AN IMPLEMENTING META HEURISTIC BAT ALGORITHM FOR MINIMIZING THE POWER LOSSES WITH OPTIMAL PLACEMENT OF DG SOURCE IN THE RADIAL DISTRIBUTION SYSTEM

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Abstract—*A new stochastic optimization technique (BAT Algorithm) for minimizing power losses in the radial distribution system. The new Meta heuristic algorithm (BAT) which can provide an optimal solution using a flow and optimal placement and injection of reactive power to the distribution system is proposed. A huge power loss reduction has been achieved. A new distributed power flow analysis is derived for determining the electrical parameters from the branch exchange method followed by a forward backward sweep algorithm. An accurate estimation of impartial function under many constraints is convoluted for both control the sectionalized switches and tie switches. The analyses and a comparison with IEEE 33, IEEE 69 buses using the MATLAB R2014 software have been executed. The simulation results were carried out for the real time 62 buses of south Indian distribution system. The result of the proposed method provides a powerful optimization solution.*

Keywords—*BAT algorithm, Distributed power flow, Fitness, loss reduction, Network Reconfiguration, Power flow maximization, Sweep algorithm.*

I. INTRODUCTION

Increase in electrical energy demand requires more power transfer capacity of distribution systems. But the construction of new substations and erection of new lines, are constrained by environmental concerns and increasing costs. Networks are required for reducing the losses including load balancing, network reconfiguration, reactive power supplies, management of active and reactive power and inserting FACTS devices. The distribution system is more critical and very tough particularly in urban areas. A sudden increase in load demand causes increase in voltage deviation, shortages of reactive power and reduces the voltage levels of the system. This strongly led to a voltage collapse. In distribution lines, resistance and inductance ratio are equal or more or less equal to single directional power flows. Thus many radial systems suffer high power loss. Most of the radial distribution system structures consist of root node, main line, lateral line, sub lateral line, minor line and large number of normally closed sectionalized switches and normally open (tie) switches, with some uniform and non-uniform tapings. Network reconfiguration is the process of altering the network structure of the feeders by changing open/closed status of the sectionalizing and tie line switches. The switches (tie, sectionalized) are used for changing the inter connection, altering the system topology, allowing the transfer of load from a stronger feeder to a weaker feeder. This process of reconfiguration is used for reducing the huge number of load flow calculations. Load flow in a distribution network is defined as the set of recursive equations called Distributed load flow equations, which are solved by branch exchange method using the forward backward sweep algorithm to find the electrical parameters. This is one of the superior methods for calculating load flow quantities like P, Q, PL, QL, V, δ in all the buses and finding the active power losses and reactive power losses of the distribution lines. The Artificial Bee colony algorithm in which food source considered nearby, varying the value of one randomly chosen parameter but keeping others parameters constant, which is not advisable for optimization problems [3].The results are not comparable with IEEE 33 bus, 69 bus system and improper modeling of distribution system executed[3]. The paper has been proposed on the probability of the mutation value as very small and the probability of cross over value a very close to the maximum value and the iteration count as very high[4]. The paper has been proposed, all the loads are constant and considered the loads as only on a single phase but distribution systems loads as normally variable with respect to time and maximum loads as in three phases in general[5]. The paper has been proposed, prediction for most critical bus, line voltage assessment using a stability indicator, but only for forecasting and not for reconfiguration [6]. The paper has been proposed, paper on minimizing the losses with three different stages for the same problem. The cross over functions is high complexity of degree [7]. The paper has been proposed on fault calculation using only sag calculated without limits on power quality terms taken as variables but these variables are not suitable for reconfiguration techniques [8]. The paper has been proposed not clear on the reconfiguration techniques that implement FACTS devices but operated only in the low voltage side and cost function is not properly addressed [9]. The paper has been proposed considered only IEEE cases, while the objective function is based on differences in voltages. Loads are lumped; regular energy is not properly calculated [10]. The paper has used BAT algorithm, but the objective function is not clearly defined. It has been used many constants but the constants obtained by his method and derived load flow using the Point estimation method are only approximations with inaccurate values of results [11]. The paper has been proposed a load flow analysis of combined Matrix and FBSA, the results are inaccurate and have used many constants [12].The paper has been derived the constant loads and his time varying and objective function is not well defined [13]. The paper has been has presented a paper on the power loss calculation from a packed software. The results are inaccurate and HOMER is not clear [14]. The paper has been executed problems without objective function [15].The paper has been proposed Bacterium movement in one direction, but not identified the direction of movement. Normally the bacterium has random movements [16]. The paper has been stated that fixing of egg is not correct and the eggs ratios normally vary and in contrary to main parameters [17].An article where object function is not clear and harmony solutions are compared with the previous results [18]. The paper has been proposed in his article, reconfiguration objective function which is not based on the current equation and voltage equation which are separate. Cost has been estimated only for a fixed time, which is not suitable for calculation of losses [19]. The SCADA systems have entirely different from reconfiguration [20]. The paper has been proposed which was based on only the power loss sensitivity. Voltage sensitivity is also one of the main parameters for calculating the capacitor placements [21]. The rest of the paper has organized as follows. In section II describe the power flow capacity of the distribution line in terms of stable or unstable conditions applied in the novel voltage stability index. In section III discuss about the producer to optimize the power loss in radial distribution line using modified BAT algorithm. In section IV shows the simulation results of the modified BAT algorithm applied in the American standard IEEE 33 and 69 bus and its results have compared with real time 62 bus of the Indian distribution system. Finally, the conclusion has been made from the simulation result that the proposed technique produced optimized power loss by minimizing the number of switches placed in the radial distribution system, optimal placement of distributed generation source and reduced the cost of DG source.

