

Improving Loss Minimization in 33kv Power Distribution Network Using Optimized Genetic Algorithm

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Abstract: The epileptic power supply from the national grid due to instability is a concern to energy consumer. This instability in power supply experienced in power distribution network could be minimized by introducing Optimized Genetic Algorithm (OGA). It is achieved by characterizing 33KV distribution network, running the load flow of the characterized 33KV distribution network, determining the distribution losses from the load flow. Minimizing the determined losses in 33kv distribution network using (OGA), and designing SIMULINK model for improving loss minimization in 33kv power distribution network using OGA. Finally, validating and justifying the percentage of loss reduction in improving loss minimization in 33kv power distribution network without and with OGA. The results obtained are conventional percentage power loss in 33KV distribution network, 75%, while that when OGA is incorporated in the system is 72.9%. With these results obtained, the percentage improvement in loss reduction in 33KV distribution network when OGA is used is 2.1%. The conventional percentage of power loss in 33KV distribution network is 80%. The percentage power loss in the distribution network now is 72.9%; hence, power loss reduction in distribution network. Unmitigated power loss was 76.7% when OGA is introduced we had 74.63%. The percentage power loss in distribution network in bus 8 is 81.7% while that when OGA is applied is 79.49%. The percentage power loss in bus 9 of 33KV distribution network is 86.7%. Finally, when optimized genetic algorithm is incorporated in the system the percentage power loss in the network was reduced to 84.36%.

Keywords: Improving, Loss Minimization, Power Distribution, Optimized, Genetic Algorithm (OGA)

1. Introduction

Electricity consumers are increasing their demand for quality power supply more than what we had three years ago. It requires a modern technique to contain the situation. The growth of electricity demand is increasing rapidly which will require techniques or methods to enhance loss reduction in the distribution network. Many authors have proposed many types of ways to achieve a considerable reduction in power losses causing power outages. A closer review of known methods will be considered in the subheading below to see which of the techniques could reduce system energy loss and alleviates distribution congestion, as well as improving voltage profile a good method should be able to enhance reliability and provides lower operating cost. Distribution means the electric power from transmission being distributed

to the final consumers in a safe and reliable manner.

1.1. Aim of the Study

This paper is aimed at using Optimized Genetic Algorithm (OGA) to improve loss minimization in 33kv Power Distribution Network in southern Nigeria.

1.2. Objectives

Frequent tripping of feeders and protective devices resulting in power failure as well power losses from copper conductors had become an endemic problem, therefore, the objective of this research work was to

- i. Collect data from the characterized 33Kv line from Abakaliki to Ugep.
- ii. Use the line parameters to run the load flow of the

characterized 33kV distribution Network in order to determine the distribution losses.

- iii. Minimize the determined losses in 33kV short transmission line (50km).
- iv. Design a SIMULINK model for improving loss minimization in 33kV power distribution network using Optimized Genetic Algorithm (OGA).
- v. Validate in order to justify the percentage of loss reduction in improving loss minimization 33kV power distribution network without and with Optimized Genetic Algorithm (OGA)

2. Extent of Past Related Works

In a distribution network there is usually negative impact when Distributed generators tied to the system are wrongly placed. They can cause system surge due to reflection of mismatched impedance (Characteristic impedance). The resultant effect could lead to low power quality and reliability levels, the voltage regulation would not be effective as well [1, 2]. The sizing and placement of DG's are determined from the optimization algorithms, which are read and analysed in the literature reviewed from different angles as in the study of [3, 4] where the Kalman filter algorithm was used to reduce power losses. The authors in previous study [5] proposed a probabilistic power flow technique with embedded Genetic Algorithm to determine the problem of the total costs reduction. In that technique, the costs that has to do with the installation of DGs in a distribution system are made up of operating cost, running and investment costs. The method of Optimized Genetic Algorithm has been widely adopted to reduce transmission losses as it is simple and user friendly [6]. Local particle swarm optimization (PSO) is another useful technique but lacks the numerical accuracy since it is a population-based stochastic optimization technique [7]. We also have optimization algorithms for multi-objective as a technique which was proposed as well as pareto-front [8]. In [9], the authors talked about the use of an advanced Pareto-front non-dominated sorting multi-objective particle swarm optimization technique. The optimization problem considered two multi-objective functions; the constraints were the power loss reduction, voltage stability improvements with voltage profile and the power balance. The multi-objective performance index was discussed [10] to improve the voltage profile and minimise the system losses. In this work [11], the criss cross optimal algorithm and Monte Carlo simulation was equally presented as the desired tool to reduce the total costs and power losses. While the work by [12], the authors proposed an improved particle swarm optimization (IPSO) algorithm for reducing, electricity price, running cost and network loss. The authors [13] recommended improved analytical method to determine the optimal size of about four different DG typologies by utilizing an effective methodology. While in the study,[14], the optimum sizes and locations of DG units were determined selecting the power losses and voltage profile as

