Hindawi
Journal of Electrical and Computer Engineering
Volume 2022, Article ID 9016554, 8 pages
https://doi.org/10.1155/2022/9016554

Research Article

Minimizing the Active Power Losses and Retaining the Voltage Profile of the Distribution System Using Soft Computing Techniques with DG Source

P. Sundararaman,[1] **E. Mohan**,[2] **S. V. Aswin Kumer**,[3] **Sridhar Udayakumar**,[4] **and Abdissa Fekadu Moti**[4]

[1]*Department of EECE, GITAM University, Bangalore, India*
[2]*Department of Computer Science and Engineering, Lord Venkateswara Engineering College, Chennai, India*
[3]*Department of Electronics and Communication Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, AP, India*
[4]*Department of Information Technology, Mettu University, Mettu, Ethiopia*

Correspondence should be addressed to Abdissa Fekadu Moti; abdisafekadu@meu.edu.et

Received 25 May 2022; Revised 18 October 2022; Accepted 11 November 2022; Published 13 December 2022

Academic Editor: Antonio Bracale

The motivation of this research is to curtail the active power losses in the radial distribution system. This paper proposes a novel voltage stability indicator to determine the optimum conductor sizes for various distribution lines and find the conductor stability limit. This work proposes a new BAT algorithm for finding the optimal switching configurations using reconfiguration, which is used to minimize the active power losses. The proposed BAT algorithm gives the optimal locations to place the required amount of DG sources to improve the stability and minimize the power losses and maintain the voltage profile of the systems. The proposed BAT algorithm has been executed with the MATLAB 2016 software and compared with the differential evolution technique for IEEE 33 bus, IEEE 69 bus, and Indian real time 62 bus systems. The test results are applied on different conductors, and the real power flow on the different conductors are mapped in the proposed method using the novel voltage stability indicator. The radial distribution system has lower power losses, best voltage profile, cost of saving the DG source, optimal placing of a suitable rating of the DG source, optimal location of the DG source, and cost of saving the DG source which were achieved in this work. In this research, the distributed load flow analysis is implemented to find the parameters by the forward-backward sweep algorithm. The minimum bus voltage 0.95 pu is virtual in all the conductors. The loss reduction in the DE for IEEE 33 bus has been reduced from 42.4% to 45.3% and the loss reduction in IEEE 69 bus from 36.2% to 38.8% and the real time 62 bus from 47.5% to 49.15%. The loss reduction in the BAT algorithm for IEEE 33 bus has been reduced from 38.46% to 45.3% and the loss reduction in IEEE 69 bus is from 32.2% to 38.8%. The Indian standard real time 62 bus has been reduced from 38.92% to 49.15%. The proposed results are compared with the DE and BAT algorithm. The proposed BAT algorithm is found to be more effectual in reducing voltage deviation (VD) and reducing the power losses in the system.

1. Introduction

In today's situations, the usage of electrical power has suddenly increased. The power system operation is very critical to operate. The power system is a very huge network for generation, transmission, and distribution to provide electricity to tail end consumers. Many components are interlinked from generation to consumer end. Each and every component has high cost, depending upon its size and operation. At present, the increase in electrical energy demand wants more priority given to the power distribution. However, the construction of new substations, new transmission systems, and construction of the new lines are major problems due to environmental issues and increasing costs.

Nearly 30% to 37% of the supply has been lost including the components [1]. The power losses in the distribution systems are due to improper conductors, aged instruments, and improper operation of the systems.

2. Novel Voltage Stability Indicator

The assumptions made on the balanced three-phase line diagram are converted into a single-phase single line diagram in a radial distribution system. This single line diagram is used to find the real and reactive power flow, the real and reactive power losses, the bus voltages, and the angle of buses using the forward-backward sweep algorithm with a branch exchange method using a novel voltage stability indicator [2]. Normally, this branch exchange method is one of the greater methods to calculate the power flow and power losses of the entire network. Figure 1 shows the expressions of the two-bus system [3]. The line joins buses "i" and "j" and is demonstrated as a single line diagram. Current flows and voltage drop across the buses are easily found using recursive equations [4] with two assumptions: sending end voltage angle is zero, and the other is receiving end voltage angle δ [5].

