



Optimal Reconfiguration of 8A & B 11kV C-2 Maitama Feeder for Power Loss Reduction and Improved Reliability

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ABSTRACT

Technical losses have been the major problem in radial distribution system. As such, a distribution network reconfiguration based on Bat Algorithm for real power loss reduction and improved reliability is proposed in this paper. A reconfiguration model based on Bat Algorithm is used to determine the optimal position of the sectionalized and tie switches that will reduce the active power loss and improve reliability. The proposed method is implemented on standard IEEE 33 Bus distribution test system and applied on 11kV 8A & B C-22 Maitama Injection Substation feeder in Federal Capital Territory (FCT), Abuja Nigeria. In IEEE 33 bus distribution test system, the optimal location of the tie switches was found to be (5), (11), (22), (31), and (35), a power loss of 74.82kW was obtained which gives about 63.93% power loss reduction. 1.1408, 0.3145 and 0.3772 was obtained for SAIDI, SAIFI and ENS respectively. In 11kV 8A & B C-2 Maitama Injection Substation feeder, a power loss of 0.4465kW was obtained which gives about 75.58% power loss reduction while 0.9328, 0.00007924 and 0.4043 was recorded for SAIDI, SAIFI and ENS respectively which is about 42.79% for reliability improvement with respect to SAIFI. The optimal locations of tie switches were found to be positions (8-9) and (16-24).

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INTRODUCTION

Distribution network reconfiguration (DNR) is a network altering process performed by power utilities of distribution networks for a number of purposes. This is achieved by modifying the connection status of distribution network branches by switching on/off normally closed/open switches in the system such that an optimal network topology achieved, which gives the best performance with respect to some specified objectives (Tuladhar *et al.*, 2016). Distribution systems operate in radial configuration with many switches located along the network at strategic points. The switches are sectionalized and tie switches. Sectionalizing switches are the protective devices that operate in conjunction with backup circuit breakers or reclosers (Gonen, 1986). In general, power systems in steady state analysis are operated with balanced three-phase generation and

likewise the loads in the transmission lines but this is not the same with the distribution system particularly for radial distribution systems because of the single-phase, two-phase and three-phase loads. That is why that along the line in the distribution systems, about 40% of the produced electrical powers are loss as a result of low voltage and high current in the network (Reddy *et al.*, 2017). Also, high resistance to reactance ratio has contributed to more power loss and voltage drop in distribution system. But, the power loss reduction, improve voltage and reliability of the distribution systems can be achieved through many ways such as reconfiguration, load feeder balancing, capacitor placement and distributed generator but reconfiguration is the most preferred method because of its cost effective and no extra equipment required apart from the existing equipment. Distribution network reconfiguration

(DNR) is the process of varying the topological arrangement of distribution feeders in a way of changing the open/closed status of sectionalizing and tie switches while maintaining the system constraints on satisfying the operators' objectives (Nguyen & Truong, 2015).

Therefore, it has been observed that the objective of reconfiguration of the distribution network was to find out the spanning tree (radial network) from the given graph (distribution network) in a way that it must have a least active/real power loss while all the operational constraints are met (Abubakar *et al.*, 2019). Reconfiguration of distribution network was first proposed by Prasad *et al.* (2015) to minimize the losses in the feeder. They tried in formulating the problem of mixed integer using the discrete branch and bound method which a non-linear optimization problem to solve it. Other examples are these evolutionary algorithms, Genetic Algorithm (Gupta *et al.*, 2014), Particle Swarm Optimization (Dahalan & Mokhlis, 2012), Modified Honey Bee Mating Optimization (Javad *et al.*, 2012), Modified Culture Algorithm (Verma & Singh, 2018), Cuckoo Search Algorithm (Nguyen, & Truong, 2015), Artificial Bee Colony Algorithm (Dharani *et al.*, 2014), Ant Colony Optimization (Abdelaziz *et al.*, 2013) and Grey Wolf optimization (Reddy *et al.*, 2017) etc.

Mendoza *et al.* (2009) defined reliability in power system as a level of which the performance of components in a bulk system of electricity is delivered to the customers in an acceptable standard. Three reliability indices used in this paper are System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI) and Energy Not Supplied (ENS).

OPTIMIZATION TECHNIQUE

Overview of Bat Algorithm

Bat Algorithm (BA) is a population based evolutionary optimization algorithm that imitates the behavior of bat animals to take their prey as developed by Xin-She Yang in 2010 (Gandomi & Yang, 2014).

Rules of Bat Algorithm

1. All bats use echolocation to sense distance to food/prey and obstacle.

2. Bats fly randomly with velocity V_i at position X_i with a frequency f_{min} varying wavelength λ and loudness A_o to search for prey.
3. Loudness can vary from a large (positive) A_o to a minimum constant value A_{min} .