II. VOLTAGE STABILITY INDEX

The conventional load flow methods such as Gauss, Gauss-Seidal, Newton-Raphson, and Fast decoupled are not suitable for distribution systems for finding the voltages and line losses due the ratio of resistance to inductance (R/X)being high. The most standard and simplest solutions "Distributed Load Flow solutions" are used with the help of recursive equations using forward backward sweep algorithm. There are many indices used for checking the power system stability analysis level. In this section, a new steady state stability index is applied to the system for identification the by the branch of distribution lines which have many chances of voltage collapse [1, 2]. The voltage stability at each branch is calculated using the stability index. The node has a low value of VSI, very near to 0, and has better chances of installing distributed generation. The node has a high value of VSI, very near to 1, and better chances of installing distributed generation while the branch carries the normal power flow.

$$\begin{aligned} VLSI &= 4\times\left(A+B\right) \\ A &= P_i \times r_{ij} - Q_i \times x_{ij} \\ B &= \left(P_j^2 - Q_j^2\right)\left(r_{ij}^2 - x_{ij}^2\right) \end{aligned} \quad (1)$$

Problem Formulation

Mathematically, the objective function and its limitations are formulated as follow derived as a nonlinear optimizing recursive equation with both the integer and the real variables. The formulations can be expressed as given below:

$$I = \left(\frac{P_i^2 + Q_i^2}{\left|V_i\right|^2}\right) \quad (2)$$

Where, P_i and Q_i are the real and reactive lines power at bus i, P_{Li+1} and Q_{Li+1} are real and reactive load power respectively at bus i. r_{ij+1} & x_{ij+1} as resistance and reactance of the line section between bus i and $i+1$. The power flow in a radial distribution network can be described by a set of recursive equations called distributed power flow braches of equation that use P,Q and to express V_s, Vr, P_r, Q_r. This can be incorporated for avoiding complex iteration problems. The power loss of the line section connecting buses i and $i+1$ can be computed as

$$P_{Loss_{i,i+1}} = r_i * \left(\frac{P_i^2 + Q_i^2}{|V_i|^2} \right),$$
$$Q_{Loss_{i,i+1}} = X_i * \left(\frac{P_i^2 + Q_i^2}{|V_i|^2} \right) \quad (3)$$

The total system power loss is evaluated by sum of power losses of all the feeders. The total power of the system is calculated by the addition of losses in all the sections. It is given by

$$P_{TotalLoss} = \sum_{i=0}^{n-1} P_{Loss_{i,i+1}} ,$$
$$Q_{TotalLoss} = \sum_{i=0}^{n-1} Q_{Loss_{i,i+1}} \quad (4)$$

Objective function

The objective function of the radial distribution system is to minimize the power losses by satisfying the equality and inequality constraints. The mathematical formulation of objective function (F) is

$$MiniF = \sum_{i=1}^{nb} r_i * \left(\frac{P_i^2 + Q_i^2}{|V_i|^2} \right) \quad (5)$$

The mathematical model has the following constraints.

Constraints

(i) Power Flow Limitation

$$P_{\max} \geq P_i \geq P_{\min} \quad (6)$$

The power flow of the each lines is given by P_i, voltage magnitude of the bus i. The maximum and minimum power flow of the each bus i is given $P_{\min}$ and $P_{\max}$.

(ii)Voltage limitation

$$V_{\max} \geq V_i \geq V_{\min} \,\&\, I_{\max} \geq I_i , I_{\min} \leq I_i \quad (7)$$

V_i be the voltage magnitude of the bus *i*, $V_{\max}$ and $V_{\min}$ are the maximum, minimum voltage limits of the bus *i*. Similarly, I_i be the voltage magnitude of the bus *i*, $I_{\max}$ and $I_{\min}$ are the maximum, minimum voltage limits of the bus *i*.

(iii) Branch apparent power flow constraints

$$S_{\max} \geq S_i , S_{\min} \leq S_i \quad (8)$$

Where, $S_{\max}$ and $S_{\min}$ are the maximum power flow and apparent power flows of the branch i.

(iv) The reconfiguration system must be radial in structure

The proposed solution algorithm contains the following switching operational sequences.