Let it be assumed that bus "i" is a slack bus; then, the current I_{ij} is found by

$$I_{ij} = \frac{V_i\angle 0 - V_j\angle\delta}{r_{ij} + jx_{ij}}. \quad (1)$$

The current flow equation is derived from active and reactive power flows as given below [6].

$$S_j = V_j * I_{ij}^*,$$
$$I_{ij}^* = \left[\frac{S_j}{V_j}\right]. \quad (2)$$

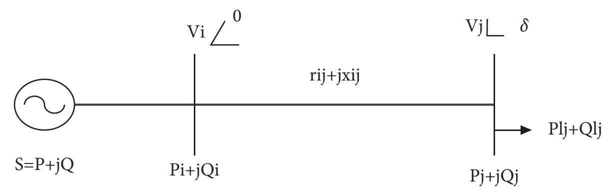

Figure 1: Single line diagram of the two-bus system for VSI.

By using the receiving end powers, the current flow I_{ij} is

$$\frac{P_j - Q_j}{V_j^*\angle - \delta} = I_{ij}^*. \quad (3)$$

The abovementioned equations are current flow equations. These equations are used to calculate the apparent [7], active, and reactive power flows and power losses using the forward-backward sweep algorithm [8].

"k" is the line number of the buses between "i" and "j."

$$P_l^k = \left|I_{ij}^2\right| * r_{ij},$$
$$Q_l^k = \left|I_{ij}^2\right| * x_{ij}. \quad (4)$$

The transmission line losses have been calculated from the power equations (9):

$$P_l = \left|I_{ij}^2\right| * r_{\mathrm{ij}} = \frac{P_i^2 + Q_i^2}{V_i^2} * r_{ij},$$
$$Q_l = \left|I_{ij}^2\right| * x_{\mathrm{ij}} = \frac{P_i^2 + Q_i^2}{V_i^2} * x_{ij}. \quad (5)$$

The complex equations have been modified [10].

$$\left\{\left(p_j + jQ_j\right)\left(r_{ij} + jx_{ij}\right) = \left(p_i + jQ_i\right)\left(r_{ij} + jx_{ij}\right) - I_{ij}^2\left(r_{ij} + jx_{ij}\right)\left(r_{ij} + jx_{ij}\right)\right\}. \quad (6)$$

The real and imaginary parts are separated and gives

$$\left(P_j r_{ij} - Q_j x_{ij}\right) = \left(P_i r_{ij} - Q_i x_{ij}\right) + I_{ij}^2\left(r_{ij}^2 - x_{ij}^2\right). \quad (7)$$

Shortening the quadratic equation (11), the real roots found the constancy of the system.

$$V_j = \frac{1 \pm \sqrt{\left(1 - 4\left(\left(p_i r_{ij} - Q_i x_{ij}\right) + t\left(p_j^2 - Q_j^2\right) n\left(r_{ij}^2 - x_{ij}^2\right) q r_{ij} h P_{L+} x P_i^2 7 r_{ij}^2 C+; Q_i^2 r_{ij}^2\right)\right)}}{2}. \quad (8)$$

The positive values are always assumed in the right-side quadratic term and compared with the minimum value of the remaining equation as [12].

$$1 - 4 * \left(\left(P_i r_{ij} - Q_i x_{ij}\right) + \left(P_j^2 - Q_j^2\right)\left(r_{ij}^2 - x_{ij}^2\right)\right) \geq 0. \quad (9)$$

The value of $\Delta = \sqrt{(b^2 - 4ac)}$ is differentiated to zero; the inner term is always zero of $\sqrt{(b^2 - 4ac)}$.

V_j lies from zero to one, and it yields multiple indicators due to the real roots limitation. If the constraint lies below one and above zero [13], the system stability is determined. The system stability depends upon the real roots of the equations. Any system, if the power losses are increased, then the system will be unstable [14]. The system line losses are curtailed if the value of stability lies between zero and one.