objective functions. Shunt capacitors (SCs) are not exceptions as they could be used to minimize the variability of some DGs from a reliable energy source. Adoption of Genetic Algorithm (GA) was used in the placement and sizing to improve the bus voltage magnitude and minimize power losses as was described and implemented in the ETAP software [15]. In the review [16], a Sequential quadratic programming-based algorithm combined with Genetic Algorithm was proposed for mitigating the costs, power losses and network upgrading. A load concentration factor-based on analytical technique was presented to determine the optimal solution for power loss reduction and improvement in the voltage profile [17]. In this work, a relevant technique for reducing transmission losses in a 33kV distribution network explained in details the feasibility of the method. This proposed technique/method is developed on the Optimized Genetic Algorithm (OGA) to solve the endemic problem. The main original contributions of this work depended on the ability of the technique to deal with DGs to regulate the reactive power introduced in the network by solving the Optimal power factor (PF) of DGs while taking into consideration the contribution of the SCs and other limitations on the initial maximum installed capacity of the Synchronous Generators.

3. Methodology

The collection of required data for analysis and determination of losses was the first step. It is done in this manner, characterizing 33KV distribution network, running the load flow of the characterized 33KV distribution network, determining the distribution losses from the load flow. Minimizing the determined losses in 33kv distribution network using optimized genetic algorithms, and designing SIMULINK model for improving loss minimization in 33kv power distribution network using optimized genetic algorithm. Finally, validating and justifying the percentage of loss reduction in improving loss minimization in 33kv power distribution network without and with optimized genetic algorithm.

3.1. Characterization of the 33kV Distribution System

Table 1. Data from 33kv substation Abakaliki-Ugep.

Bus No	P.u.volts Voltage	Load (MW)	Load (MVAR)	Gen (MW)	Gen (MVAR)
1	1.04	00.0	0.0	0.0	0.0
2	1.0	00.0	0.0	0.0	0.0
3	1.0	150.0	120.0	0.0	0.0
4	1.0	0.0	0.0	0.0	0.0
5	1.0	120.0	60.0	0.0	0.0
6	1.0	140.0	90.0	0.0	0.0
7	1.0	0.0	0.0	0.0	0.0
8	1.0	110.0	90.0	0.0	0.0
9	1.0	80.0	50	0.0	0.0
10	1.035	0.0	0.0	200.0	0.0
11	1.03	0.0	0.0	160.0	0.0

