality of the network, the objective of the research is to improvise the system reliability in terms of voltage profile maximization and overall system loss minimization. Binary Particle swarm optimization (BPSO) is applied to achieve best switching without violating parameters allied to distribution system thereby ensuring the security of the system. The results obtained are satisfactory.

Keywords: Binary Particle swarm optimization, Network reconfiguration, Power loss, Voltage profile.

I. INTRODUCTION

Due to intensification of the population and the demand of electricity by the consumers is growing rapidly. To ensure the catering of electricity to rapid growing loads the government has taken an initiative to connect Distributed generators at the feeder / consumer points. These connections of generators lead to violation of ampacity factor of a individual or multiple lines leading to outage of specific feeder which endangers the reliability of the power supply as well the losses in the system will keep increasing if not operated optimally. Optimal network reconfiguration is the topological structure of feeders by interchanging the status (open / closed) of sectionalizing and ties switches exhibiting minimum system loss and maximum voltage contour without violating the radiality structure. These switches are basically used for the purpose of protection, maintenance and for voltage regulation in the primary distribution network [1]. Usually radial configuration is practiced for the significant management of the protective devices as they are used to maintain reliability of power supply to the end consumers. In pervasive, networks are configured to trim down real power losses and improve the overall efficiency of the system [1]. Due to increased demand there exists a mismatch between the generated power and demand by the connected loads [1]. This results in load shedding or brown outs [2]. In order to overcome this problem to a certain level, network reconfiguration by changing the status of switches is practiced.

II. PROBLEM FORMULATION

In this paper two objectives are taken into consideration for implementing a BPSO to the given system.

The two objectives are [1]:
(i) Power loss minimization (P_L).
(ii) Voltage improvement without violating the limits specified.
Power loss reduction of the entire system is the fundamental objective

$$Min(P_L) = \sum_{y=1}^{Ml} \sum_{x=1}^{N} s|I_x|^2 R_x \text{ …….. (1)}$$

Where,
s= status of switch (i.e. 1/0 depending upon On Off status).
I_x= magnitude of current at different points.
R_x= Resistance of each branch.
Total power loss is calculated using equation no. (1)

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$$P_L = \sum_{i=1}^{n} G_i (V_j^2 + V_k^2 - 2V_j V_k \cos(\delta_j - \delta_k) \ldots (2)$$

Where,
n= total branches in the system.
Gi = conductance of the i^{th}branch connecting the sending (‘j’) and receiving bus (‘k’) [1].
Vj, Vk = magnitude of voltage at bus ‘j’ and ‘k’. [1].
δi, δk = voltage angles of bus ‘j’ and bus ‘k’. [1].

Constrain for bus voltages and phase angles are circumscribed between maximum and minimum values and are defined by system operator.
Below are the constrains:

$$V_j^{Min} \leq V_j \leq V_j^{Max} \qquad (3)$$

$$\delta_j^{Min} \leq \delta_j \leq \delta_j^{Max} \qquad (4)$$

Where,
V_j^{Min}, V_j^{Max} = Minimum and maximum range of voltages respectively [1].
δ_j^{Min}, δ_j^{Max} = Minimum and maximum ranges of voltages angles respectively [1].

Network Reconfiguration:
Number of tie switches (T) in a network reconfiguration process is given by

T=X-Y+1

Where,
X = total branches.
Y= total nodes.
Initial open switches used for IEEE 69 standard distribution network is:

S_0	69	70	71	72	73

Switching pattern to be followed for system reconfiguration is given below:

TABLE 1: Switching Pattern

TAP No.	Switch No.																
	11	12	13	14	43	44	45	71	0	0	0	0	0	0	0	0	0
	4	5	6	7	8	52	53	54	55	56	57	58	72	46	47	48	49
	3	9	10	35	36	37	38	39	40	41	42	69	0	0	0	0	0
	21	22	23	24	25	26	59	60	61	62	63	64	73	0	0	0	0
	15	16	17	18	19	20	70	0	0	0	0	0	0	0	0	0	0

III. BINARY PARTICLE SWARM OPTIMIZATION

A. *Introduction*

The optimization technique is basically based on the pattern of birds flocking and it’s a stochastic. The velocity and position of each bird movement is influenced by its local best, which updates other birds which are predictable to move the swarm toward the best solution. By adding a sigmoid function we can make PSO to work as Binary Particle swarm optimization (BPSO).