The novel voltage stability indicator equation has been presented as

$$4 * \left(\left(p_i r_{ij} - Q_i x_{ij}\right) + \left(P_j^2 - Q_j^2\right)\left(r_{ij}^2 - x_{ij}^2\right)\right) = 1. \quad (10)$$

In this equation, the insufficient [15] of reactive power flow has been given below

$$\mathrm{VSI} = 4 * \left(\left(P_i r_{\mathrm{ij}} - Q_i x_{\mathrm{ij}}\right) + \left(P_j^2 - Q_j^2\right)\left(r_{\mathrm{ij}}^2 - x_{\mathrm{ij}}^2\right)\right) = 1\,. \quad (11)$$

In this research, the novel VSI has been derived and found the breaking point very clearly. The VSI value has been found and placed from zero to 1, so the system is pure stable [16]; otherwise, the system has been found unstable. If there is any sudden changes in the lines or sudden increase in the load, the VSI value increased more than one or decreased less than zero. The novel VSI is the best tool for determining the system conditions.

2.1. Soft Computing Techniques. Now, soft computing techniques are the greatest tool in the intelligence exposed by machines and softwares. The intelligent techniques are talented to think, reason, invent the meaning, simplify, extricate, learn from past familiarity, and correct their mistakes. Soft computing techniques are the cleverness of a proposed machine or computer which can achieve any rational assignment which a mortal being can achieve. The conventional techniques [17] are implemented in the area of analysis, design, and control of power systems. The conventional techniques are difficult and more complicated.

The soft computing techniques are more critical to understand, intricate, flexible, and large amounts of statistics are used in the calculation for finding the faults and learning. The raise in the processing speed and computational time and accurate results are due to wide and vast system data management. The recent power system operations are near to the boundaries due to the sudden increasing energy consumption [18] and existing electrical transmission systems. This condition involves a less predictable power system operation, control, and design, which is probable only by constantly checking the system conditions in a much more detailed manner than required conditions [19]. Now, so many computer tools are available to solve difficult problems like power system planning, design, operation, analysis, and controls. Among these computer tools, soft computing techniques have been growing in the recent years and have been applied to power systems. Recent techniques are differential evolution and the BAT algorithm [20]A, which have been applied in this research to curtail the power losses.

3. Differential Evolution

Differential evolution has been planned over 1994–1996 by Storm and Price at Berkeley as a new stochastic direct search optimization method. Several techniques have been used to reconfigure the systems to minimize the power losses. The soft computing techniques, artificial intelligence techniques, Genetic algorithms, Artificial Neural Network, Artificial Bee Colony, Particle Swarm Optimization, ant colony algorithms, fuzzy logic, Cuckoo Crunch algorithm, Harmony Search algorithm, CAT algorithm, and Grey Wolf algorithm are used for optimizing the power losses. Differential evolution is a proficient investigative process for search and optimization techniques. The differential evolution technique is a great tool, which is capable of handling non-differentiable and difficult optimization on large problems. DE is a real mutation method to ensure diversity and objective function directly. The standard DE is a group of characteristics for retention of the optimal result and information allocation within the population with a faster convergence rate because of one-to-one competition among the adequate issues with the consequential parent. The main advantages of differential evolution include parallel processing in nature, current global optimization proficiency, self-referential mutation operations, actual on integer, dissertate, and mixed constraint optimization. The main advantages of differential evolutions are the ability to handle nondifferentiable, noisily, time dependable autonomous function; tasks on flat surfaces; capacity to send many solutions in a single route and operative in nonlinear optimization problems with penalty problems; well-organized algorithm without sorting matrix multiplications; and fast and simple for applications and modifications [21]. The algorithm is similar to the principles with genetic algorithms, including four basic evolutionary steps of initialization, mutation, crossover, and selection. Standard differential evolution utilizes a random path to mutate individuals that may point to the capable area during the evolutionary process.

3.1. Initialization. The first stage is to develop a random initial population in "D" dimension and suppose "n" dimension with decision space; so, the individual "i" of differential evolution can be exemplified as follows [22]

$$X_{ij,1} = X_{ij}^2 + \mathrm{rand}\left(X_{ij}^U - X_{ij}^L\right), \quad i = 1, 2, \ldots, N_p \& j = 1, 2, \ldots, D. \quad (12)$$

XU/ij and XL/ij are the upper and lower limits of j^{th} variable in the population. The above equation is the initial equation of the problem.

