A Novel Technique and New Stability Indicator Implemented to Reduce The Power Losses with Optimal Placement of DG Source and Conductor strength in Radial Distribution System

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Introduction

Abstract: In this paper, an efficient BAT optimization algorithm (BA) is proposed for distribution system using automatic sectionalizing switching operation in the large scale distribution systems. A novel "Distributed power flow analysis" has been derived for finding the electrical quantities using the branch exchange method by a forward backward sweep algorithm and to improve the voltage stability. Network reconfiguration attempts to determine a better solution in the manner of a greatest-descent algorithm, but it cannot give any guarantee for the convergence property. Numerical examples demonstrated through IEEE 33 bus and IEEE 69 bus system. The validity and effectiveness of the proposed methodology have been tested in TNEB 33 KV, 62 bus real time distribution systems. The test results are minimizing the real power losses, minimizing the deviation of node voltages, minimizing the branch currents, minimizing the switching operations and included Distribution generations reveal that the proposed method yields optimal reconfiguration and optimal conductor strength with reduced computational burden. The result of the proposed method provides a powerful optimization solution. The algorithm is to avoid escape from local minima by accepting improvements in cost, but the use of this algorithm is also responsible for an excessive computation time.

Keywords : Distribution systems , Reconfiguration , Loss minimization , BAT algorithm, Fitness , Cost function, conductor capacity.

I. INTRODUCTION

Now a day's increase in electrical energy demand requires more attention to the power flow capacity of distribution systems. But the erection of new substations and construct the new lines are constrained by environmental concerns and increasing costs. 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 leads to a voltage collapse.

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. 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 or tie switches, with some uniform and non-uniform tapings. 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, P_L, Q_L, V, δ in all the buses and finding the active power losses and reactive power losses of the distribution lines.

A distribution generation (DG) uses distributed generation units (DGU) which generates electrical power from a nearby energy sources on the type of availability like the solar cells or concentrators, wind turbine, etc. which reduces strain on the main transmission line, increases reliability, reduces cost of power generation and saves non-renewable power resources. 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 mentioned 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 described 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 showed 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 implemented 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 suggested 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 offered considered only IEEE cases, while the objective function is based on differences in voltages. Loads are lumped cases, regular energy is not properly calculated [10].This paper has been 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 anticipated a load flow analysis of combined Matrix and FBSA (Forward Backwards Sweep Algorithm), 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 presented power loss calculation from 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 recommended 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 ratio 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 anticipated 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 (Supervisory Control and Data Aquestation) system is entirely different from the reconfiguration family [20]. The paper has been offered which was based on only the power loss sensitivity. Voltage sensitivity is also one of the main parameters for calculating the capacitor placements [21].

II. NOVEL VOLTAGE STABILITY INDICATOR

The conventional load flow methods Gauss-Seidal, Newton-Raphson, and Fast decoupled methods 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 indicator is applied to the system for identification of stability of the each lines or branch of distribution lines which have many chances of voltage collapse [1,2]. The voltage stability at each branch is calculated using the stability indicator . The node has a low value of VSI (Voltage Stability Indicator), 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.

$$VSI = 4*((P_i * r_{ij} - Q_i * x_{ij}) + (P_j^2 - Q_j^2)(r_{ij}^2 - x_{ij}^2)) \qquad (1)$$

III. 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:

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

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*. $r_{i,j+1}$ and $x_{i,j+1}$ 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 expressV_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

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

The total system power loss P_{LOSS}, Q_{LOSS},is the sum of power losses of all the feeders in the system. The total power of the system is calculated by the addition of losses in all the sections. It is given by

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

3.1 Objective Function

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

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

The mathematical model has the following constraints.

3.2 Constraints:

3.2.1 Power Flow Limitation

$$P_{\max} \geq P_i \geq P_{\min} \tag{6}$$

Pi is the power flow of the each lines, voltage magnitude of the bus *i*, $P\min$ and $P\min$ are the maximum, minimum power flow of the each bus *i*.

3.2.2Voltage limitation

$$V_{\max} \geq V_i \geq V_{\min} \tag{7}$$

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

3.2.3 Branch apparent power flow constraints

$$S_{\max} \geq S_i, S_{\min} \leq S_i \tag{8}$$

are the maximum power flow and apparent power flows of the branch i.

