International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 4 Series I || April 2021 || PP 58-66

Reduction of Power System Losses in Transmission Network Using Optimization Method

Aneke N.E[1], Ngang, N.B [2]
[1,2]Department of Electrical /Electronic Engineering, Enugu State University of Science and Technology, PMB 01660 Enugu, Nigeria

ABSTRACT: *Power failure or incessant power failure in our country are caused by power loss, low power factor, overcurrent, over voltage to mention a few. power failure could be overcome by determining line losses, determining the phase values of the voltages at load buses, determining the slack bus real and reactive power, optimizing these values to determine active power loss reduction in the buses and designing a model that reduces power losses in transmission network using simplest method optimization technique. This result gotten in optimization technique is at about 67% better than using proportional integral, PI, proportional integral derivative (PID) and other conventional techniques.*

KEYWORDS*: Power losses, transmission, network, optimization.*

Date of Submission: 29-03-2021 Date of Acceptance: 12-04-2021

I. INTRODUCTION

As the growth of electricity demand is increasing rapidly, optimization is one of the better alternatives to fulfill this ever-growing energy demand. Moreover, it reduces system energy loss, alleviates transmission congestion, improves voltage profile, enhances reliability and provides lower operating cost. Because of its small size compared with conventional generation units, optimization is more flexible to install in terms of investment and time. As a result, integration of transmitted energy resources (TER) with transmission network offers a promising solution; therefore, an intensive level of research is needed to understand the impacts of transmitted resources on transmission system. Before operating transmitted and dispersed generation in power system different technical, environmental, commercial and regulatory issues should be analyzed properly. Most significant technical barriers are protection, power quality, stability and outstanding operation. However, there are some other issues which should be analyzed before to maximize these technical benefits. From previous studies, it has been seen that different penetration level and various placement of DER will impact the transmission system differently (Rizy,2010) moreover, improper optimization fuzzy size and inappropriate allocation of DER may lead to higher power loss than when there is no dispersed generation in the system at all (Mithulanthan,2015). Therefore, detail and exact analysis method is required to determine the proper location and size of optimization more accurately and precisely. In transmission system, optimization should be allocated in an optimal way such that it will reduce system losses and hence improve voltage profile (Acharya, 2006). In our study, we focused on optimum location and size of optimization to decrease total system power loss. In most of the previous researches of optimization sizing and location of optimization has been connected with grid directly. Significant risks are associated in connecting such equipment directly to utility transmission system. The insulation level of the machines may not synchronize with the system. Therefore, direct connection of optimization fuzzy is often discouraged (Arritt, 2008).

The problem of inconsistence power supply has become the order of the day in our country Nigeria. The causes of this have arisen as a result of power losses in transmission network, distortion, harmonic, short circuit, burning of feeder pillar to mention a few. This project focuses its attention in power losses in transmission network as a result of distortion and harmonic. This unfortunate situation of inconsistence power supply in our country has demoralized the moral of investors to desist from so doing thereby enhancing the rate of unemployment in our country Nigeria. This can be overcome by using optimization.

In the real setting, Distribution system, DG has to be provided in an optimal way such that it will minimize system losses and improve the voltage profile (Acharya, P,2006).

The research is to have a stable power supply through the determination of line losses in transmission network using Newton Raphson method, the phase values of the voltage at load buses, the slack bus real and reactive powers, power losses in transmission network using optimization, active power loss reduction in the buses and to design a model that reduces power losses in transmission network using

Lastly, following the above project research procedures and recommendations, it is noticed that there was a gap left to be filled during Loss reduction in transmission network using Newton Raphson method.

Distributed Generation can come from a variety of sources and technology. To analysis the DER impacts, different types of 'generator groups' can be considered (McDermott, 2009). That was the reason for using optimization other than ordinary Transmission STATCOM(TSTATCOM) or with PI controller which cannot reduce loss in transmission network faster. The optimization introduced in this report is part of the transmission system that works better than the PI controller in terms of flexibility, speed and reliability for reduction of voltage fluctuations, harmonic distortions and low power factor to its lowest minimum value. Analytical Procedures involving radial and network distribution systems having different load configurations are given in. (Wang,2004).

II. METHODOLOGY

To determine line losses transmission network using NEWTON RAPHSON

The data employed in this analysis was obtained from the National Control Center (NCC) Osogbo, Osun State, Nigeria. The per unit values of the line impedances were computed on the following base values: Using MATLAB program, the northern Nigeria 330KV network was developed and the load flow was run. The network showing connected devices is depicted in fig. 2. It depicts a solution with Newton – Raphson Power flow algorithm. Tables 1 and 2 show generator records and bus records after load flow, respectively. The results in table 2 show voltage
violation in the p.u. values of buses 1, 7, 8, 9, 10, and 13. The normal range of bus voltages is assumed to be 0.95-1.05 p.u.[7].

```
basemva = 330;  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];
```

Fig 1: Newton Raphson 330kv power flow result

```
%          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
```