3.2. Mutation. The generation evolutionary target vector is $X_{i,G}$,, $i = 1, 2, \ldots, N_p$; then, the mutation operations are as follows

$$V_{i,G+1} = X_{r1,G} + FX\left(X_{r2,G} - X_{r3,G}\right). \quad (13)$$

The above equation is the mutation of the function. F is the scaling factor, always more than 1 that controls the strait of direction. $(X_{r2,G} - X_{r3,G})$ procedures a path that is the starting point of differential evolution and a reason for direction-based search. $r1, r2, r3 \in [1, N_p]$ are the three cooperatively different numbers and also different from the successively index "i". F is one of the main limits of differential evolution given as [0, 2].

3.3. Crossover. Increasing the diversity of the population, crossover equation is given below:

$$U_{ij,G+1} = \left\{ \begin{array}{ll} V_{ij,G+1}, \text{if}\,(\text{randb}\,(j) \leq CR) & \text{on } j = rnbr\,(i) \\ X_{ij,G}, \text{if}\,(\text{randb}\,(j) \geq CR) & \text{on } j \neq rnbr\,(i) \end{array} \right\}. \tag{14}$$

The above equations are the crossover of the function, where r and b (j) variable denotes an equally distributed random fraction with [0, 1] and also used to state limit governing the effect of crossover, r and j are randomly selected indexes to confirm that at least any one of the variables should be altered, and CR is a user-defined limit supervising the effect of crossover within the limit of b (0, 1). $U_{ij,G+1}$ is not a duplicate of $X_{ij,G}$.

3.4. Selection. The fresh individual is better than the original one. The new individual has to be an offspring for the new generation, and the original one is retained as the new generation.

$$X_{i,G+1} = \begin{cases} U_{i,G}, \\ X_{i,G}, \\ \text{if } f\left(X_{i,G}\right) > f\left(U_{i,G}\right), \\ \text{otherwise.} \end{cases} \tag{15}$$

The above equation is new individual of the function. The target vector $U_{I,\ G}$ competes with X_i is called target vector survival of the succeeding generation. Mutation, crossover, and selection have been carried out for Np individuals in one generation. $f\,(U_{i,G})$ is the suitability task. If the objective function value of the trail vector is better than the value of the individual vector, the trail vector will be selected as the new individual vector $X_{i,G}$ of the next generation [17]. The single vector $X_{i,G}$ is kept as the individual, and the vector $X_{i,G+1}$ is the succeeding generation. The optimization loop of DE tracks iteratively until the stop conditions are met.

4. BAT Algorithm

The BAT algorithm is one of the soft computing techniques for optimizing the power losses and improve the stability of the system. It is a population-based evolutionary optimization problem [23] based on the voice or echolocation actions of natural bats in detecting their prey or food. Normally, bats emit sound called echolocation that they use to find the food or prey in and around them and detect their way even in full darkness. Bats are eye-catching animals, which have wings and advanced echolocation capability to detect their prey or food.

(1) Individual bat employs the echolocation practice to sense the distance, and they also recognize the difference between food/prey and background sprints in some mystic way using echolocation.

(2) Each bat fly in the direction of xi flies randomly with the velocity Vi producing pulse with wavelength λ, frequency fmn, and loudness $A0$ to try to catch the prey.

(3) It is an ability to control the emitted pulse and adjust the rate of the emission of "r" range of [0, 1] believing the closeness of its aim.

(4) The loudness suggestions in all the ways decrease from the higher position $A0$ to lower position$A$ min.

(5) Further generating the initial accidental bat population, the objective function is calculated for all the bats, and the G best bat is stored.

4.1. Initialization of Population. Primarily, the population is the number of major bats for the BAT algorithm created randomly. Normally, the number of bats for this objective function is from 10 to 40. After succeeding to get the initial fitness of the population for an expected function, the values are based on the loudness, movement, and pulse rate.

4.2. Movement of Virtual Bats. In this BAT algorithm, the three rules for updating the positions and velocities of the virtual bats are as follows:

$$\begin{aligned} f_i &= f_{\min} + (f_{\max} - f_{\min})\beta, \\ v_i^t &= V_i^{t-1} + \left(x_i^{t-1} - x^*\right) f_i, \\ x_i^t &= x_i^{t-1} + v_i^t, \end{aligned} \tag{16}$$

where $\beta, \in [0,\ 1]$ is a random vector drawn from an even distribution and x^*[24] is the present total best solution among all the entire bats. New solution for all the bats using random march is given below.

$$x_{\text{new}} = x_{\text{old}} + \varepsilon\, A^t, \tag{17}$$

where "ε" is the topping factor in the range of [−1, 1]. Though $A^t = |(A_i^t)|$ is e loudness of all the bats at this time step.