3.2.4Branch current limits

$$I_{\max} \geq I_i, I_{\min} \leq I_i \tag{9}$$

3.2.5 The reconfiguration system must be radial in structure.

The proposed solution algorithm contains the following switching operational sequences.

(i) The sectionalizing switch to be opened.

(ii) If the radial structure is violated after closing a switch, this switch cannot be selected as a backup switch.

(iii) 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.

IV. BAT ALGORITHM (BA)

BAT Algorithm is a population based evolutionary optimization problem. 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,Vi generating pulse with the frequency f_{min}, 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]relaying 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.

4.1Initialization 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.

4.2 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

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

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

$$x_i^t = x_i^{t-1} + v_i^t \tag{12}$$

Where $\beta \in [0,1]$ is a random vector drawn from a uniform distribution. x^* is 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.

$$x_{new} = x_{old} + \varepsilon A^t \tag{13}$$

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.

4.3 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

$$A_i^{i+1} = \alpha A_i^t \tag{14}$$

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

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.

V. IEEE 33BUS SYSTEM.

The standard IEEE 33 bus has 5 tie line switches,3.715MVA, 2.300 MVAr 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.

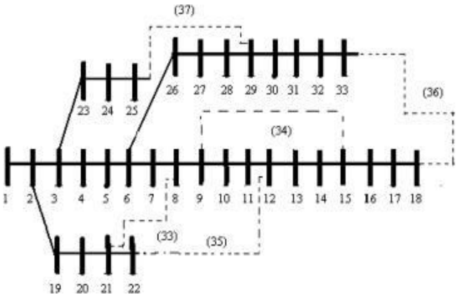

Fig 1.Single line diagram of IEEE 33 bus system.

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

Sn	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 results are compared with so many types procedure is repeated by closing other tie switches also. Radially is checked at every stage. The results for final reconfiguration are tabulated.

Table2: Comparison of IEEE 33 bus results

s No	Type	Tie switches	P LOSS (KW)	Min Node voltage
1	HAS [13]	7,10,14, 36,37.	142.72 29 node	0.9115, Node 33
2	GA [7]	9,28,33, 34,36.	139.89	0.9378 Node 33
3	AI A [15]	7,9,14, 32, 37.	121.1	0.9076 Node 33
4	SPSO [12]	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	Before		After	
	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.

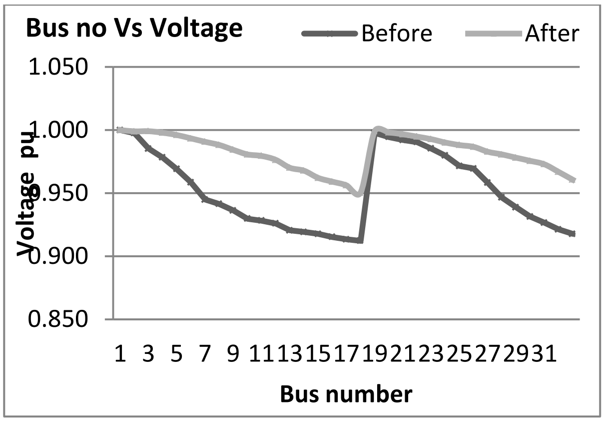

Fig 2 Bus voltage with bus number

VI. IEEE 69 BUS SYSTEM

The standard IEEE 69 bus network contains7 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 190.64KVAr respectively. The optimal reconfiguration of the systems are achieved from active losses 224.996 KW to190.64 KW while reactive power losses from 103.27KVArto 89.56KVAr. Based on the simulation results the maximum voltage deviations are identified.

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

The procedure is repeated by closing other tie switches also. It has been checked radials at every stage.

Table5:
Comparison of IEEE 69 bus results

S no	Type	Tie switches	P_{LOSS} (KW)	Min Node voltage
1	HAS [13]	s69,s18, s13,s45, s50.	106.23	0.9502 Node 45
2	GA [7]	s69,s70, s14,s46, s50	98.2521	0.9482 Node 46
3	AISA 15]	s69,s70, s14,s45, s50	99.0012	0.9482 Node 45
4	SPSO [12]	s69,s70,s14,s45, s52	99.670	0.9478 Node 45
5	Proposed BAT Algorithm	s69,s70s71,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

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.