- The sectionalizing switch to be opened.
- If the radial structure is violated after closing a switch, this switch cannot be selected as a backup switch.
- If the inner loops are still generated after the above steps, one switch in the loop should be arbitrarily opened.
- The proposed method uses a set of simplified and fast and it is often used in published power flow analysis of a radial distribution system.

III. BAT ALGORITHM (BA)

Bat algorithm is a most popular based evolutionary technique for optimization problem. It is fully based on the echolocation activities of natural Bats in locating their food. Normally Bats radiates a sound called echolocation that helps detecting the objects around them and finding their way even in total darkness. Bats are attractive animals, which have wings and advanced echolocation capability to find their food. Each bat utilizes the echolocation process to sense the distance, and also knows the difference between food/prey and the background hurdles in some magical way using the echolocation property. Each bat flies in the position x_i randomly with the velocity, V_i generating pulse with the frequency f_{mn}, wave length λ, loudness A_0 to seek the prey. It is the ability to regulate the emitted pulse and regulate the rate of the emission of '*r*' in the range of [0, 1] relying on the proximity of its aim. The loudness of A_i differs in many ways such as reducing from a large position A_0 to lower positions $A_{\min}$ After the generation of the initial random bat population, the objective function is calculated for all the bats and the G_{best} bat is stored.

(a) Initialization of Population

Initially, the population, that is the number of fundamental bats for the bat algorithm is generated randomly. The number of virtual bats should be anywhere between 10 and 40. After getting the initial fitness of the population for a given function, the values are updated on the basis of the loudness, movement and pulse rate.

(b) Movement of Virtual bats

In the bat algorithm, there are rules for updating the positions of x_i and velocities V_i of the virtual bats. These are given by

$$f_i = f_{min} + (f_{max} - f_{min})\beta \quad (10)$$

$$V_i^t = V_i^{t-1} + (x_i^{t-1} - x^*) f_i \quad (11)$$

$$x_i^t = x_i^{t-1} + v_i^t \quad (12)$$

Where, $\beta \in [0,1]$ is a random vector drawn from a uniform distribution. x^* be the present global best solution among all the number of bats. A Locally generated new solution for all bats using a random walk is given below.

$$x_{new} = x_{old} + \varepsilon A^t \quad (13)$$

Where 'ε' is the scaling factor in the range of [-1, 1]. While $A^t = |(A_i^t)|$ is the average loudness of all the bats at this time step.

(c) Loudness and Pulse Emission Rates

The loudness and the pulse emission rates of each bat are updated with an iteration using the following relations. The pulse rate increases while loudness decreases.

$$A_i^{i+1} = \alpha A_i^t \quad (14)$$

$$r_i^{t+1} = r_i^0 [1 - exp(-\gamma * Iter)] \quad (15)$$

Where α and γ are constant values. *Iter* is the number of iterations used during the optimization processes and usually taken as 0.9. For any value of 0<α<1, γ>0, we have $A_i^t \to 0,\ r_i^t \to 0, as\ t \to \infty$. The initial value of loudness A_0 can be in the range of [0, 1], while the emission rate r_i can be in the range of [0, 1], Loudness and pulse rates are self-adjustable.

IV. SIMULATION RESULTS

This paper uses RACCOON type the conductor for calculation of VSI. The following specifications have been considered for the RACCOON conductor. The size of the conductor is 7x4.09 mm. The maximum continuous current rating is 270A, ambient temperature is 40°C, resistance of the line is 0.39Ω/km and reactance is 0.29 Ω/km. The apparent power flow of 0.85 power factor lagging of the line load factor is 4.145 times, the corresponding VSI which has been measured as 0.9995 of the base power. It indicates the stability of the systems, when the load factor is up to 4.145. When it increases by 0.001 time (i.e., Load factor is 4.146 times), VSI is 1.005.

(a) IEEE 33 Bus System

The standard IEEE 33 bus has 5 tie line switches, 3.715MVA; 2.300MVAr Power ratings are shown in Figure 1. The initial statuses of the all sectionalizing switches are closed, while all tie switches (switch no 33-37) are open. The base network power loss is 283.56 KW. The configuration done by the proposed method is seen as the best solution obtained so far. The active power losses obtained from this base case is 202.4KW. The minimum value of voltage obtained is 0.9020pu are shown in Table 1.

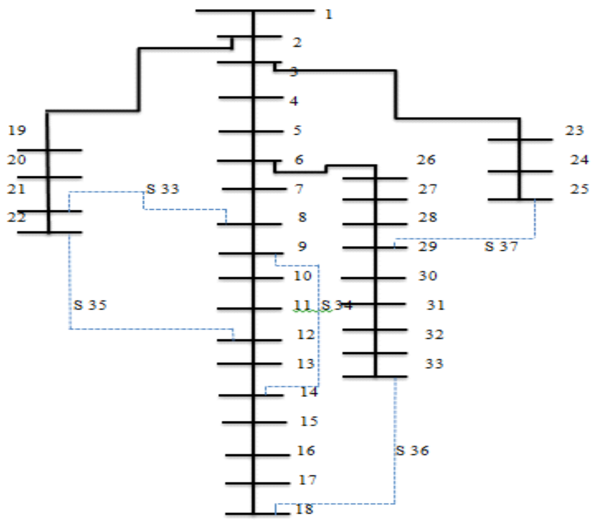

Fig. 1 Single line diagram of IEEE 33 bus system

The tie switch with maximum voltage difference is 35 and it is closed. When sectionalizing switch 7-8 when opened, results in the minimum losses compared to other sectionalizing switches.