Population

Initial population is a number of bats BA (n) that are generated randomly. The numbers are in between 10 and 30.

Movement of Virtual Bats

The abovementioned rules can be translated into frequency, velocity and position of the solutions which can be calculated based on the following formulas:

$$f_i = f_{min} + (f_{max} - f_{min})\beta \quad (1)$$

$$V_i^t = V_i^{t-1} + (x_i^{t-1} - x_{gbest}^t)f_i \quad (2)$$

$$x_i^t = x_i^{t-1} + V_i^t \quad (3)$$

Where the value of β is a random number within the range of $[0, 1]$, f_i is the frequency of the i th bat that controls the range and speed of movement of the bats, V_i and x_i denote the velocity and the position of i th bat, respectively and x_{gbest}^t stands for the current global best position at time step t .

Equation (4) gives the new solution for each bat that generated locally using random walk as given below

$$X_{new} = X_{old} + \epsilon A^t \quad (4)$$

Where $\epsilon \in [-1, 1]$ is a random number, X_{old} is the solution in the current optimization solution set, and $A^t = \langle A_i^t \rangle$ is the average loudness of all the bats at time step t .

Bat Loudness and Pulse rate

The loudness of bat decreases once a bat has gotten a food while the pulse rate emission increases. When $A_{min} = 0$, it shows that the bat has just gotten a food and thereby stop emitting any sound.

$$A_i^{t+1} = \omega A_i^t \quad (5)$$

$$r_i^{t+1} = r_i^o [1 - \exp(\gamma t)] \quad (6)$$

$$A_i^t \rightarrow 0, r_i^t \rightarrow r_i^o \text{ as } t \rightarrow \infty \quad (7)$$

At the first step of algorithm, the values of these two parameters are chosen randomly, generally $A_i(0) \in [1, 2]$ and $r_i(0) \in [0, 1]$. Equation (8)

below state the new switches of sectionalized and tie switches location.

$$SWlocV_i^t = V_i^{t-1} + (SWloc_i^t - bestloc)f_i \quad (8)$$

Where $SWloc$ is the switch location for sectionalized and tie switches, β is a random number between $[0, 1]$, f_i denotes the best positions of the optimal network switches and to control the pace and range of the bat's movement, V is a current best location and f_i is given in equation (9). Then the new solution or position for the bat can be generated by the equation given below,

$$SWloc_i^t = SW_i^{t-1} + locV_i^t \quad (9)$$

REVIEW OF SIMILAR WORK

A lot of relevant literature with regards to reconfiguration of distribution feeder for loss minimization and improved reliability has been published in order to address the issue in distribution system. Gupta *et al.* (2014) proposed a distribution network reconfiguration for power quality and reliability improvement using Genetic Algorithm. The system reliability indices like SAIDI, SAIFI and ENS were used to evaluate the reliability of the distribution network. The effectiveness of the proposed algorithm was investigated on two different IEEE standard test distribution system (33 and 69) bus and the result that was obtained was compared with the existing GA based method and degree of satisfaction of Pareto optimal solution of 33 and 69 bus systems as a way of solving multi-objective reconfiguration problem of distribution systems. Sedighzadeh *et al.* (2017) presented a multi-objective framework for optimal network reconfiguration in power loss reduction and improved reliability. They used fuzzy membership to transform the objective functions into same scale and then to determine the satisfaction level of the afforded solution using fuzzy fitness. The efficiency of the proposed method was tested on IEEE 33 and 69 bus distribution test system and was implemented using MATLAB software package. A power loss 139.53kW was recorded

and the values of SAIDI, SAIFI and ENS were given as 1.6423, 1.1782 and 1.9052. Srividhya *et al.* (2020) proposed a reliability improvement of radial distribution system through feeder reconfiguration based on Binary Particle Swarm Optimization. The effectiveness of the algorithm was tested on standard IEEE 33 and 69 bus distribution test system. A power loss 150.22kW and 1.3627, 2.2584 and 0.6034 for SAIDI, SAIFI and ENS was recorded respectively.

This brief review of recent relevant literature has shown the important of reconfiguration in distribution system as it helps to reduce the active power loss and improve the reliability. The research aims to develop a reconfiguration model that will reduce the power loss and improve reliability.

MATERIALS AND METHODS

Model of Network Reconfiguration

The power loss reduction and improved reliability are the objective function for this network reconfiguration.