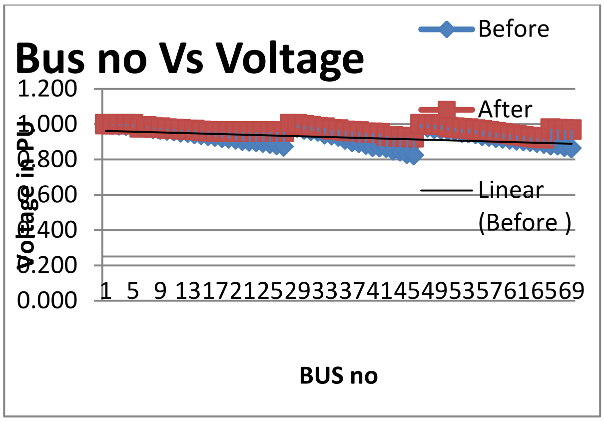

Fig 3 Bus Voltages and Bus numbers

VII. INDIAN REAL TIME SYSTEM

Vellore distribution circle is the largest load center in Tamilnadu, India. The various load centers are Bagaveli, Poondi, Sumaithangi are 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 79 bus system.

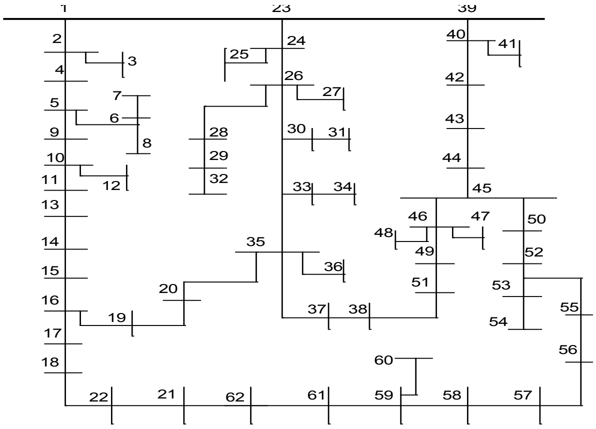

Fig 4 Single line diagrams of three substations with 62 buses.

The maximum voltage deviations have been identified has the bases of the results of simulation.

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

S no	Before Voltage (pu)	P loss (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

VIII. SIMULATION RESULTS

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 [23].

Table 8:
Results of the distribution system after reconfiguration.

S no	Type	Tie switches	P_{LOSS} (KW)	Min Node voltage	loss reduction%
1	HAS [13]	33,34 35,36, 37	182.17 (29 node)	0.9115, Node 33	31.2
2	GA [7]	33,9,34,36,28	139.89	0.9378 Node 33	30.6
3	AISA [15]	7,9,14 32, 37	121.1	0.9076 Node 33	17.3
4	B&B [11]	7,9,14 32, 37	139.26	0.92998 Node 33	31.2
5	SPSO [12]	4,8,9, 11,15	192.02	0.9478 Node 32	15.46
6	DFA [17]	11-12	138.28	0.9232	21
7	Proposed BAT Algorithm	7,9,14 , 32, 37	196.41	0.9483 node 32	38.92

. 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.

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. (4 switches)	196.31 KW	121.85 KVAr	0.9357, Node 11 0.9278, Node 35 0.9391, Node 58	38.92 %

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.

IX. COST FUNCTION

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 [23] at a particular bus and it is finds to locate reactive power injection. The DG (Distribution generation) are solar, wind, biogas, diesel and Shunt capacitors are placed [24] 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.

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

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

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

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 10,11,12 for the systems[25].

Table 12:
Results of the real time Indian distribution system

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

X. CONDUCTOR SIZING:

The Raccoon (manufacturer name) type of conductor is utilized for calculation which isthe size of conductor 7/4.09 mm, maximum continous current rating is 270 A at for temperature rise of an ambient of 40°C,resistance of the line is 0.39Ω/km, reactance is 0.29 Ω/km. Based on the result implemeted new stability Indicator the apparent power flow 0.8 power factor lagging of the line LMF is 4.145 times, VSI is 0.9995 of base power. Upto LMF 4.145 system is stable, if more than 0.001 time (LMF is 4.146 times, VSI is 1.005) the distribution line is not able to carry the power, In 0.9 power factor lagging of the line LMF is 5.04 VSI 0.9990 times of base power the transmission line transfers the power from sending end to receiving end.If LMF is more than 5.041 times, VSI is 1.0008,the line is not able to carry the power, In 0.95 power factor lagging the LMF is 6.33 and VSI is 0.9979 the distribution line is withstanding the stable point if LMF is more than6.34,VSI is 1.0652, the system will not be stable, the line is not able to carry the power. The system will lead to unstability and all the constriants are changed its original conditions. Thedistribution lineis not able to carry thepower and the system will lead to unstability