Table. 1 IEEE 33 bus results of the distribution system

S. No	Tie Switch Closed	Sectionalizing Switch Opened	P_{Loss} (KW)	Q_{Loss} (KVAr)
1	All open	All closed	283.56	232.12
2	35	7-8	135.9	123.45
3	37	28-29	131.7	101.09
4	36	32-33	130.9	108.96
5	34	14-15	29.89	12.56

The procedure is repeated by closing other tie switches also. Radially is checked at every stage. The results for final reconfiguration are tabulated.

Table. 2 Comparison of IEEE 33 bus results

S. No	**Type**	**Tie switches**	P_{Loss} **(KW)**	**Min Node voltage**
1	Harmony search algorithm	7, 10, 14, 36, 37.	142.72 (29 node)	0.9115, Node 33
2	Genetic Algorithm	9, 28, 33, 34, 36.	139.89	0.9378 Node 33
3	Artificial immune system algorithm	7,9,14, 32, 37	121.1	0.9076 Node 33
4	Selective Particle Swarm Optimization	7,9,14,28,37	139.95	0.9478 Node 32
5	Proposed BAT Algorithm	7,9,14, 32, 37	139.23	0.9562 node 32

Table. 3 Results of individual bus voltages and power losses of IEEE 33 bus systems

S. No	**Voltage (pu)**	P_{Loss} **(KW)**	**Voltage (pu)**	P_{Loss} **(KW)**
1	1.000	0.012	1.000	0.008
2	0.9987	0.053	0.9997	0.047
3	0.9901	0.020	0.9913	0.016
4	0.9867	0.019	0.9885	0.014
5	0.9801	0.038	0.9769	0.024
6	0.9778	0.002	0.9615	0.0017
7	0.9709	0.005	0.9549	0.0043
8	0.9697	0.004	0.9678	0.0031
9	0.9623	0.004	0.9563	0.0033
10	0.9592	0.001	0.9541	0.0006
11	0.9568	0.001	0.9672	0.0005
12	0.9446	0.003	0.9622	0.0019
13	0.9321	0.001	0.9204	0.0003
14	0.9219	0.000	0.9589	0.0002
15	0.9199	0.000	0.9517	0.000
16	0.9164	0.000	0.9496	0.000
17	0.9165	0.000	0.9432	0.000
18	0.9178	0.000	0.9401	0.000
19	0.9989	0.001	0.9977	0.0007
20	0.9961	0.000	0.9745	0.000
21	0.9932	0.000	0.9921	0.000
22	0.9912	0.003	0.9905	0.0021
23	0.9876	0.005	0.9854	0.0038
24	0.9788	0.001	0.9802	0.0006
25	0.9742	0.003	0.9776	0.0027
26	0.9701	0.003	0.9695	0.0022
27	0.9598	0.011	0.9554	0.007
28	0.9466	0.008	0.9546	0.005
29	0.9402	0.004	0.9437	0.0031
30	0.9345	0.002	0.9414	0.0014
31	0.9297	0.000	0.9401	0.000
32	0.934	0.000	0.9376	0.000
33	0.9189	0.000	0.9476	0.000

Based on the simulation results the maximum voltage deviations are identified and the shortage of reactive power has been injected to improve the stability of system.