4.3. Loudness Values and Amount of Pulse Production. The volume and the pulse emission rates of each bat are updated with iteration using the dealings. The pulse rate is inversely proportional to loudness.

$$\begin{aligned} A_i^{i+1} &= \alpha A_i^t, \\ r_i^{t+1} &= r_i^0\,[1 - \exp(-\gamma * \text{Iter})], \end{aligned} \tag{18}$$

where α is a constant value. Iter is the number of iterations during the optimization processes and generally taken as 0.9. For any rate of $0 < \alpha < 1$, $\gamma > 0$, we have $A_i^t \longrightarrow 0,\ r_i^t \longrightarrow 0,\ as\, t \longrightarrow \infty$. The initial value of loudness A_0 can be in the range of [0, 1]. While emission rate r_i can be in the range of [0, 1], loudness and pulse rates are self-adjustable. DE and BAT algorithms can be used for designing the physical components of the power systems. It can be used to raise the efficiency of the apparatuses used in the power systems. DE and BAT algorithms can be abundantly used to grow a stable, accurate, and ambiguity-free output. The computer programs have executed the operations of the

Table 1: Technical specification of different types of conductors.

S. no.	Name of the conductor	Size (mm)	Size (inch)	Copper area (sq. mm)	R (Ω/km)	X_L (Ω/km)	Current capacity
1	RACOON	7/4.09	7/0.161	48	0.395	0.29	200
2	BEAVER	7/3.99	7/0.157	45	0.42	0.3	189
3	WEASEL	7/2.59	7/0.102	20	0.587	0.333	100
4	RABBIT	7/3.35	7/0.132	30	0.685	0.347	148

Table 2: Simplified results of the conductor strength.

S.No.	RACCON		BEAVER		WEASEL		RABBIT	
	LMF	VSI	LMF	VSI	LMF	VSI	LMF	VSI
0.85 pf	4.145	0.9995	3.78	0.9983	3.90	0.9986	2.11	0.9998
0.9 pf	5.040	0.9999	4.56	0.9981	4.55	0.9981	2.37	0.9977
0.95 pf	6.3339	0.9997	5.58	0.9985	5.37	0.9982	2.68	0.9919

power system better than manually done [25]. Modifications are easily possible even after designing the computer programs. Any values coding has been modified and estimated virtually for improving the system stability. It is eternal and consistent, and it can be easily accepted for paper works. Some refining steps have been taken for a stable and acceptable system. Suppose the optimal conductor of RACCOON is used for power transmission.

5. Identify Optimum Location Using BAT Algorithms

A distribution system has many transmission lines for power transmission from one transformer to another transformer and transformer to the consumer extremity end. The name of the lines is called by animal names (manufacturer name) such as mole, squirrel, saber, weasel, dog, wolf, panther, zebra, beaver, leopard, lion, tiger, bear, goat, sheep, and camel [26]. Table 1 shows the technical specifications and parameters of the different lines. There are four conductors taken for this research such as raccoon, beaver, weasel, and rabbit. All the transmission lines are stranded, twisted, and aluminum conductor steel reinforced (ACSR) [27]. Tables 2–6 show the stability point of different conductors. The different power factors have been implemented to calculate the stability point in the Raccoon conductor in the distribution systems as shown in Table 3. The apparent power of the transmission line is gradually increased, and at a particular point, the conductor reaches the instability limit; in this instability limit, the conductor may lose the stranded, or produce sparks or short circuit between the conductors. Using the novel voltage stability indicator equation, applying apparent power LMF (load multiplication factor) gradually increased the load from 1.0 pu. The value of voltage stability indicator (VSI) is obtained. If the VSI lies between 0 and 1, the system will be in stable condition and the power flow is easy. If the VSI lies between less than 0 and more than 1, the system will lead to instability. So, the transmission line creates problems of either losing the stranded or short circuits happen. Based on the VSI equation, stability limits of all four conductors have been found correctly and also implemented in the electricity board in real time. In any distribution system, the active power flow mainly depends on the load angle and the reactive power flow depends on the voltages of the buses.