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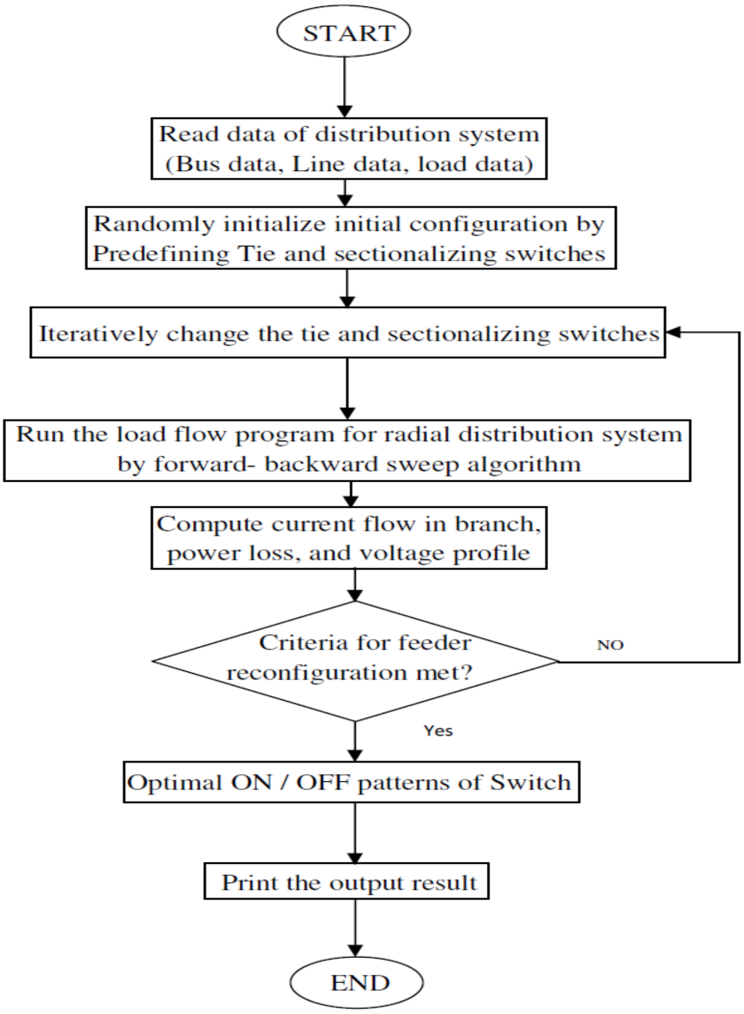
B. Flow chart for optimal reconfiguration using BPSO



IV. RESULTS

In order to validate the effectiveness of the projected method, PSO is tested on standard IEEE 69bus distribution system network.

A. IEEE 69 Bus Distribution system

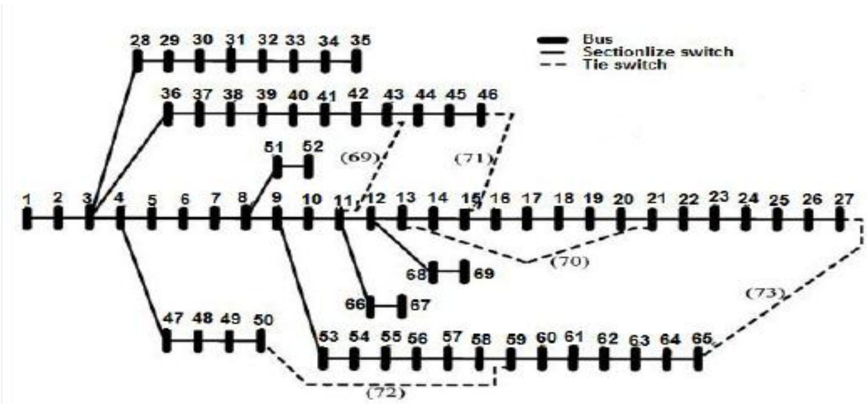


Fig.1 Single line diagram of IEEE-69 bus distribution system before reconfiguration