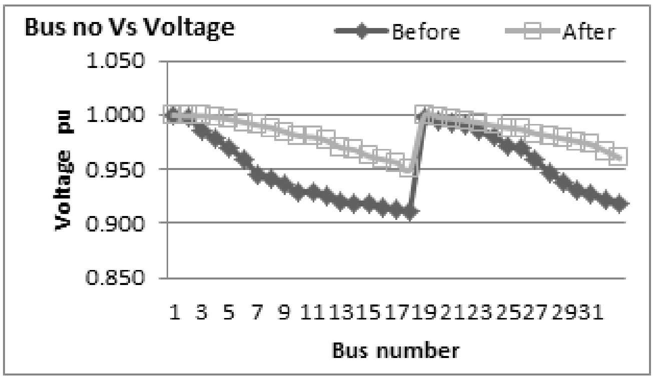

Fig. 2 Bus voltage with bus number

(b) IEEE 69 Bus System

The standard IEEE 69 bus network contains 7 main feeder, 3 laterals and 5 tie lines with the capacity of 3.80 MW and 2.69 MVAr and 12.66 KV. The optimal reconfiguration obtained by applying the proposed algorithm is to keep s69,s70 open and close s71,s72,s73 and open s14,s56,s63 and close S69,s70, s71, s72,s73. The percentage reduction in power losses is equal to 44.05%. There are three loops in the 69 bus system with the switches that do not belong to any loop are s1,s2,s27,s28,s29, s30,s31,s32, s34,s50,s51, s65,s66, s67and s68. The switches, which belong only to one loop presenting the dimensions of the algorithm. d1=[s46,s47,s48,s49,s72],d2=[s3,s35,s36,s37,s38,s39,s40,s41,s42],d3=[s43,s44,s45,s71],d4=[s21,s22,s23,s24,s25,s26,s59,s60,s61,s62,s63,s64,s73],d5=[s15,s16,s17,s18, s19,s20]. Prior to reconfiguration, the active losses and reactive power loss are 224.476 KW and 190.64 KVAr respectively. The optimal reconfiguration of the systems are achieved from active losses 224.996 KW to 190.64 KW while reactive power losses from 103.27 KVAr to 89.56KVAr are shown in Figure 3.Based on the simulation results the maximum voltage deviations are identified.

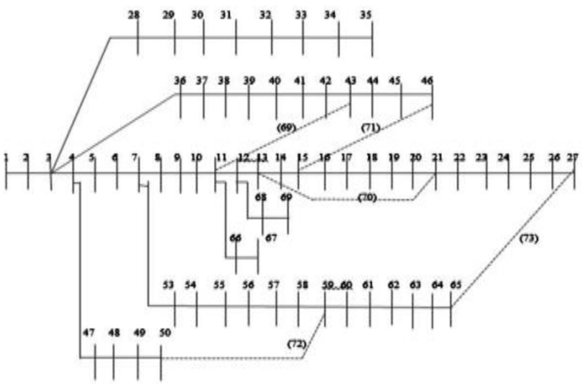

Fig 3 single line diagram of IEEE 69 bus system

The voltages and the power losses have been tabulated, on the basis of on the simulation results while the maximum power consumed by the individual transmission lines has been identified and suitable actions to be taken for eliminating voltage collapse are suggested.

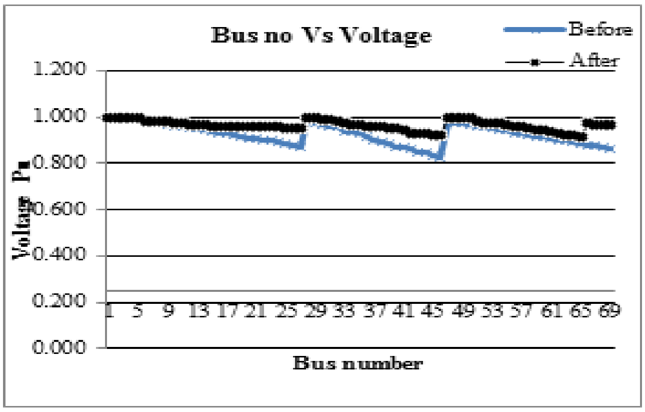

Fig. 4 Bus Voltages and bus numbers

(c) Indian Real Time System

Vellore distribution circle is the largest load center in Tamilnadu, India. The various load centers are Kazhinjur, Gandhi Nagar, V G Rao Nagar and installed capacity of loads are 3600 KVA, 4000 KVA and 5350 KVA and the installed capacity of 10 MVA, 0.95 lagging of power transformers. The incoming line voltage is 33 KV. Outgoing lines are 11 KV and the conductor size is 91.97mm^2. The ACSR conductor is a distribution of overhead system with radial networks. The real time system of simple distribution system. The minimum operating voltage in the existing systems is nearly 10 KV. The distribution system with tie lines and meshed topology are demonstrated. The position of the switches to be selected in the distribution network as suitable is expressed by 0, 1 integer variables. Most of the genetic algorithms in the power system applications use the binary encoding strategy. The proposed BAT Algorithm for loss reduction has been tested and evaluated by implementing it on the IEEE 33, IEEE 69 bus systems and real time Indian distribution system of 62 bus system.

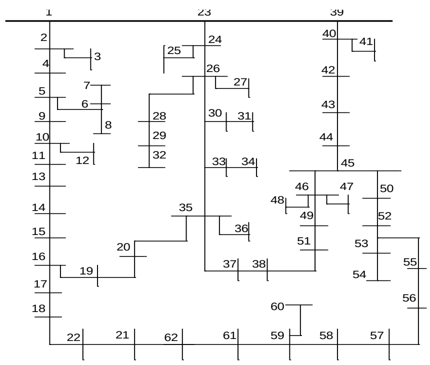

Fig 5 Single line diagrams of three substations with 62 buses.