The outcomes of the BEAVER type of conductor is used for calculation inwhich the size of conductor is 7/3.99 mm, maximum continous current rating is 260 A at for temperature rise of an ambient of 40°C,resistance of the line is 0.42Ω/km, reactance is 0.3Ω/km, based on the result the apparent power flow is 0.8 power factor lagging LMF is 3.78 and VSI is0.9983. Upto the limit system will stable if more than LMF is 3.781and VSI is 1.0750, the distribution line not able to carry the power, In 0.9 power factor lagging the LMF is 4.56 and VSI is 0.9981, the distribution line is holding the power from sending end to receiving end if more than LMF 4.561 and VSI is 1.1870,in this point the system will not be stable, the line is not able to carry the power, In 0.95 power factor lagging the LMF is 5.58 and VSI is 0.9985.If more than LMF is 5.581 and VSI is 1.5023, the system will not be stable, the line is not able to carry the power, the system will lead to unstability and all the constants change its original conditions. The transmission line is unable to carry the power and the system will results in unstability.

The results for Rabbit types of conductor is utilized for calculationwhich is the size of conductor is 7/3.55 mm, maximum continous current rating is 220 A at for temperature rise of an ambient of 40°C,resistance of the line is 0.587Ω/km, reactance is 0.333 Ω/km, based on the result the apparent power flow 0.8 power factor lagging LMF is 3.90,VSI is 0.9986 times of base power. Upto the limit system will stable if more than LMF is 3.901,VSI is 1.02310 times the transmission line is not able to carry the power, In 0.9 power factor lagging the LMF is 4.55,VSI 0.9981 is times of base power.If more than LMF is 4.551,VSI is 1.3812 , the system will not be stable,, In 0.95 power factor lagging the LMF is 5.37,VSI is0.9982 times of base power the distribution line is withstanding the stable point if more than 5.371,VSI is 1.6290, the system will not be stable, the line is not able to carrythe power, The system will lead to unstability and all the constants are changed its original conditions. The transmission line is not able to carry the power.

The above results for WEASEL types of conductor is utilized for calculationwhich issize of conductor is 7/2.59 mm, maximum continous current rating is 170 A at for temperature rise of an ambient of 40°C,resistance of the line is 0.985Ω/km, reactance is 0.341 Ω/km, based on the result the apparent power flow 0.8 power factor lagging LMF is 2.11,VSI is 0.9998 times of base power.Upto the limit system will stable if more than LMF 2.12,VSI is 1.4210 times the dsitribution line is not able to carry the power, In 0.9 power factor lagging theLMF is 2.37,VSI is 0.9971 times of base power the distribution line is withstanding the stable point if more than LMF is 2.38,

Table 13. Conductor strength based on the New stability Indicator

RACCOON				BEAVER				RABBITTE				WEASEL			
LMF	VSI 0.85 pf	VSI 0.9 pf	VSI 0.95 pf	LMF	VSI 0.85 pf	VSI 0.9 pf	VSI 0.95 pf	LMF	VSI 0.85 pf	VSI 0.9 pf	VSI 0.95 pf	LMF	VSI 0.85 pf	VSI 0.9 pf	VSI 0.95 pf
1.0	0.2180	0.1750	0.1360	1.0	0.2376	0.1926	0.1545	1.0	0.2255	0.1904	0.1601	1.0	0.4311	0.3798	0.3337
1.5	0.3326	0.2668	0.2071	1.5	0.3635	0.2944	0.2357	1.5	0.3517	0.2897	0.2445	1.5	0.6348	0.2897	0.2445
2.0	0.4508	0.3615	0.2802	2.0	0.4943	0.3990	0.3196	2.0	0.4721	0.3971	0.3319	2.0	0.9393	0.8193	0.7107
2.5	0.5728	0.4591	0.3553	2.5	0.6297	0.5092	0.4062	2.5	0.6102	0.6264	0.4223	**2.11**	**0.9998**	**0.8951**	0.8249
3.0	0.6984	0.5595	0.4324	3.0	0.7700	0.6221	0.4954	3.0	*0.7397*	0.6701	0.5156	2.37		**0.9971**	0.9371
3.5	0.8277	0.6628	0.5116	3.5	0.9150	0.7387	0.5874	3.5	0.8463	0.6940	0.6119	**2.68**			**0.9917**
4.0	0.9608	0.7690	0.5928	**3.78**	**0.9983**	0.7953	0.6319	**3.90**	**0.9986**	0.8334	0.7045				
4.145	**0.9995**	0.7875	0.6081	4.0		0.8590	0.6820	4.0		0.8595	0.7111				
4.5		0.8780	0.6760	4.5		0.9830	0.7792	4.50		0.9421	0.8133				
5.0		0.9899	0.7612	4.56		**0.9981**	0.7827	**4.55**		**0.9981**	0.8920				
5.04		0.9990	0.7748	5.0			0.8792	5.0			0.9185				
5.041		**1.0008**	0.7802	5.5			0.9818	**5.37**			**0.9982**				
5.5			0.8485	**5.58**			**0.9985**								
6.0			0.9378												
6.33			0.9979												
6.34			**1.0652**												