3.2. To Run the Load Flow of the Characterized 33KV Distribution Network

```

1  %IMPROVING LOSS MINIMIZATION IN POWER 33KV DISTRIBUTION NETWORK USING
2  %OPTIMIZED GENETIC ALGORITHMS
3  basemva = 33; accuracy = 0.0001; maxiter = 10;
4  % The impedances are expressed on a 100 MVA base.
5  % the base is mistakenly stated as 100 MVA.
6  %      Bus  Bus  |V|  Ang  ---Load---  ---Gen---  Gen Mvar Injected
7  %      No.  code p.u.  Deg  MW      Mvar  MW      Mvar  Min  Max  Mvar
8  busdata=[1  1  1.04  0  00.0  0.0  0.0  0.0  0  0  0
9            2  0  1.0  0  00.0  0.0  0.0  0.0  0  0  0
10           3  0  1.0  0  150.0 120.0  0.0  0.0  0  0  0
11           4  0  1.0  0  0.0  0.0  0.0  0.0  0  0  0
12           5  0  1.0  0  120.0 60.0  0.0  0.0  0  0  0
13           6  0  1.0  0  140.0 90.0  0.0  0.0  0  0  0
14           7  0  1.0  0  0.0  0.0  0.0  0.0  0  0  0
15           8  0  1.0  0  110.0 90.0  0.0  0.0  0  0  0
16           9  0  1.0  0  80.0  50.0  0.0  0.0  0  0  0
17          10  2  1.035 0  0.0  0.0  200.0 0.0  0  180 0
18          11  2  1.03  0  0.0  0.0  160.0 0.0  0  120 0];
19
20 %      Bus  Bus  R      X      1/2B
21 %      No.  No.  p.u.  p.u.  p.u.
22 linedata=[1  2  0.00  0.06  0.0000  1
23            2  3  0.08  0.30  0.0004  1
24            2  6  0.12  0.45  0.0005  1
25            3  4  0.10  0.40  0.0005  1
26            3  6  0.04  0.40  0.0005  1
27            4  6  0.15  0.60  0.0008  1
28            4  9  0.18  0.70  0.0009  1
29            4  10 0.00  0.08  0.0000  1
30            5  7  0.05  0.43  0.0003  1
31            6  8  0.06  0.48  0.0000  1
32            7  8  0.06  0.35  0.0004  1
28            4  9  0.18  0.70  0.0009  1
29            4  10 0.00  0.08  0.0000  1
30            5  7  0.05  0.43  0.0003  1
31            6  8  0.06  0.48  0.0000  1
32            7  8  0.06  0.35  0.0004  1
33            7  11 0.00  0.10  0.0000  1
34            8  9  0.052 0.48  0.0000  1];
35 %      Gen.  Ra  Xd'
36 gendata=[ 1  0  0.20
37           10 0  0.15
38           11 0  0.25];
39 lfybus % Forms the bus admittance matrix
40 lfnewton % Power flow solution by Newton-Raphson method
41 busout % Prints the power flow solution on the screen
42 Zbus=zbuidpi(linedata, gendata, yload)%Forms Zbus including the load
43 symfault(linedata, Zbus, V) % 3-phase fault including load current
44

```

Figure 1. Load flow analysis of the 33kV distribution network.

3.2.1. Improving Loss Minimization in Power 33kv Distribution Network Using % Optimized Genetic Algorithms

```

basemva = 33; accuracy = 0.0001; maxiter = 10;
% The impedances are expressed on a 100 MVA base.
% the base is mistakenly stated as 100 MVA.
% Bus Bus |V| Ang ---Load--- ---Gen--- Gen Mvar Injected
% No. code p.u. Deg MW Mvar MW Mvar Min Max Mvar
busdata=[1 1 1.04 0 00.0 0.0 0.0 0.0 0 0 0
2 0 1.0 0 00.0 0.0 0.0 0.0 0 0 0
3 0 1.0 0 150.0 120.0 0.0 0.0 0 0 0
4 0 1.0 0 0.0 0.0 0.0 0.0 0 0 0
5 0 1.0 0 120.0 60.0 0.0 0.0 0 0 0
6 0 1.0 0 140.0 90.0 0.0 0.0 0 0 0
7 0 1.0 0 0.0 0.0 0.0 0.0 0 0 0
8 0 1.0 0 110.0 90.0 0.0 0.0 0 0 0
9 0 1.0 0 80.0 50.0 0.0 0.0 0 0 0
10 2 1.035 0 0.0 0.0 200.0 0.0 0 180 0
11 2 1.03 0 0.0 0.0 160.0 0.0 0 120 0];

% Bus Bus R X 1/2B
% No. No. p.u. p.u. p.u.
linedata=[1 2 0.00 0.06 0.0000 1
2 3 0.08 0.30 0.0004 1
2 6 0.12 0.45 0.0005 1
3 4 0.10 0.40 0.0005 1
3 6 0.04 0.40 0.0005 1
4 6 0.15 0.60 0.0008 1
4 9 0.18 0.70 0.0009 1
4 10 0.00 0.08 0.0000 1
5 7 0.05 0.43 0.0003 1
6 8 0.06 0.48 0.0000 1
7 8 0.06 0.35 0.0004 1
7 11 0.00 0.10 0.0000 1
8 9 0.052 0.48 0.0000 1];

% Gen. Ra Xd'
gendata=[1 0 0.20
10 0 0.15
11 0 0.25];

lfybus % Forms the bus admittance matrix
lfnewton % Power flow solution by Newton-Raphson method
busout % Prints the power flow solution on the screen
Zbus=zbuildpi(linedata, gendata, yload)%Forms Zbus including the load
symfault(linedata, Zbus, V) % 3-phase fault including load current