Table 3: Results of stability point of the RACCON conductor.

LMF	RACCON		
		VSI	
	0.85 pf	0.9 pf	0.95 pf
1.0	0.2181	0.1751	0.1361
1.5	0.3325	0.2669	0.2072
2.0	0.4507	0.3614	0.2803
2.5	0.5729	0.4592	0.3554
3.0	0.6983	0.5596	0.4325
3.5	0.8278	0.6627	0.5115
4.0	0.9609	0.7691	0.5927
4.145	0.9996	0.7876	0.6082
4.5		0.8781	0.6761
5.0		0.9890	0.7613
5.04		0.9991	0.7749
5.041		1.0007	0.7803
5.5			0.8486
6.0			0.9379
6.33			0.9975
6.34			1.0651

6. Reactive Power and Voltage Control

Reactive power control can enhance the power system's voltage profile. Reactive power only control and enhance the power system's stability, and the voltage stability is an insufficient reactive power flow or excess reactive power flow of the distribution systems. In this research, the voltage level of the test system decreased below the determined level on the buses node 11, node 34, and node 58 as shown in Table 7. Before reconfiguration, the node voltages are below the stability value, and when the reactive power injected Table 8 on the same bus is at the appropriate level, the bus voltages are improved, then the system will go to the stability limit, at the same time, active power losses will also decrease and stability will be maintained. The two soft computing

Table 4: Stability points of the BEAVER conductor.

LMF	BEAVER VSI 0.85 pf	0.9 pf	0.95 pf
1.0	0.2377	0.1927	0.1546
1.5	0.3636	0.2946	0.2358
2.0	0.4944	0.3991	0.3197
2.5	0.6298	0.5093	0.4063
3.0	0.7701	0.6222	0.4955
3.5	0.9151	0.7388	0.5875
3.78	0.9984	0.7954	0.6318
4.0		0.8591	0.6821
4.5		0.9834	0.7793
4.56		0.9982	0.7828
5.0			0.8793
5.5			0.9819
5.58			0.9988

Table 5: Stability points of the WEASEL conductor.

LMF	WEASEL VSI 0.85 pf	0.9 pf	0.95 pf
1.0	0.2256	0.1905	0.1601
1.5	0.3516	0.2898	0.2445
2.0	0.4722	0.3972	0.3319
2.5	0.6103	0.6265	0.4223
3.0	0.7398	0.6702	0.5156
3.5	0.8464	0.6941	0.6119
3.78	0.9989	0.8335	0.7045
3.90	0.2256	0.8596	0.7111
4.5		0.9422	0.8133
4.54		0.9983	0.8920
4.55		0.1905	0.9185
5.2			0.9982
5.37			0.1601

Table 6: Stability points of the RABBIT conductor.

LMF	RABBIT VSI 0.85 pf	0.9 pf	0.95 pf
1.0	0.4313	0.3799	0.3337
1.5	0.63486	0.2899	0.2446
2.0	0.9394	0.8195	0.7107
2.11	0.9999	0.8953	0.8248
2.37		0.9977	0.9374
2.68			0.9919

Table 7: Results of power losses of Indian 62 bus systems using the BAT algorithm.

Type	Tie switches placed	P_{LOSS} (kW)	Q_{LOSS} (KVAr)	Min node voltage	Power loss reduction
Proposed BA	12–32, 36–48, 38–57 (3 switches)	63.44 kW	42.58 KVAr	0.9357, node 11. 0.9278, node 35. 0.9391, node 58.	38.92%

techniques DE and BAT have been applied for network reconfiguration and placing the reactive power injected in the instability buses are shown in Table 9 The voltage abnormality and supervisory variables are converted into DE and BAT algorithm symbolizations to construct the affairs between voltage deviation and the governing ability of the

Table 8: Switch position for test 62 bus systems for VSI.

S. no.	Tie switch closed	Sectionalizing switches opened	P loss (kW)	Q loss (KVAr)
1	12–32, 32–35, 34–45	13–14, 29–28, 44–45	128.15	99.032
2	51–54, 37–62, 19–22	53–54, 14–15, 61–62	79.93	53.17
3	12–32, 36–48, 38–57.	15–16, 46–48, 51–38.	63.44	42.58

Table 9: Results of Q power injected to the real time 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

Table 10: Main parameters for the systems after reconfiguration.