Real Power Loss Reduction

The minimization of the total real power arising from feeders can be calculated as follows

$$OF_1(P_{Loss}) = \sum_{i=1}^{Nbr} R_i I_i^2 \chi_i = \left(\frac{P_i^2 + Q_i^2}{V_i^2} \right) K_i \quad (10)$$

Where X is the vector of control variables

$$K_i = [Tie_1, Tie_2, \dots, Tie_{N_{ie}}, Sw_1, Sw_2, \dots, Sw_{N_{ie}}] \quad (11)$$

Where

R_i is the resistance of the i^{th} branch

Nbr is the number of the buses

K_i is the switch state of i -th branch, with 0 indicating switch open and 1 indicating switch closed

Sw is the tie switches to maintain the radial topology of the network

P_i is the active power flowing through the terminal of i^{th} branch

Q_i is the reactive power flowing through the terminal of i^{th} branch

V_i is the terminal node voltage of the i^{th} branch

Reliability Indices

I. System Average Interruption Index (SAIDI) is the average of the total duration of interruptions affecting customers during a given year.

$$OF_2(SAIDI_i) = \frac{\sum_{i=1}^{Nbr} U_i S_i}{\sum_{i=1}^{Nbr} S_i} k_i = \frac{\sum_{i=1}^{Nbr} (P_i + Q_i) r_i}{\sum_{i=1}^{Nbr} (P_i + Q_i)} K_i (\text{hours/customer}) \quad (12)$$

II. System Average Interruption Frequency Index (SAIFI) is the average number of sustained interruption duration by a customer in a specified time period.

$$OF_3(SAIFI_i) = \frac{\sum_{i=1}^{Nbr} \lambda_i S_i}{\sum_{i=1}^{Nbr} S_i} = \frac{\sum_{i=1}^{Nbr} (P_i + Q_i) \lambda_i}{\sum_{i=1}^{Nbr} (P_i + Q_i)} K_i (\text{interruption/customer}) \quad (13)$$

III. Energy Not Supplied (ENS) is expressed as given in equation (14)

$$OF_4(ENS_i) = \sum_{i=1}^{Nbr} (P_i + Q_i) U_i (\text{kWh/customer}) \quad (14)$$

$$U_i = \lambda_i r_i \quad j \in \{1, 2, \dots, N\} \quad (15)$$

U_i is the unavailability for each load point

These objectives are the function of active load demand P_i and apparent load demand Q_i of the N system load points as well as of the failure rate λ_i , repair time r_i and the unavailability U_i for each of the load point of the line. The above objectives functions are subjected to constraint that must be satisfied at same time. These constraints are given as follows;

1. Power Flow Constraint

$$P_i = P_{imax}$$

$$Q_i = Q_{imax}$$

2. Radial Network Constraint

$$\text{Min}\{SOF\} = w_1 \times OF_1 + w_2 \times OF_2 + w_3 \times OF_3 + w_4 \times OF_4 \quad (17)$$

Where,

OF_1 is given in equation (10) and OF_2 , OF_3 and OF_4 is given in equation (12), (13) and (14) respectively. w_1, w_2, w_3 and w_4 are the weighting power incorporated to assign the relative dominance to these OF_1, OF_2, OF_3 and OF_4 respectively.

Backward-Forward Sweep (BFS) Method for Power Flow Analysis

The Backward-Forward Sweep (BFS) method is based on the imperative condition that the network ought to be radial as it is the most cases in distribution systems, whereby that the replicate of current paths is possible while the topology of radial is to limit the short-circuits power and reduce the protection complexity

$$N_{Tie} = N_{br} - (N_{br} - N_{SS}) \quad 16)$$

3. No bus Isolation

Single Objective Function

The Single Objective Function (SOF) is a function which brings in all the objectives into a composite function. This composite function is all about parameters of the network to be selected which are important to the objectives. Therefore, considering the aforementioned three objectives, the Single Objective Function proposed for this research work shall be given in equations below

(Gomez-Exposito *et al.*, 2008). This method is simple in practice, start finding the line currents from backwards (from the farthest buses) up to the reference bus which may be substation and assuming that the voltages are known, then it proceeds forward using the computed currents to update the voltages (Augugliaro *et al.*, 2008 & kaur & Gill, 2017).