```

3.2.2. Power Flow Solution by Newton-Raphson Method Maximum Power Mismatch=2.83789e-007 No. of Iterations=10

Bus No.	Voltage Mag.	Angle Degree	Load MW	Load Mvar	Generation MW	Generation Mvar	Injected Mvar
1	1.040	0.000	0.000	0.000	280.945	234.260	0.000
2	1.000	-2.815	0.000	0.000	0.000	0.000	0.000
3	0.865	-9.857	150.000	120.000	0.000	0.000	0.000
4	0.957	-7.229	0.000	0.000	0.000	0.000	0.000
5	0.764	-32.321	120.000	60.000	0.000	0.000	0.000
6	0.835	-12.945	140.000	90.000	0.000	0.000	0.000
7	0.911	-20.108	0.000	0.000	0.000	0.000	0.000
8	0.784	-21.606	110.000	90.000	0.000	0.000	0.000
9	0.763	-20.335	80.000	50.000	0.000	0.000	0.000
10	1.005	-4.339	0.000	0.000	200.000	204.496	0.000
11	0.980	-16.995	0.000	0.000	160.000	227.795	0.000
Total			600.000	410.000	640.945	666.550	0.000

The total power is 600MW. On the other hand the faulty buses are bus 3, 5, 6, 8 and 9 because their P.u.volts did not

fall within 0.95 to 1.05p.u. Volt. Their respective power losses are 150MW, 120MW, 140MW, 110MW and 80MW.

3.3. To determine the Distribution Losses from the Load Flow

Table 2. Showing determined distribution losses.

No of Loss Buses	P.u.volts That Attributes to the Power Losses in the Distribution Network	Distributed Power Losses (MW) in These Buses
3	0.865	150
5	0.76	120
6	0.835	140
8	0.784	110
9	0.763	80

Total power 600MW

Then, applying formula to find power loss in the buses

$$PLR_{bus} = \frac{P_{bus} - PL_{bus}^{final}}{P_{bus}} \times \frac{100}{1}$$

Where

PLR_{bus} is percentage of power loss in a given bus in distribution network

P_{bus} is total power in the distribution network bus

PL_{bus}^{final} is power loss in the bus of distribution network

To find power loss in bus 3 of distribution network

$$PLR_3 = \frac{P - PL_3^{final}}{P} \times \frac{100}{1}$$

$$PLR_3 = \frac{600 - 150}{600} \times \frac{100}{1}$$

$PLR_3 = 75\%$

To determine power loss in bus 5

$$PLR_5 = \frac{P - PL_5^{final}}{P} \times \frac{100}{1}$$

$$PLR_5 = \frac{600 - 120}{600} \times \frac{100}{1}$$

$PLR_5 = 80\%$

To determine power loss in bus 6

$$PLR_6 = \frac{P - PL_6^{final}}{P} \times \frac{100}{1}$$

$$PLR_6 = \frac{600 - 140}{600} \times \frac{100}{1}$$

$PLR_6 = 76.7\%$

To determine power loss in bus 8

$$PLR_8 = \frac{P - PL_8^{final}}{P} \times \frac{100}{1}$$

$$PLR_8 = \frac{600 - 80}{600} \times \frac{100}{1}$$

$PLR_8 = 76.7\%$

To determine power loss in bus 9

$$PLR_9 = \frac{P - PL_9^{final}}{P} \times \frac{100}{1}$$

$$PLR_8 = \frac{600-110}{600} \times \frac{100}{1}$$

$$PLR_8=81.7\%$$

To determine power loss in bus 9

$$PLR_9 = \frac{P-PL_9^{final}}{P} \times \frac{100}{1}$$

$$PLR_9 = \frac{600-80}{600} \times \frac{100}{1}$$

$$PLR_9=86.7\%$$

3.4. To minimize the Determined Losses in 33kv Distribution Network Using Optimized Genetic Algorithms

Minimize

$$P=3X1 + 0.865X2 + 150 X3$$

ST.