S. no.	n	A_0	r_0	f_{min}	f_{max}
1	55	0.48	0.467	0	2.058

monitoring device. The generator excitation, transformer taps, and VAR compensators are the main control variables. DE and BAT algorithms are shaped to identify these control variables and their efforts. The calculation of the system reactive power demands and controls the strategies for setting up the reactive power control properties. The control variables are designated on the basis of local controllability towards a bus having undesirable voltage and overall controllability towards the buses having a low-voltage profile. The main parameters used for the BAT algorithm for this research are shown in Table 10.

7. Conclusion

The radial distribution system has lower power losses, best voltage profile, cost of saving the DG source, optimal placing of a suitable rating of the DG source, and optimal location of the DG source, and cost of saving the DG source have been achieved in this work. Reconfiguration of the distribution system and optimal placement of the DG source have been done in fast convergence and saving the minimum cost level. There are two works carried out in this research that, one is the reconfiguration technique to find the electrical parameters of the system and another one is applied soft computing techniques for finding the optimal location and optimal sizes of DG source. DE and BAT algorithms have been executed, compared, and implemented in IEEE 33, IEEE 69, and Indian standard test system of 62 bus using the MATLAB 2016 software. In this research, the distribution load flow analysis was performed to find the parameters by the forward-backward sweep algorithm, reduction techniques, and branch exchange methods. Two standard systems IEEE 33 and IEEE 69 results have been achieved and implemented in the real time system of 62 bus Indian standard systems. In these results, the BAT algorithm has achieved the less cost of the DG source, optimal location of the DG source, improved voltage profile,and less active power losses. The loss reduction in the DE for IEEE 33 bus has been reduced from 42.4% to 45.3%, and the loss reduction in IEEE 69 bus from 36.2% to 38.8% and the real time 62 bus from 47.5% to 49.15%.

The loss reduction in the BAT algorithm for IEEE 33 bus has been reduced from 38.46% to 45.3% and the loss reduction in IEEE 69 bus from 32.2% to 38.8% and the real time 62 bus from 38.92% to 49.15%. More numbers of research works have to be performed to achieve the power losses reduction. At last, network reconfiguration techniques using the FBS algorithm using reduction techniques has been faster than other load flow analysis. The BAT algorithm has been utilized to find optimal cost saving, optimal location finder, and suitable DG source injected compared to other soft computing techniques.

Abbreviation

ACSR: Aluminum conductor steel reinforced
DE: Differential evolution
DG: Distributed generation
LMF: Load multiplication factor
VAr: Reactive power unit
VSI: Voltage stability indicator.
VD: Voltage deviation

Data Availability

The IEEE 33 bus and IEEE 69 bus system data of this research paper have been taken for executing the program and comparing these results with soft computing techniques, and the Indian standard 62 bus test systems data were measured manually and implemented for this research. These data have not been copied from any other papers and are not implemented wrongly.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] S. Pashaei, "Network reconfiguration in distribution power systems with distributed generators for power loss minimization," in *Proceedings of the International Conference on Advances in Computer and Electrical Engineering*, pp. 17-18, Manila (Philippines), November 2012.

[2] P. Kumar, "Network reconfiguration of radial distribution system using particle swarm optimization techniques," *International Journal of Engineering and Computational*, vol. 5, no. 8, p. 1p, August 2016.

[3] C. Tzong, "Network reconfiguration of distribution systems using improved mixed integer differential evolution" 2003 evolution"," *IEEE Transactions on Power Systems*, vol. 18, pp. 1022–1027p, July 2003.

[4] Chidanandappa, *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, Netherlands, 2015.

[5] K. Y. Lie, "A network reconfiguration method of data uncertainty in small radial distribution system," *Journal of Energies*, vol. 10, p. 21p, 2017.

[6] K. Maya, *A three phase load flow algorithm for distribution systems for distributed generator models"*, vol. 21, pp. 126–135p, Elsevier Procedia Technology, Netherlands, 201.

[7] T. T. Tung, "A distribution systems network reconfiguration of radial distribution system using one rank cuckoo search algorithm," *International Journal of T.T. Trans, D.N l*, vol. 10, p. 4p, 2016.