VSI is 1.2165, the system will not be stable, the line is not able to carry the power, In 0.95 power factor lagging the LMF is 2.68,VSI is 0.9917 times of base power. if more than LMF is2.69 ,VSI is1.0265 the system will not be stable, the line is not able to carry the power, the system will lead to unstability and all the constants are changed its original conditions. The transmission line is not able to carry the power and the system will lead to unstability. The objective of loss minimization reduces the active power loss in power system by network reconfiguration method. The algorithm for network reconfiguration for minimizing the losses and maximizing the power flow proved by results.

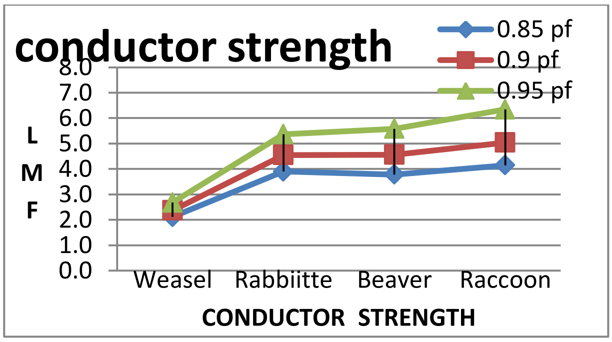

Fig 5. Proposed LMF, VSI for all conductors using new stability Indicator.

It shows the indicator would be ideally stable when VSI is 0 to 1, when VSI is more than 1 and less than 0 the system is unstable. The above data indicates that system is stable , when Raccoon conductor at 0.95 pf lagging of LMF is 6.34 , Beaver conductor at 0.95 pf lag of LMF is 5.58 ,Rabbit conductor at 0.95 pf lag of LMF is 5.37and Weasel conductor at 0.95 pf lag is 2.68 times. The capacity of apparent power flow is depend on the resistance and reactance, losses of the line. But practically cost of the line is depending upon the distance. The distribution line apparent power flow is depend upon the resistance and inductance, length, area of the cross section of the lines. Based on the above results a new voltage stability indicator VSI is effectively identifies the load multiplication of the each conductor. The point of breaking of line and stability point are easily dentified through the indicators. Network reconfiguration gives minimum power loss and stability indicator gives voltage stability point of any distribution lines.

XI. RESULTS AND DISCUSSION

The proposed Bat Algorithm has been implemented and provides the better results in 62 bus 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-16, 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 as36.48KW.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. An exhaustive technique is used for determining pre-reconfiguration to post-reconfiguration of the optimal switching configuration and loss minimization on the basis of BAT Algorithm.

XII. CONCLUSION

The minimum power loss has been achieved in the real time system of 62 bus system using a BAT algorithm with the help of distributed power flow analysis using branch exchange method followed by forward backward sweep algorithm. 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 proves a 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 agonized are the minimum with increased voltage flow in all 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.

References

[1] Baron. ME and Wu FF, "Network reconfiguration in distribution system for loss reduction and load balancing index" IEEE transactions on power delivery,vol4,pp-1401-1407,April 1989.

[2] Askarim.R(2015) "A new optimization frame work to solve the optimal feeder reconfiguration and capacitor placements" International Journal of scientific and technology research. Vol4 .pp 207-214.