$$5X1 + 0.76X2 + 120X3 \leq 80$$

$$6X1 + 0.835X2 + 140X3 \leq 76.7$$

$$8X1 + 0.784X2 + 110X3 \leq 81.7$$

$$9X1 + 0.763X2 + 80X3 \leq 86.7$$

Where

X1 is no of loss buses

X2 is p.u.volts that attributes to the power losses in the distribution network.

X3 is distributed power losses (mw) in these buses

P is percentage of loss in the distribution network

```

1  %IMPROVING LOSS MINIMIZATION IN 33KV POWER DISTRIBUTION NETWORK USING OPTIMIZED GENETIC ALGORITHM
2  % Minimize
3  %P = 3X1 + 0.865X2 + 150 X3
4  %ST.
5  %5X1 + 0.76X2 + 120X3 ? 80
6  %6X1 + 0.835X2 + 140X3 ? 76.7
7  %8X1 + 0.784X2 + 110X3 ? 81.7
8  %9X1 + 0.763X2 + 80X3? 86.7
9
10 %Where
11 %X1 is no of loss buses
12 %X2 is p.u.volts that attributes to the power losses in the distribution network.
13 %X3 is distributed power losses (mw) in these buses
14 %P is percentage of loss in the distribution network
15
16 % Chromosome ( X1, X2, X3, P)
17 - f=[-3 -0.865 -150];
18 - A=[5 0.76 120;6 0.835 140;8 0.784 110;9 0.763 80];
19 - b=[80;76.7;81.7;86.7];
20 - Aeq=[0 0 0];
21 - beq=[0];
22 - LB=[0 0 0];
23 - UB=[inf inf inf];
24 - [X,FVAL,EXITFLAG]=linprog(f,A,b,Aeq,beq,LB,UB)

```

Figure 2. Optimized Genetic Algorithm Technique.

3.5. Improving Loss Minimization in 33kv Power Distribution Network Using Optimized Genetic Algorithm

% Minimize

$$\%P=3X1 + 0.865X2 + 150 X3$$

%ST.

$$\%5X1 + 0.76X2 + 120X3 \leq 80$$

$$\%6X1 + 0.835X2 + 140X3 \leq 76.7$$

$$\%8X1 + 0.784X2 + 110X3 \leq 81.7$$

$$\%9X1 + 0.763X2 + 80X3 \leq 86.7$$

%Where

%X1 is no of loss buses

%X2 is p.u.volts that attributes to the power losses in the distribution network.

%X3 is distributed power losses (mw) in these buses

%P is percentage of loss in the distribution network

% Chromosome (X1, X2, X3, P)

$$f=[-3 -0.865 -150];$$

$$A=[5 0.76 120;6 0.835 140;8 0.784 110;9 0.763 80];$$

$$b=[80;76.7;81.7;86.7];$$

$$Aeq=[0 0 0];$$

$$beq=[0];$$

$$LB=[0 0 0];$$

$$UB=[\text{inf}\text{inf}\text{inf}];$$

$$[X,FVAL,EXITFLAG]=\text{linprog}(f,A,b,Aeq,beq,LB,UB)$$

Optimization terminated.