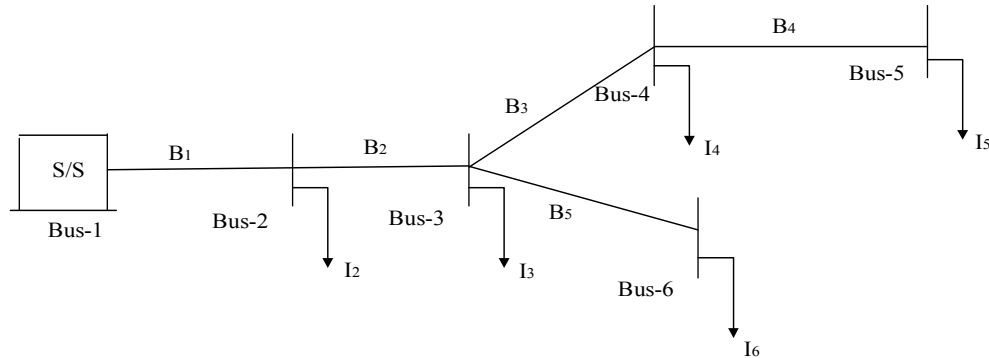


Figure 1: A simple 6-bus radial distribution network (Reddy *et al.*, 2018; Verma & Singh, 2018)

In radial distribution network, the large R/X ratio causes a major problem in convergence of conventional load flow algorithms. Assuming in a balanced RDN, the network can be represented by an equivalent single-line diagram. The injected current at buses can be calculated as given by

$$I_i = \frac{S_i}{V_{i*}} \quad (18)$$

When adopting the backward sweep using KCL for Figure 1 which is given as (Reddy *et al.*, 2017) Branch current can be written in terms of injected current is as follows (Verma and Singh, 2018).

$$\begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_2 \\ I_3 \\ I_4 \\ I_5 \\ I_6 \end{bmatrix} \quad (19)$$

But the correlation among the load current ($I_{L,n}$) and line currents ($I_{B,K}$) in Bus-injection to Branch-current (BIBC) matrix structure is given as

$$[B] = [BIBC] \cdot [I_L] \quad (20)$$

Where BIBC is an upper triangular matrix and this contains the values of 0 and 1 only.

When considering the forward sweep, KVL covers for the receiving end voltage of one branch of p,q nodes as given below is Figure 2.

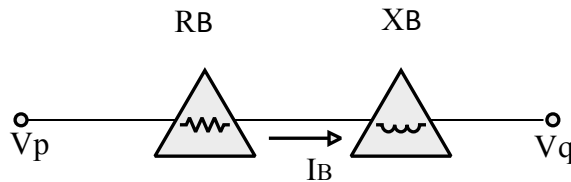


Figure 2: Representative of a branch Bus (Reddy *et al.*, 2018)

But ideally, the relationship between branch currents and bus voltages can be written as in this matrix form (Verma and Singh, 2018).

$$\begin{bmatrix} V_1 - V_2 \\ V_1 - V_3 \\ V_1 - V_4 \\ V_1 - V_5 \\ V_1 - V_6 \end{bmatrix} \begin{bmatrix} Z_{12} & 0 & 0 & 0 & 0 \\ Z_{12} & Z_{23} & 0 & 0 & 0 \\ Z_{12} & Z_{23} & Z_{34} & 0 & 0 \\ Z_{12} & Z_{23} & Z_{34} & Z_{45} & 0 \\ Z_{12} & Z_{23} & 0 & 0 & Z_{36} \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \end{bmatrix} \quad (21)$$

Therefore, the above matrix equation (20) can be rearranged and the change in voltage vector $[\Delta V]$ can be giving by (21)-(22)

$$[\Delta V] = [BCBV] \cdot [B] \quad (22)$$

Therefore, the relationship between bus current injections and bus voltage can be given by

$$[\Delta V] = [BCBV]. [BIBC]. [I_i] \quad (23)$$

$$[\Delta V] = [\Delta LF]. [I_i] \quad (24)$$

But

$$[\Delta LF] = [BCBV]. [BIBC] \quad (25)$$

Where

$[\Delta LF]$ Matrix relates the bus voltage deviations and bus current injections. The relationship between equivalent current injection (ECI) matrix at k^{th} iteration is giving by

$$[\Delta V^{K+1}] = [\Delta LF]. [I^K] \quad (26)$$

Where

$[I^K]$ is the equivalent current injection (ECI) matrix at k^{th} iteration. Therefore, the equivalent current injection (ECI) at bus $-i$ for k^{th} iteration is given as

$$I_i^K = \left(\frac{P_i + jQ_i}{V_i^K} \right)^* \quad (27)$$

Where

P_i and Q_i are the constant active and reactive power loads connected at bus $-i$. I_i^K and V_i^K are the equivalent current injection and bus voltage of i^{th} bus and for k^{th} iteration respectively.

Bat Algorithm Parameters

The parameters used in BA for simulation are as follow: dimension (D) = 5, $\alpha(A)$ & $\gamma(r)$ = 0.9, $F_{min} = 0$, $F_{max} = 2$, $iter_{max} = 100$ and population = 20.