Table. 4 IEEE 69 bus results of the distribution system

S. No	Tie Switch Closed	Sectionalizing Switch Opened	P Loss (KW)	Q Loss (KVAr)
1	All open	All closed	224.47	178.56
2	s69, s70	s71, s72, s73	237.87	164.32
3	s14, s56, s63	s69, s70, s71, s72, s73	190.64	145.21

Table. 5 Comparison of IEEE 69 bus results

S. No	Type	Tie switches	P_{LOSS} (KW)	Min Node voltage
1	Harmony search algorithm	s69, s18, s13, s45, s50.	106.23	0.9502 Node 45
2	Genetic Algorithm	s69,s70, s14,s46, s50	98.2521	0.9482 Node 46
3	Artificial immune system algorithm	s69,s70, s14,s45, s50	99.0012	0.9482 Node 45
4	Selective Particle Swarm Optimization	s69,s70, s14,s45, s52	99.670	0.9478 Node 45
5	Proposed BAT Algorithm	s69, s70 s71, s72, s73.	139.23	0.9562 nodes 71

Table. 6 Results of individual bus voltages and power losses of IEEE 69 bus systems

S. No	Before reconfiguration		After reconfiguration	
	Voltage (pu)	P loss (KW)	Voltage (pu)	P loss (KW)
1	1.0000	0.08	1.0000	0.05
2	0.9999	0.08	1.0000	0.05
3	0.9999	0.20	1.0000	0.14
4	0.9998	1.94	0.9999	1.16
5	0.9990	28.30	0.9991	27.45
6	0.9808	28.41	0.9809	26.72
7	0.9858	6.91	0.9859	5.32
8	0.9801	3.38	0.9802	3.15
9	0.9798	4.79	0.9799	4.06
10	0.9742	1.02	0.9743	0.08
11	0.9727	2.20	0.9728	1.65
12	0.9694	1.29	0.9695	0.67
13	0.9673	1.25	0.9675	0.76
14	0.9657	1.21	0.9658	0.85
15	0.9609	0.22	0.9610	0.18
16	0.9599	0.32	0.9601	0.21
17	0.9582	0.00	0.9583	0.00
18	0.9581	0.10	0.9584	0.05
19	0.9579	0.07	0.9580	0.04
20	0.9575	0.11	0.9577	0.09
21	0.9571	0.00	0.9572	0.00
22	0.9571	0.01	0.9573	0.01
23	0.9570	0.01	0.9572	0.01
24	0.9568	0.01	0.9670	0.01
25	0.9565	0.00	0.9569	0.00
26	0.9555	0.00	0.9566	0.00
27	0.9505	0.00	0.9567	0.00
28	0.9999	0.00	1.0000	0.00
29	0.9998	0.01	1.0000	0.01
30	0.9997	0.01	0.9999	0.01
31	0.9997	0.01	0.9998	0.01
32	0.9996	0.01	0.9997	0.01
33	0.9994	0.01	0.9995	0.01
34	0.9994	0.00	0.9995	0.00
35	0.9992	0.00	0.9993	0.00
36	0.9999	0.02	1.0000	0.02
37	0.9998	0.02	0.9999	0.02
38	0.9997	0.01	0.9999	0.01
39	0.9996	0.00	0.9998	0.00
40	0.9995	0.05	0.9997	0.03
41	0.9991	0.02	0.9992	0.02
42	0.9992	0.00	0.9993	0.00
43	0.9988	0.00	0.9990	0.00
44	0.9985	0.01	0.9987	0.01
45	0.9985	0.00	0.9987	0.00
46	0.9985	0.02	0.9987	0.02
47	0.9999	0.58	1.000	0.48
48	0.9992	1.63	0.9993	1.16
49	0.9961	0.12	0.9963	0.06
50	0.9958	0.00	0.9957	0.00
51	0.9824	0.00	0.9825	0.00
52	0.9792	5.79	0.9793	4..56
53	0.9754	6.73	0.9756	6.01
54	0.9731	9.14	0.9733	8.23
55	0.9689	8.81	0.9690	6.96
56	0.9642	49.78	0.9643	45.48
57	0.9458	24.54	0.9460	20.67
58	0.9342	9.52	0.9345	7.21
59	0.9267	10.69	0.9269	8.24
60	0.9209	14.05	0.9211	12.61
61	0.9154	0.11	0.9156	0.06
62	0.9133	0.15	0.9134	0.11
63	0.9124	0.66	0.9125	0.43
64	0.9111	0.04	0.9113	0.02
65	0.9099	0.00	0.9101	0.00
66	0.9732	0.00	0.9733	0.00
67	0.9712	0.02	0.9713	0.02
68	0.9682	0.00	0.9683	0.00
69	0.9681	0.00	0.9682	0.00