X=

$$0.0000$$

$$0.0000$$

$$0.5479$$

FVAL=

$$-82.1786$$

EXITFLAG=

$$1$$

>>

The distributed power loss is minimized to 0.5479 or 0.55

3.6. To design a SIMULINK Model for Improving Loss Minimization in 33kv Power Distribution Network Using Optimized Genetic Algorithm

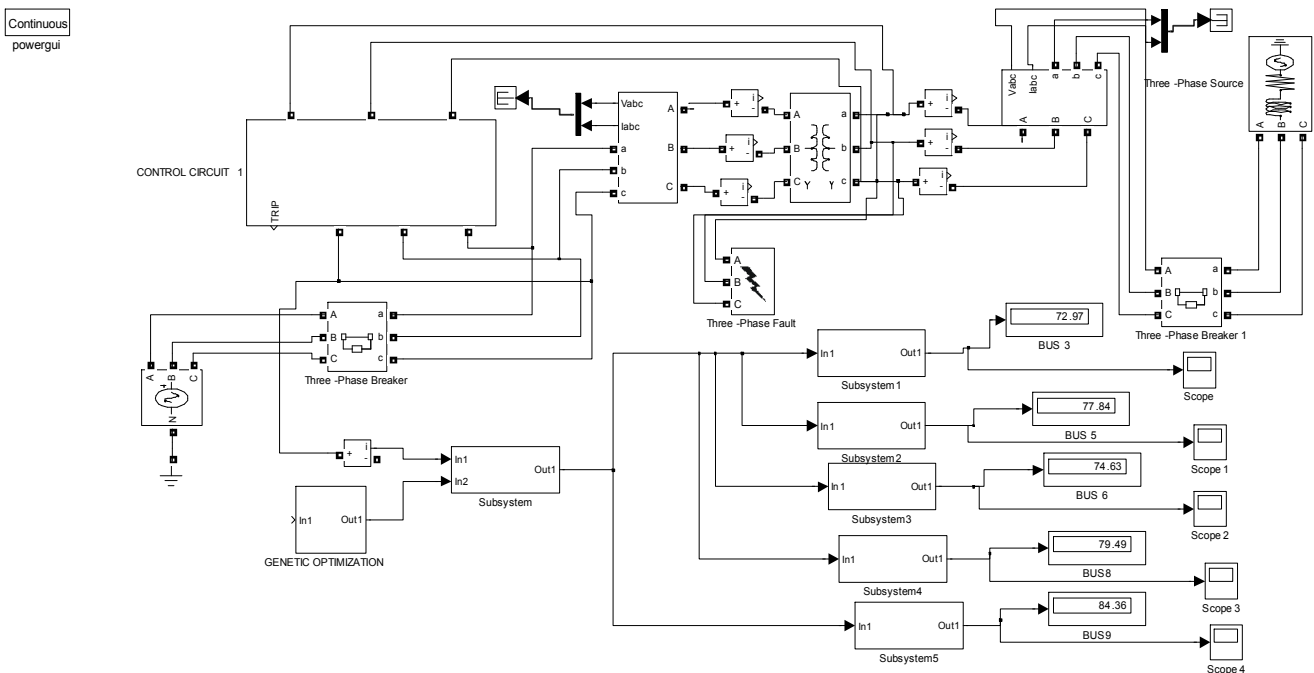


Figure 3. Designed SIMULINK model for improving loss minimization in 33kv power distribution network using optimized genetic algorithm.

4. Results and Discussion

Figure 1 is the Load flow analysis of the 33kV distribution network under consideration while Figure 2 shows the step by step technique of using Optimized Genetic Algorithm. Figure 3 depicts the designed SIMULINK model for improving loss minimization in 33kv power distribution network using optimized Genetic algorithm. Figure 4 is a comparison of percentage power loss in bus 3 of 33KV distribution network with and without Optimized genetic algorithm, Figure 5, Compares percentage power loss in bus 5 of 33KV distribution network with and without Optimized genetic algorithm Table 2 shows determined distribution losses.

The results obtained at different faulty buses in the distribution network shows that there is reduction in percentage of power losses in distribution network as detailed in figures 4 and Figure 5 respectively.

In figure 4, the Percentage power loss in bus 3 of 33kV distribution network with and without Optimized Genetic Algorithm was compared, and the result presented here showed that the conventional percentage power loss in 33KV distribution network is 75% while that when optimized genetic algorithm is incorporated in the system is 72.9%. With these results obtained, the percentage improvement in loss reduction in 33KV distribution network when optimized genetic algorithm is imbibed in the system is 2.1%.