Implementation to Solve the Optimization Problem

1. First, read the system data inputs (load data, line data and network topology)
2. Select the lower and upper bounds limit for the parameter to be tuned, determine BA setting such as frequency, pulse rates, loudness and the maximum number of iterations.
3. Generate the initial bat population randomly in the feasible range. Each bat indicates a promising optimal location of switching unit in the distribution network.
4. Evaluate the fitness function, in this step, the total active power loss and reliability indices of the objective function can be calculated by using BFS method for each solution or bat.
5. Choose the better bat in the population (minimum total active power loss and minimum values of reliability indices).
6. Update frequency, velocity, and location of bats using equation (1), (2) and (3).

7. Run the load flow and determine the total active power loss and reliability indices with the updated population using equation (10)
8. Check the stopping criterion. The stopping criterion can be the maximum number of iterations to update the Bat algorithm population or a specific value which should be reached by the objective function.
9. Choose the best compromise solution with the minimum value of active power loss and reliability indices as the objective function.
10. The best minimum objective function is compare with the base case. Power loss reduction and reliability is calculated.

Data Collected and Analysis

The following data were collected from Abuja Electricity Distribution Company (AEDC). These are as follow:

1. C-2 Maitama Injection Substation schematic diagram
2. C-2 Maitama Injection Substation 11kV feeder line and bus data

3. Failure rate and repair time of the line for 8A & B 11kV feeder from the C-2 Maitama Injection Substation.

RESULTS AND DISCUSSION

This section discusses the results obtained when the proposed algorithm is implemented on IEEE 33 bus and then applied on C-2 Maitama Injection Substation 8A & B 11kV Feeder.

The Standard IEEE 33 Bus Distribution Test System

The distribution test network has a voltage of 12.65kV and the base power of 10MVA and the load of $(47.5 + j \times 2300)$ KVA. The system consist of 33 buses, 1 main feeder, 3 lateral, 32 sectionalize switches and 5

tie switches. The system line diagram is depicted in figure 3 while the bus data is given in (Gupta *et al.*, 2014). The optimal solution of IEEE 33-bus using the developed algorithm was depicted in Table 1. The optimal location of tie switches was found on 5, 11, 22, 31 and 35 with an active power loss reduction 63.93% (74.82kW) as compare to the active power loss of (207.44kW) of the initial configuration. Figure 4 shows a plot of the active power loss as a function of number in 50 iterations. The SAIDI, SAIFI and ENS are 1.1408, 0.3145 and 0.1874 respectively as compare to the initial of 1.2463, 0.3212 and 0.3772. The computation time for the developed bat algorithm is 1.696363 seconds which is evidence that the developed algorithm has improved the network.