Table 7: Results of individual bus voltages and power losses of test systems

S. No	Before Voltage (pu)	P los (KW)	After Voltage (pu)	P loss (KW)
1	1.000	14.28	1.000	10.974
2	0.9586	0.001	09998	0.001
3	0.9583	2.316	0.9988	1.646
4	0.9512	2.748	0.9869	1.369
5	0.9428	2.806	0.9801	1.775
6	0.9413	0.022	0.9784	0.013
7	0.9412	0.003	0.9708	0.003
8	0.9411	0.003	0.9627	0.003
9	0.9328	2.726	0.9539	1.785
10	0.9213	0.793	0.9508	0.561
11	0.9177	0.011	0.9478	0.216
12	0.9204	0.615	0.9417	0.565
13	0.9143	0.594	0.9401	0.344
14	0.9118	0.471	0.9386	0.223
15	0.9085	0.851	0.9306	0.493
16	0.9034	0.079	0.9296	0.042
17	0.9012	0.055	0.9212	0.053
18	0.8997	0.006	0.9175	0.005
19	0.8815	0.119	0.9107	0.106
20	0.9008	0.024	0.9080	0.015
21	0.9002	0.001	0.9018	0.001
22	0.9000	1.961	0.9190	1.771
23	1.000	0.014	1.000	0.014
24	0.9948	2.196	0.9987	1.356
25	0.9933	0.014	0.9884	0.014
26	0.9862	0.028	0.9876	0.036
27	0.9859	0.023	0.9871	0.018
28	0.9857	0.001	0.9864	0.001
29	0.9855	0.004	0.9853	0.004
30	0.9855	0.046	0.9797	0.030
31	0.9854	0.053	0.9722	0.032
32	0.9853	0.002	0.9719	0.001
33	0.9852	0.014	0.9713	0.0142
34	0.9851	0.015	0.9709	0.0130
35	0.9850	0.029	0.9702	0.0197
36	0.9849	0.008	0.9668	0.0086
37	0.9845	3.601	0.9621	2.011
38	0.9842	3.011	0.9588	2.769
39	1.000	10.408	1.000	8.920
40	0.9958	11.247	0.9997	9.217
41	0.9943	6.324	0.9997	4.892
42	0.9792	3.940	0.9899	2.190
43	0.9616	0.231	0.9802	0.174
44	0.9511	0.018	0.9759	0.006
45	0.9264	0.007	0.9685	0.012
46	0.9247	0.013	0.9648	0.001
47	0.9239	0.0101	0.9612	0.007
48	0.9238	2.618	0.9602	2.020
49	0.9234	0.002	0.9569	0.001
50	0.9216	1.568	0.9523	1.128
51	0.9233	4.449	0.9511	0.464
52	0.9116	2.019	0.9498	0.214
53	0.9208	0.970	0.9463	0.265
54	0.9207	1.567	0.9412	1.191
55	0.9046	3.413	0.9386	3.029
56	0.9045	0.598	0.9355	0.530
57	0.8994	0.023	0.9321	0.020
58	0.8997	0.367	0.9273	0.326
59	0.8886	0.310	0.9248	0.275
60	0.8867	0.276	0.9234	0.182
61	0.8845	0.128	0.9213	0.073
62	0.8826	0.008	0.9187	0.005

The distribution line is not able to carry the power, if the Load factor value is more than 5.041, the corresponding VSI is 1.0008. In the case of 0.95 power factor lagging, the load factor value is 6.33 and the corresponding VSI is 0.9979, the distribution line withstands the stable point. When, LMF value is more than 6.34, the corresponding VSI is 1.0652. In this proposed algorithm is tested IEEE 33, IEEE 69 bus system based on the VSI index. The maximum power flow capacity of the Raccoon conductor load factor is 6.34. It maintains 0.95 lagging power factors. The connected loads for feeders are not in full load condition. Hence the total power consumption of connected loads for three feeders is 13.5 MW. This system receives voltage of 440V. The best convergence features of the proposed algorithms which are 100 iterations are used. Population size is 20, the number of generation is 50, loudness is 0.565 and pulse rate is 0.531.Again the parameters are set empirically by a trial and error method. The test system taken for the research work consists of 3 buses out of 12 buses in the distribution system. In the proposed network reconfiguration process, there are only three sectionalized switches for minimum loss when compared to the earlier configuration, which had fifteen switches for the same network. The distribution system is operated with forward backward sweep. The algorithms for load flow analysis of simulation results are given below. A comparison of real and reactive power losses is also given below. A big increase of bus voltages are hugely increased to 11.03 KV. The aim of the research is to get a reduction in the real power loss, reactive power loss, thereby improving the voltage profile and optimizing the number of switches. The power losses have been calculated for all buses and to select the appropriate buses for reactive power injection. The stability factors reflect how the feeder power losses change if more real power is injected at a particular bus and it is finds to locate reactive power injection.

Table 8: Results of the distribution system after reconfiguration

S. No	Type	Tie switches	P_{LOSS} (KW)	Min Node voltage	loss reduction %
1	Harmony search algorithm	33,3435,36, 37	182.17 (29 node)	0.9115, Node 33	31.2
2	Genetic Algorithm	33,9,34,36,2 8	139.89	0.9378 Node 33	30.6
3	Artificial immune system algorithm	7,9,1432, 37	121.1	0.9076 Node 33	17.3
4	B&B	7,9,1432,37	139.26	0.92998 Node 33	31.2
5	Selective Particle Swarm Optimization	4,8,9,11,15	192.02	0.9478 Node 32	15.46
6	Dragon fly Algorithm	11-12	138.28	0.9232	21
7	Proposed BAT Algorithm	7,9,14, 32, 37	196.41	0.9483 node 32	38.92