[8] A. LikeY, "Network Reconfiguration method of data uncertainty in small radial distribution system," *Journal of Energies*, vol. 10, 2017.

[9] P. ReddyK, "Network Reconfiguration of radial distribution system using harmony search algorithm," *Journal of Electrical engineering" vol*, vol. 12, 2017.

[10] S. kumar and V. kumar, "Distribution network reconfiguration for loss minimization using differential evolution algorithm," *APRN journal of engineering and applied sciences*, vol. 10, pp. 2861–2866, April 2015.

[11] S. A. Taher and M. H Karimi, "Optimal reconfiguration and DG allocation in balanced and unbalanced distribution systems," *Ain Shams Engineering Journal*, vol. 5, no. 3, pp. 735–749, 2014.

[12] T. TungT, "Aradial distribution system using one rank cuckoo search algorithm," *International journal of T.T. Trans, D.N l*, vol. 10, 2016.

[13] VaraprasadT, "Soft computing based enhancement of transmission lines," *Journal of Engineering research and applications*, vol. 4, pp. 508–512, 2014.

[14] M. Ravindra and R. S. Rao, "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, no. 10, pp. 33–39, 2017.

[15] A. AmonD, "A modified bat algorithm for power loss reduction in electrical distribution systems", TELKOMNI KA," *Indonesian journal of electrical engineering*, vol. 14, pp. 55–61, 2015.

[16] N. Kanwar, "Multi objective optimal DG allocation in distribution networks using bat algorithm," *SASEC, International journal of solar power energy conversion*, vol. 87, pp. 176–182, 2015.

[17] X. S. Yang and X He, "Bat algorithm: literature review and applications," *International Journal of Bio-Inspired Computation*, vol. 5, no. 3, pp. 141–149, 2013.

[18] M. Abdelaziz, "Distribution network reconfiguration using a genetic algorithm with varying population size," *Electric Power Systems Research*, vol. 142, pp. 9–11, 2017.

[19] F. R. Alonso, D. Q. Oliveira, and A. C. Zambroni de Souza, "Artificial immune systems optimization approach for m distribution system reconfiguration," *IEEE Transactions on Power Systems*, vol. 30, no. 2, pp. 840–847, 2015.

[20] O. Badran, S. MokhilsH Mekhliefgs, HalanW, and J. Jallad, "Minimum Switching Losses for Solving Distribution NR Problem with Distributed Generations"," *IET Generations transmission and distribution*, vol. 12, no. 8, 2018.

[21] A. Sinha and D. Hazarika, "A comparative study of voltage stability indices in a power system," *International Journal of Electrical Power & Energy Systems*, vol. 22, no. 8, pp. 589–596, 2000.

[22] M. Ismail and T. K. Rahman, "Estimation of maximum load ability in power systems by using fast voltage stability index (FVSI)," *Journal of Power and Engineering Systems*, vol. 25, pp. 181–189, 2005.

[23] Y. Kataoka, M. Watanabe, S. Sakaeda, and S. Iwamoto, "Voltage stability preventive control using VMPI sensitivities," *Electrical Engineering in Japan*, vol. 173, no. 4, pp. 28–37, 2010.

[24] M. M. Hamada, M. A. A. Wahab, and N. G. A. Hemdan, "Simple and efficient method for steady-state voltage stability assessment of radial distribution systems," *Electric Power Systems Research*, vol. 80, no. 2, pp. 152–160, 2010.

[25] H. Musa, B. Usman, and S. S. Adamu, "Improvement of Voltage Stability index Using Distributed Generation for Northern Nigeria Sub Transmission Region," in *Proceedings of the Computing Electrical and Electronics Engineering (ICCEEE)*, Khartoum, Sudan, Augest 2013.

[26] X. Zhang and C. K. Wong, "Comparison of Voltage Stability Indexes Considering Dynamic Load," in *Proceedings of the IEEE Electrical Power and Energy Conference*, Winnipeg, MB, Canada, October 2011.

[27] H. Musa and S. S. Adamu, "Enhanced PSO Based Multi Objective Distributed Generation Placement and Sizing for Power Loss Reduction and Voltage Stability index Improvement," in *Proceedings of the 2013 IEEE Energytech*, pp. 1–6, IEEE, Cleveland, OH, USA, May 2013.