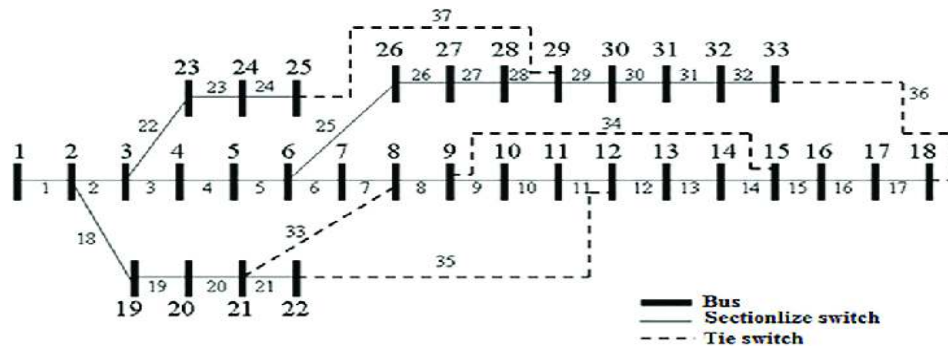


Figure 3: System Line Diagram of IEEE 33 Bus Distribution Test System

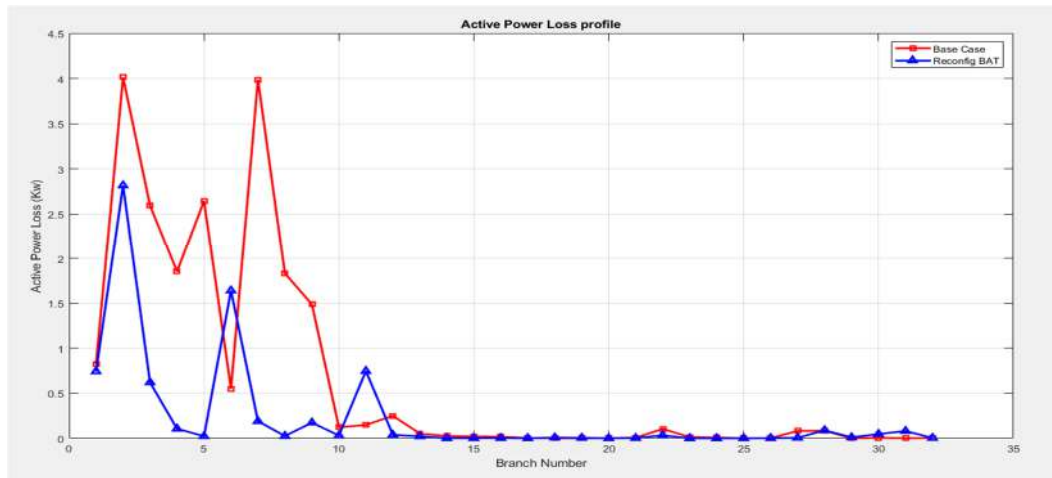


Figure 4: Power Loss Profile for 33 Bus Network

Table 1: Summary of Optimal Solution Results of 33-Bus Distribution Test Network.

33-Bus Network Status	Open Sectionizing Switches	Active Power Loss (kW)	Computation Time sec.	SAIDI (h/m/s)	SAIFI (f/yr.)	ENS (kWh)
Base Case (original configuration)		207.44		1.2463	0.3212	0.1874
Proposed Configuration	5, 11, 22, 31, 35	74.82	1.696363	1.1408	0.3145	0.3772
Reduction (%)		63.93				

8A & B 11kV Feeder

The 8A & B 11kV feeder consists of 29 buses, 28 sectionalize switches and 2 tie switches which is fed from C-2 Maitama Injection Substation. The network is a single 33/11kV injection substation which is fed from two incoming 33kV namely AT3 Maitama by-pass Katampe and AT5 central Area owned by Abuja Electricity Distribution Company (AEDC), the defunct NEPA. The total active power obtained after the reconfiguration is 0.4465kW and the total active power loss before reconfiguration was 1.8286kW. This shows that there is a power loss reduction of 75.58%. The SAIDI, SAIFI and ENS before the reconfiguration are 1.8516, 0.000138253 and 0.4043 respectively. After the

reconfiguration, the values for SAIDI, SAIFI and ENS is 0.9328, 0.00007924 and 0.2563 respectively which shows 42.79% reliability improvement in respect to SAIFI. The optimal positions for the tie switches after the reconfiguration is (8-9) and (16-24) which has changed from (11-15) and (8-16) before the network topology is reconfigured. Figure 6 shows the power loss profile for 8A & B 11kV feeder. Table 2 gives the summary of C-2 Maitama Injection Substation 11kV 8A & B feeder network performance before and after reconfiguration. The schematic diagram of 8A & B feeder is depicting on figure 5 and the bus data given Table 3.