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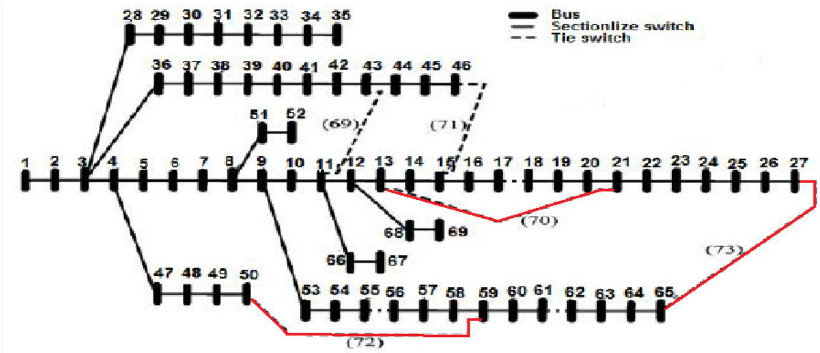

Fig.2 Single line diagram of IEEE-69 bus distribution system after reconfiguration

TABLE 2: Comparative results of Base case and optimal case

	BEFORE RECONFIGURATION	AFTER RECONFIGURATION
Tie switches	69 70 71 72 73	17 55 61 69 71
Power loss (Active)	208.4592 kW	130.9275kW
Power loss reduction(Active)	------	37.19%
Minimum voltage	0.90908 pu	0.94274 pu

From TABLE.2 clearly states that there is considerable reduction in power loss as well it is observed that there is improvement in voltage profile compared to the initial configuration.

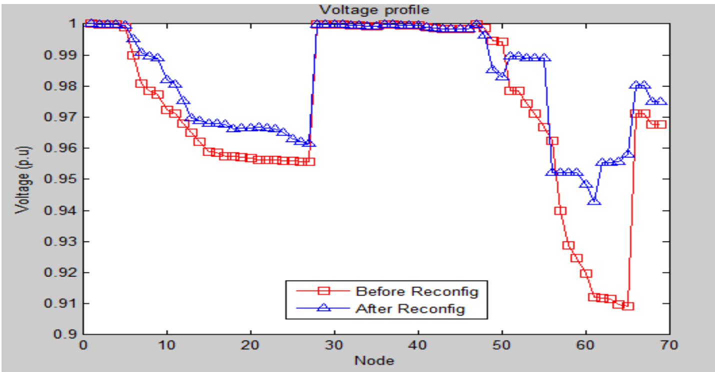

Fig.2: Comparison of voltage profile.

From figure.2 it is observed that there is an enhancement in the voltage profile compared to the base case.

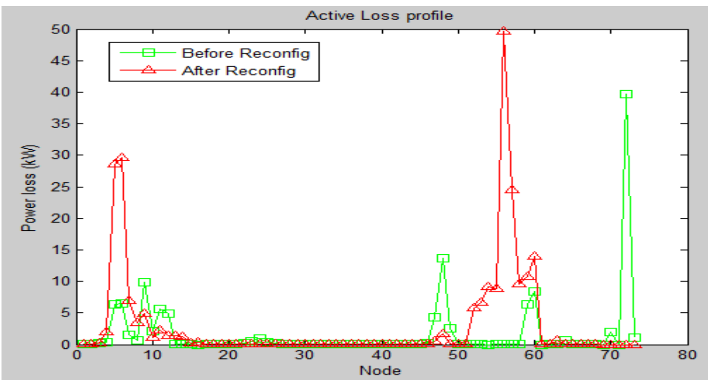

Fig.3: Comparison of Power loss (Active) before and after reconfiguration

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From figure.3 it is noticed that there is reduction in the power loss profile compared to the initial case.