Table. 9 Results of the real time Indian distribution system

Type	Tie switches placed	P_{LOSS} (KW)	Q_{LOSS} (KVAr)	Min Node voltage	Power loss reduction
Proposed BA	12-32, 36-48, 38-57, 56-57. (4switches)	196.31 KW	121.85 KVAr	0.9357, Node 11 0.9278, Node 35 0.9391, Node 58	38.92 %

Distributed generations represents a change in the structure of power system, since to generate or to store the energy at small scale, it nearby load Centre. The DG are solar, wind, biogas, diesel and Shunt capacitors are placed whenever the shortage or insufficient reactive power and prepared in discrete in sizes and normally an integer multiply of the smallest capacitor size for improvement of stability of systems. The most minimum annual cost was found to install the 14 numbers of 1000 KW each one.

$$Q^{c}_{\max} = L * Q^{c}_{o} \tag{16}$$

Q^{c}_{o} is the size of smallest reactive power source in KVAr and L is an integer. The available reactive power source sizes are tabulated 10, 11, and 12 for the systems. The proposed Bat Algorithm has been implemented and provides the better results in 62 buses of Indian system before and after reconfiguration, when compared with the IEEE 33 bus. The results are superior to those from the older reconfiguration. Active power losses reduced from 36.64 KW to 31.09 KW. In this condition, all the operating bus voltages show drastic increase from 10.34 KV to 11.59 KV. The voltage profile and loss reduction in respective cases have been compared. The voltage levels have increased from 9.9 KV to 11.59 KV at the tail end of the distribution systems after the reconfiguration. Real and reactive losses have also decreased. The latest versions of electrical power system software’s MATLAB-14, MIPOWER were used for determining the load flow parameters to optimize switching schemes for minimize the losses. The results show the power loss of the 62 bus as 36.48KW.With the network reconfiguration the power loss can be minimized from 36.64 KW to 31.09KW. Approximately 5.5 KW can be saved by network reconfiguration for 62 bus radial distribution system. The energy saving is may amount up to Rs 0.78 lakhs per month. This is the best method for using soft computing.

Table. 10 Q power injected to IEEE 33 bus system

S No	Q source	Rating KVAr	Bus node	Min Node voltage
		Before Reconfiguration		
1	DG 1	0.2364	Node 32	0.9438
2	DG 2	1.1652	Node 31	0.9319
		After Reconfiguration		
3	DG1	0.1556	Node 32	0.9522
4	DG2	0.9762	Node 31	0.9443

Table. 11 Q power injected to IEEE 69 Bus system

S No	Q source	Rating KVAr	Bus node	Min Node voltage
		Before Reconfiguration		
1	DG 1	0.7546	Node 45	0.9123
2	DG 2	0.8754	Node 46	0.9348
3	DG 3	0.2793	Node 71	0.9452
		After Reconfiguration		
4	DG 1	0.5432	Node 45	0.9201
5	DG 2	1.2786	Node 46	0.9431
6	DG 3	0.1972	Node 71	0.9612

Table. 12 Results of the real time Indian distribution system

S No	Q source	Rating KVAr	Bus node	Min Node voltage
		Before Reconfiguration		
1	DG 1	0.7546	Node 11	0.9156
2	DG 2	0.8754	Node 34	0.9048
3	DG 3	0.2793	Node 58	0.9182
		After Reconfiguration		
4	DG 1	0.5432	Node 11	0.9357
5	DG 2	1.2786	Node 34	0.9278
6	DG 3	0.1972	Node 58	0.9391

V. CONCLUSION

In this research paper, a radial distribution system with minimum power loss is achieved using the network reconfiguration and the BAT Algorithm. In the proposed method, some constraints parameters are calculated from branch exchange method followed by forward backward sweep algorithm. These are branch voltages, current flow of the branches, the maximum apparent and reactive power flow and maintain the radial structure. These parameters have independent mutation for each dimension to match the decimal cyclic encoding methodology fed into the Indian distribution system of 62 buses. It has been tested and compared with IEEE 33 and IEEE 69 bus. The simulation results of the proposed method demonstrate quick convergence, simplicity, efficiency, reduced complexity with the adjustment of the order of the branch nodes while running the algorithm and performing the problem of part of branch current reversed after the reconfiguration. Hence, the power losses suffered are minimized with improved voltage flow in the branches. Hence, the proposed method is superior to the other soft computing techniques. Future research work in the reconfiguration of radial distribution system could be taken-up one by simplifying MATLAB coding without any hurdles using a different soft computing technique within a few seconds and using a different power flow equation and suitable application of restructured power management to eliminate the voltage stability and also to suggest the valuable appropriate devices for improving the voltage stability in the real time distribution systems. In future, a different power flow equation can be obtained from different soft computing techniques to reconstruct the power management topology introduced in the reconfiguration of the radial distribution system thereby improves the voltage stability in the real-time distributed systems.

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