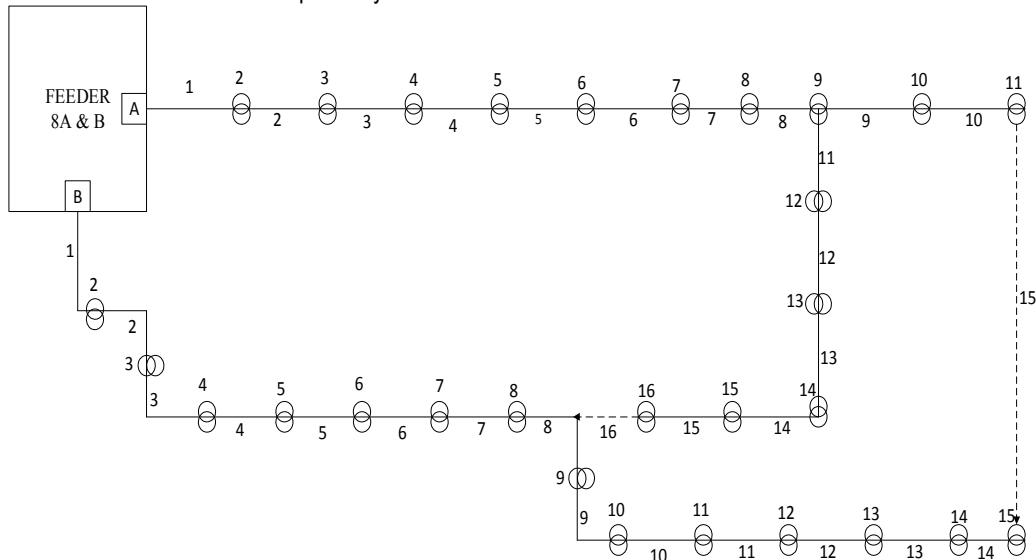


Figure 5: Single Line Diagram of 8A & B Feeder

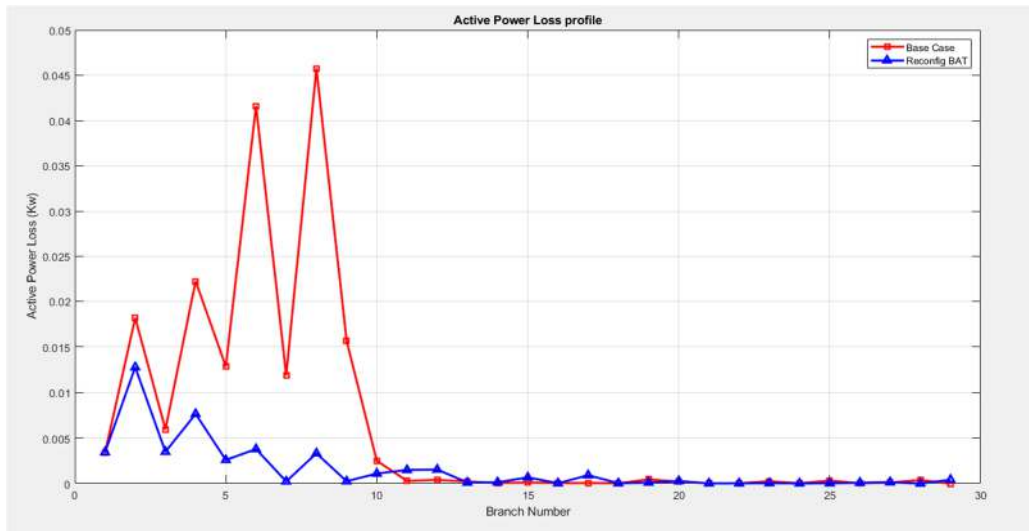


Figure 6: Power Loss Profile Before and after Reconfiguration for C-2 Maitama 11kV 8A & B Feeder.

Table 2: Summaries of the C-2 Maitama 8A & B 11kV Injection Substation Feeder Network Performance Before and After Reconfiguration.

Network Performance Description	8A & B 11kV Feeder	
	Before Reconfiguration	After Reconfiguration
Active Power Loss (kW)	1.8286	0.4465
SAIDI	1.8516	0.9328
SAIFI	0.00013853	0.00007924
ENS	0.2563	0.4043
Reduction in Power Loss (%)		75.58
Improvement in Reliability (%)		42.79
Tie Switches	(11-15) and (8-16)	(8-9) and (16-24)
Computational Time (sec)		2.077420

The reconfigured line diagram for 8A & B is shown in Figure 7 below

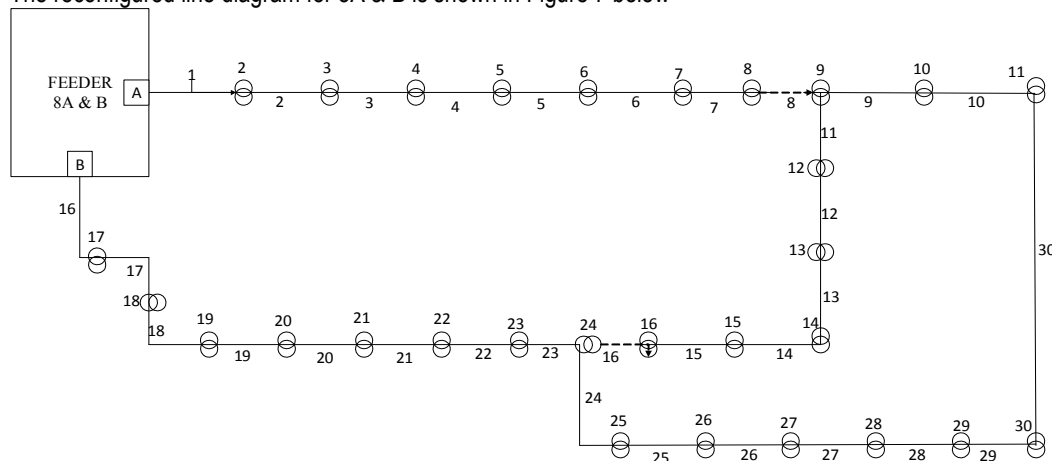


Figure 7: The Reconfigured Networks for C-2 Maitama 8A & B 11kV Feeder



CONCLUSION

A bat algorithm optimization has been presented in this paper for a radial distribution network reconfiguration problem for multi-objective function. The proposed DNR was aimed at minimizing the active power loss and improved reliability. The effectiveness of the algorithm was tested on standard IEEE 33 bus

distribution test network and applied on C-2 Maitama Injection substation 11kV 8A & B Feeder. The main advantage of this proposed algorithm is its simplicity to implement and it has a very low computational time which is very essential for a medium and large multi-scale distribution network.