TABLE 4: Comparison of Power Loss profile

Bus No.	Before Reconfiguration	After Reconfiguration
1	0.0724	0.0701
2	0.0724	0.0701
3	0.1891	0.1824
4	1.963	0.4503
5	28.5573	6.5508
6	29.675	6.7929
7	6.9686	1.5453
8	3.4189	0.6852
9	4.9671	9.8093
10	1.0566	2.132
11	2.3119	5.6058
12	1.3968	4.8668
13	1.3574	0.1241
14	1.3154	0.1082
15	0.2445	0.0201
16	0.3547	0.012
17	0.0029	0
18	0.1241	0.0106
19	0.0798	0.0068
20	0.1281	0.0114
21	0.0009	0.0223
22	0.0051	0.2288
23	0.0112	0.498
24	0.0061	0.9227
25	0.0025	0.3806
26	0.0004	0.1967
27	0.0003	0.0003
28	0.0021	0.0021
29	0.0041	0.0041
30	0.0007	0.0007
31	0.0036	0.0036
32	0.0087	0.0087
33	0.006	0.006
34	0.0005	0.0005
35	0.0014	0.0014
36	0.0151	0.0151
37	0.0173	0.0173
38	0.005	0.005
39	0.0002	0.0002
40	0.0487	0.0487
41	0.0201	0.0201
42	0.0027	0.0027
43	0.0005	0.0005
44	0.0061	0.0061

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45	0	0
46	0.0231	0.1656
47	0.5829	4.1885
48	1.6334	13.2893
49	0.1159	2.5546
50	0.0018	0.0017
51	0	0
52	5.7846	0.0051
53	6.7154	0.005
54	9.1259	0.0016
55	8.7917	0
56	49.6946	0
57	24.4967	0
58	9.5081	0
59	10.6737	6.332
60	14.0278	8.3218
61	0.1121	0
62	0.135	0.0015
63	0.6613	0.0075
64	0.0412	0.7204
65	0.0026	0.0026
66	0	0
67	0.0233	0.023
68	0	0
69	0	0
70	0	1.6309
71	0	0
72	0	38.2454
73	0	1.0418

From Table.4 it is observed that there is scalable reduction in power loss profile of entire network as compared to the initial configuration.

TABLE 5: Comparison of Voltage Profile before and after reconfiguration

Bus No.	Before Reconfiguration	After Reconfiguration
1	1	1
2	1	1
3	0.9999	0.9999
4	0.9998	0.9999
5	0.999	0.9997
6	0.99	0.9976
7	0.9807	0.9955
8	0.9785	0.995
9	0.9773	0.9948
10	0.9723	0.9922
11	0.9712	0.9916
12	0.968	0.9905
13	0.965	0.972
14	0.962	0.976
15	0.9591	0.9801

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16	0.9585	0.9798
17	0.9576	0.9795
18	0.9576	0.9795
19	0.9571	0.9795
20	0.9568	0.9693
21	0.9563	0.9693
22	0.9563	0.9693
23	0.9562	0.9688
24	0.956	0.9679
25	0.9559	0.966
26	0.9558	0.9652
27	0.9558	0.9648
28	0.9999	0.9999
29	0.9999	0.9999
30	0.9998	0.9998
31	0.9997	0.9997
32	0.9997	0.9997
33	0.9995	0.9995
34	0.9992	0.9992
35	0.9992	0.9992
36	0.9999	0.9999
37	0.9998	0.999
38	0.9996	0.998
39	0.9995	0.9977
40	0.9995	0.9977
41	0.9988	0.9914
42	0.9986	0.9887
43	0.9985	0.9883
44	0.9985	0.9883
45	0.9984	0.9873
46	0.9984	0.9873
47	0.9998	0.9997
48	0.9985	0.9963
49	0.9947	0.9851
50	0.9942	0.9825
51	0.9784	0.9949
52	0.9784	0.9949
53	0.9746	0.9947
54	0.9713	0.9946
55	0.9668	0.9945
56	0.9625	0.9513
57	0.94	0.9513
58	0.9289	0.9513
59	0.9247	0.9513
60	0.9196	0.9473
61	0.9122	0.9414
62	0.9119	0.9414

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63	0.9116	0.9595
64	0.9097	0.9595
65	0.9091	0.9616
66	0.9711	0.9915
67	0.9711	0.9915
68	0.9676	0.9902
69	0.9676	0.9902

From Table.5 it is clear that there is scalable improvement in voltage profile at each node with respect to the initial configuration.

V. CONCLUSION

In the present work the main focus was to locate the most suitable network topology for an IEEE 69 bus radial distribution system. From the results it is experimental that BPSO gives the finest combination resulting in minimum power loss and enhanced voltage profile.

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