Figure 5 shows the comparison between percentage power loss in bus 5 of 33KV distribution network with and without Optimized genetic algorithm; the result presented revealed that the conventional percentage of power loss in 33KV distribution network is 80% while the percentage power loss in the distribution network when Optimized genetic algorithm is incorporated in the system is 72.9%. This shows that there is power loss reduction in distribution network when optimized genetic algorithm is introduced in the system.

Table 3. Comparing percentage power loss in bus 3 of 33KV distribution network with and without Optimized genetic algorithm.

Time (s)	Conventional power loss in bus3 of 33kv power distribution network (%)	Optimized genetic algorithm power loss in bus3 of 33kv power distribution network (%)
0	75	72.9
1	75	72.9
2	75	72.9
3	75	72.9
4	75	72.9
10	75	72.9

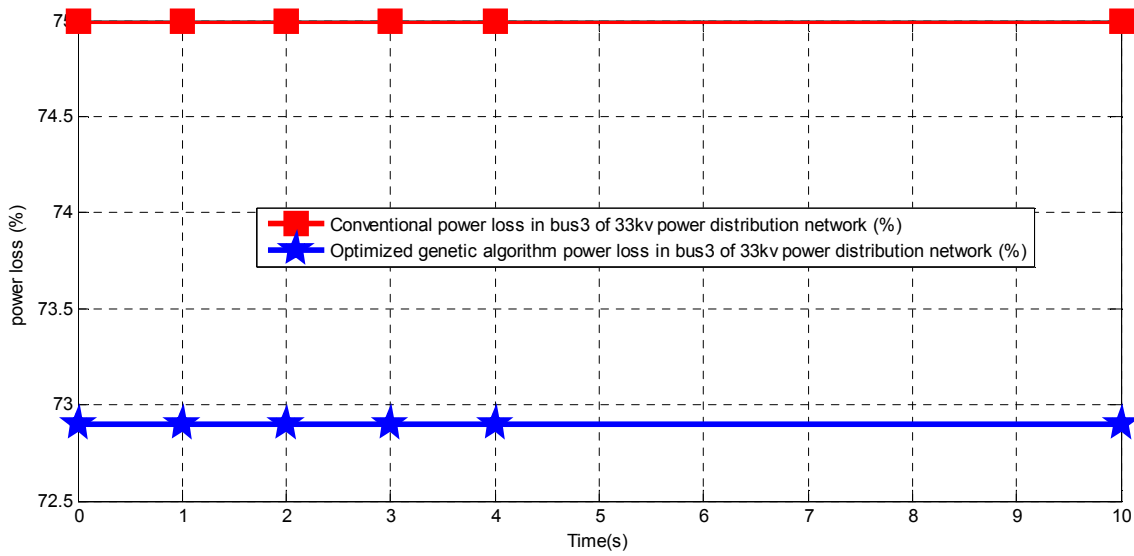


Figure 4. Comparing percentage power loss in bus 3 of 33KV distribution network with and without Optimized genetic algorithm.

Table 4. Comparing percentage power loss in bus 5 of 33KV distribution network with and without Optimized genetic algorithm.

Time (s)	Conventional power loss in bus5 of 33kv power distribution network (%)	Optimized genetic algorithm power loss in bus5 of 33kv power distribution network (%)
0	80	72.9
1	80	72.9
2	80	72.9
3	80	72.9
4	80	72.9
10	80	72.9