Table 3: Network Data for C-2 Maitama 11kV 8A & B Feeder

Line No	From Bus	To Bus	Length (Km)	CSA (mm ²)	R(Ω) 75°C	X(Ω) 75°C	λ (F/yr.)	(r)	U_l (hr./yr.)	AOT (hr.)	XFM (KVA)	P (KW)	Q (KVAR)
												AT BUS POINT	
1	1	2	0.0027	150	0.00216734	0.06896595	0.00000	0.0000	0.0000	0.0000	1250	1000	750
2	2	3	0.1572	..	0.01319362	0.59985492	0.00036	29.2500	0.1066	29.5993	500	400	300
3	3	4	0.4139	..	0.00512492	0.10187117	0.00069	13.4754	0.0936	13.5622	500	400	300
4	4	5	0.2578	..	0.02362229	0.93970313	0.00077	11.6471	0.0901	11.7096	1250	1000	750
5	5	6	0.5190	..	0.01814412	0.75978338	0.00020	45.3000	0.0928	46.4177	800	640	480
6	6	7	0.3519	..	0.06915911	0.69657521	0.00035	31.6129	0.1116	31.8761	315	252	189
7	7	8	0.6012	..	0.02655822	0.88960365	0.00093	11.8049	0.1102	11.8495	1250	1000	750
8	8	9	0.3351	..	0.12478200	0.74968624	0.00015	32.3077	0.0478	31.8761	500	400	300
9	9	10	0.2481	..	0.09504284	0.85473204	0.00050	10.9000	0.0546	10.9204	500	400	300
10	10	11	0.3561	..	0.06843481	0.88736502	0.00043	16.8421	0.0729	16.9441	500	400	300
11	9	12	0.2187	..	0.03429807	0.90935343	0.00066	11.1724	0.0738	11.1773	750	600	450
12	12	13	0.3018	..	0.01715171	0.77981139	0.00014	61.6667	0.0842	60.1744	500	400	300
13	13	14	0.4517	..	0.04870428	0.93873739	0.00090	10.4810	0.0943	10.4736	500	400	300
14	14	15	0.4869	..	0.06823515	0.74688953	0.00058	15.2157	0.0883	15.2315	315	252	189
15	15	16	0.2685	..	0.02007210	0.70971622	0.00061	13.4810	0.0829	13.5861	500	400	300
16	1	2	0.5418	..	0.05965099	0.94812539	0.00000	0.0000	0.0000	0.0000	1250	1000	750
17	2	3	0.3481	..	0.01608326	0.63979788	0.00051	16.6222	0.0852	16.6970	500	400	300
18	3	4	0.1184	..	0.03417693	1.35957049	0.00011	32.4000	0.0369	33.5320	1000	800	600
19	4	5	0.1853	..	0.07535518	0.97709856	0.00032	31.4286	0.1001	31.3069	500	400	300
20	5	6	0.4613	..	0.09879872	0.71647735	0.00064	14.8571	0.0947	14.7996	1250	1000	750
21	6	7	0.2810	..	0.03010314	0.70936154	0.00029	38.3077	0.1134	39.0993	750	600	450
22	7	8	0.4571	..	0.03467497	0.91934631	0.00022	24.7368	0.0535	24.3210	500	400	300
23	8	9	0.4819	..	0.04290767	0.84892641	0.00081	10.8395	0.0999	12.3401	500	400	300
24	9	10	0.2958	..	0.03473481	0.78923602	0.00015	40.0000	0.0592	39.4657	1250	1000	750
25	10	11	0.6314	..	0.05573745	1.68908062	0.00026	18.7826	0.0492	18.9155	500	400	300
26	11	12	0.5240	..	0.03748009	0.76908728	0.00031	16.9630	0.0521	16.8065	1250	1000	750



27	12	13	0.7158	..	0.04922241	0.94872396	0.00089	10.8462	0.0963	10.8216	500	400	300
28	13	14	0.2891	..	0.16320348	0.81399643	0.00072	14.2000	0.1019	14.1473	750	600	450
29	14	15	0.3954	..	0.16739347	0.66938735	0.00017	64.0000	0.1092	64.2880	800	640	480
30	8	16	0.4057	..	0.04471744	0.88887589	0.00000	0.0000	0.0000	0.0000	1000		
31	11	15	0.6318	..	0.16496748	0.65968609	0.00000	0.0000	0.0000	0.0000	1250		

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