[3] Ali.I, Thomas,M. S.,&Kumar,P(2015). Energy efficient reconfiguration for practical load combinations indistribution systems. IET Generation, Transmission& Distribution, 9(11), 1051-1060.

[4] Chidanandappa(2015)"GA based network reconfiguration in distribution systems with multiple A three phase load flow algorithm for distribution systems for time varying loads " Elsevier procedia technology SMART grid technologies.

[5] Ganesh,"Network reconfiguration distribution systems using Artificial Bee colony algorithm,"International journalof Electrical,computer,energeticand communication engineering ",vol 8 pp.396-402, 2014.

[6] H.H.Goh,"Evaluation for voltage stability indices in power system using ANN, "Elsevier Procedia engineering ,vol 118, pp1127-1136, 2015.

[7] Kumar,P.,Ali,I.,Thomas,M,&Singh,S.(2017). Imposing voltage security and network radially for reconfiguration of distribution systems using efficient heuristic and meta-heuristic approach. IET Generation, Transmission & Distribution.11(10), 2457 – 2467.

[8] B.Seyedi,H.Mohammadiivatloo,B,Zare,K.&Shargh,S(2017).Reconfiguration of distrib ution networks considering coordi-nation of the protective devices.IET Generation, Transmission & Distribution,11(1), 82-92.

[9] Kumar,P.&Singh,S.(2015).Reconfiguration of radial distribution system with static load models for loss minimization. IEEE PEDES.

[10]Like.Y,(2017)." A Network Reconfiguration method of data uncertainty in small radial distribution system. "Journal of Energies "vol10 .

[11]Maya.K.(2015) "A three phase load flow algorithm for distribution systems for distributed generator models "Elsevier procedia technology. Vol21.pp 126-135.

[12]Priyeshkumar(2016)"NetworkReconfigurationof radial distribution system using Particle swarm optimization techniques"International journal of Engineering and computational" vol 5 issue 8 August 2016.

[13]PremdeepReddy.K,(2017)."NetworkReconfiguration of radial distribution system using harmony search algorithm " Journal of Electrical engineering " vol 12 issue.

[14]Sureshkumar & Vijayakumar, "Distribution network reconfiguration for loss minimization using differential evolution algorithm, " APRN journal of engineering and applied sciences, vol 10,pp. 2861-2866 April 2015.

[15]Taher,S.A.(2014) "optimal reconfiguration and DG allocation of balanced and unbalanced radial distribution system " AIMS shams Engineering Journal no 5 pp735-749.

[16]Tung.T.T.(2016)."Aradial distribution system using one rank cuckoo search algorithm" International journal of T.T. Trans .D.N l" vol 10 .

[17]VaraprasadT (2014) "soft computing based enhancement of transmission lines "Journal of Engineering research and applications. Vol 4 .pp 508-512.

[18]Ravindra .M (2017)" An upgraded binary bat algorithm approach for optimal allocation of PMUs in power system with complete observability", International journal of Advanced and Applied Sciences " Vol 4(10), pp 33-39.

[19]Amon.D.A.(2015)" A modified bat algorithm for power loss reduction in electrical distribution systems", TELKOMNI KA,Indonesian journal of electrical engineering " Vol14, pp55-61.

[20]Kanwar .N (2015)" Multi objective optimal DG allocation in distribution networks using bat algorithm"SASEC, International journal of solar power energy conversion ," Vol87, pp176-182.

[21]Yang.X.(2015)" BAT algorithm review and applications" International journal of computation and Nano science" Vol5, pp 141-149.

[22] Abdelazz.M (2017). Distribution network reconfiguration using Genetic Algorithm by Variying Population size . Electric Power systems Research 142 9-11.

[23] Alonso FR, OliveriaD Q And Souza ACz (2015). Artificial Immune system optimization approach for multi objective distribution system reconfiguration . IEEE Transactions On power systems 30(2, 840-847.

[24]Badran O, MokhilsH Mekhliefgs S Dhalan W, jallad J (2018). Minimum switching losses for solving distribution NR problem with distributed generations IET generations , transmission and distribution .

[25]Yahyoui, Hiba, krischen, saussen (2018) GPU – based power flow method and a multi objective power optimization model for reconfiguration problem in radial distribution networks . International journal of Energy optimization and engineering.