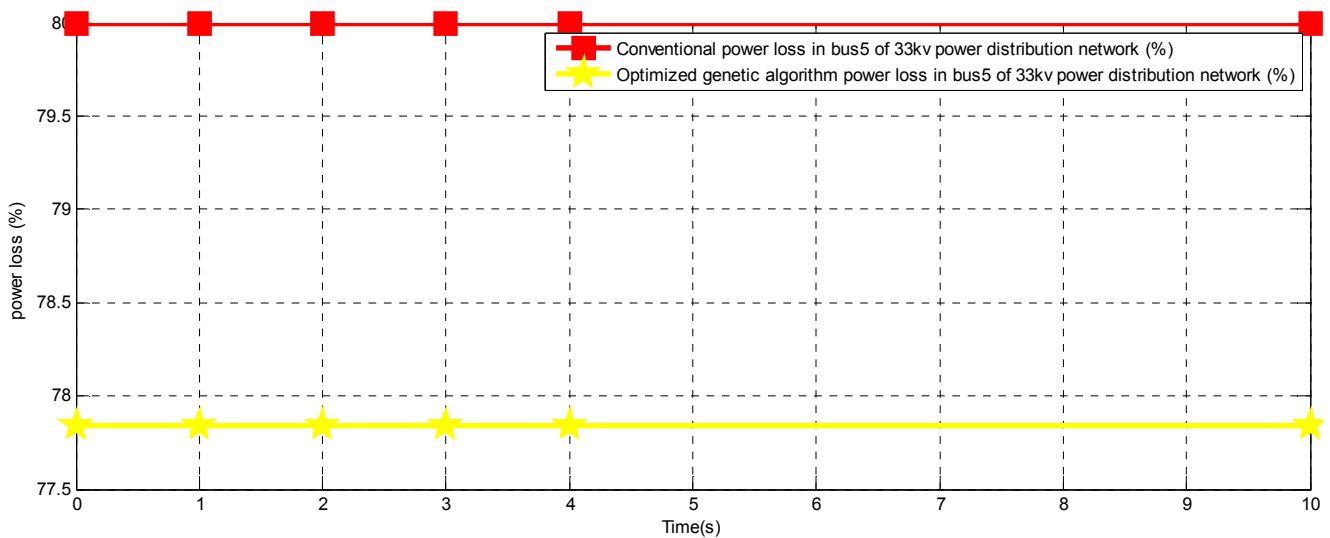


Figure 5. Comparing percentage power loss in bus 5 of 33KV distribution network with and without Optimized genetic algorithm.

5. Conclusion and Recommendation

The intermittent power supply in our distribution network has liquidated some establishment that solely depend on power to run their daily work. This is due to power loss in the distribution network. This irregular power supply in the distribution network is overcome by improving loss minimization in 33kv power distribution network using optimized genetic algorithm. It is done in

this manner, characterizing 33KV distribution network, running the load flow of the characterized 33KV distribution network, determining the distribution losses from the load flow.

Minimizing the determined losses in 33kv distribution network using optimized genetic algorithms, and designing SIMULINK model for improving loss minimization in 33kv power distribution network using optimized genetic algorithm. Finally, validating and justifying the percentage of loss reduction in improving

loss minimization in 33kv power distribution network without and with optimized genetic algorithm. The results obtained are conventional percentage power loss in 33KV distribution network is 75% while that when optimized genetic algorithm is incorporated in the system is 72.9%. With these results obtained the percentage improvement in loss reduction in 33KV distribution network when optimized genetic algorithm is imbibed in the system is 2.1%. *The conventional percentage of power loss in 33KV distribution network is 80%.* On the other hand, the percentage power loss in the distribution network when Optimized genetic algorithm is incorporated in the system is 72.9%. This shows that there is power loss reduction in distribution network when optimized genetic algorithm is incorporated in the system. The conventional power loss in distribution network is 76.7% while that when optimized genetic algorithm is inculcated in the system is 74.63%. The conventional percentage power loss in distribution network in bus 8 is 81.7% while that when optimized genetic algorithm is imbibed in the system is 79.49%. The conventional percentage power loss in bus 9 of 33KV distribution network is 86.7%. Finally, when optimized genetic algorithm is incorporated in the system the percentage power loss in the distribution network reduced drastically to 84.36%. With these results, it shows that the improvement in minimizing power loss in 33KV distribution network is 2.34%.

6. Recommendations

To ensure optimum performance reliability of electricity supply in 33kV power distribution, the following recommendations are suggested based on the findings:

1. Losses could be minimized using Synchronous phase modifiers.
2. Capacitor banks should be placed in parallel to load centers to improve power factor.
3. Solid State var compensators should be encouraged in the distribution substations.
4. Preventive maintenance should be implemented quarterly to improve the integrity of power system components.
5. 4 Corona technical losses and non- technical losses could be minimize with timely replacement of dilapidated and old power system equipment. The Government should make provision for training technical personnel in the industry.

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