Continuation of fig 1: Newton Raphson 330kv power flow result

Power Flow Solution by Newton-Raphson Method

Maximum Power Mismatch = 2.83789e-007

No. of Iterations = 10

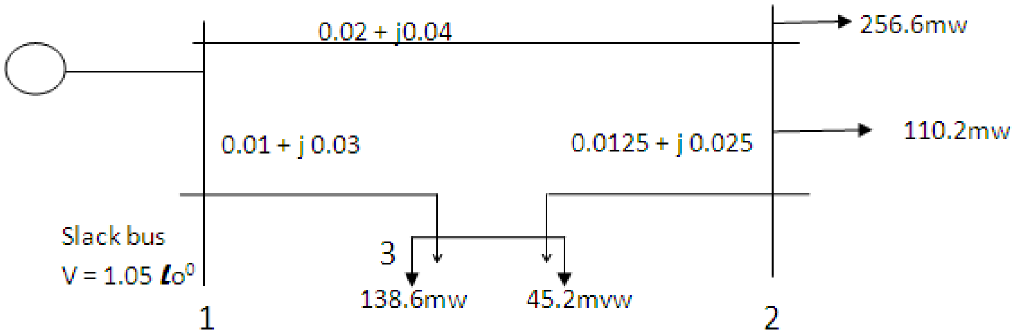
Bus No.	Voltage Mag.	Angle Degree	------Load------ MW	Mvar	---Generation--- MW	Mvar	Injected Mvar
1	1.040	0.000	0.000	0.000	280.945	234.260	0.000
2	1.000	-2.815	0.000	0.000	0.000	0.000	0.000
3	0.865	-9.857	150.000	120.000	0.000	0.000	0.000
4	0.957	-7.229	0.000	0.000	0.000	0.000	0.000
5	0.764	-32.321	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

Fig. 2: Newton Raphson 330kv power flow result.

Fig. 2 shows the result obtained when newton Raphson 330kv transmission loss reduction is simulated. The result obtained herein is 640KVA load. This result shows that the reduction is not good enough that is the reason for using optimization method to get considerable loss reduction in 330kv transmission line.

To determine the phasor values of the voltage at load buses

One-line diagram of a simple three – bus power system with generation at bus 1. The magnitude of voltage at bus 1 is adjusted to 1.05 per unit. The scheduled loads at buses 2 and 3 are as marked on the diagram. Line impedances are marked in per unit on a 100 MVA base and initial power loss in the system before using optimization are PL_{12} = 150mw PL_{13} =153.94mw and PL_{23} = 120mw



To convert line impedance to admittance

$Z_{12} = 0.02 + j0.04$

$Z_{13} = 0.01 + j0.03$

$Z_{23} = 0.0125 + j0.025$

To find Y_{12}

$Y_{12} = \frac{1}{Z12}$

$Y_{12} = \frac{1}{0.02+j0.04}$

$Y_{12} = \frac{1}{0.02+j0.04} x \frac{0.02-j0.04}{0.02-j0.04}$

$Y_{12} = \frac{0.02-j0.04}{0.004-j0.0008 + j0.0008-j^2 0.0016}$

$Y_{12} = \frac{0.02-j0.04}{0.004- 0.0016}$

$Y_{12} = \frac{0.02-j0.04}{0.002}$

$Y_{12} = 10 - j20$

Similarly$Y_{13} = 10 - j30$ and $Y_{23} = 16 - j32$

At P – Q buses, the complex loads expressed in per units are

For bus 2

$S_2^{ach} = \frac{(P+jQ)}{Sb}$

$S_2^{ach} = \frac{(256.6+j1102)}{100}$

$S_2^{ach} = 2.566 - ji.102$pu

To convert load to per unit in bus 3

$S_3^{ach} = \frac{(p + jQ)}{Sb}$

$S_3^{ach} = \frac{(138.6 + j45.2)}{100}$

$S_2^{ach} = 1.386 - j0.452$

To determine the slack bus real and reactive powers

The slack real and reactive power powers are

$P_1 = 5.3139$pu $= 5.3139$ x 100

$P_{1\ ToTAL} = 531.39$mw

$Q_1 = 0.7652$pu $= 0.7652$ x 100

$Q_1 = 76.52$Mvar

Similarly, P_2 when calculated gave P_2 total = 117mw

The result gotten are P1 total = 531.31KW and P2 total = 117KW

To optimize a power loss reduction in a transmission network using optimization.

An EEDC company produces two types of power supply in a transmission network A and B that require power P1 and P2. Each unit of type A require 1KW of P1 and 2KW of P2. Type B requires 2KW of P1 and 1KW of P2 (Each unit).The company has only 531.31KW of P1 and 117KW of P2. Each unit of type A brings a profit of #500Million and each unit of type B brings a profit of #400Million for 330 KVA. Formulate the optimization problem to maximize profit that will optimize power loss reduction in a transmission network.

Fig.1: Optimization data.

Power	P1 (KW)	P2 (KW)	Profit (Naira)
A	1	2	500
B	2	1	400
	531.31	117	

The optimization equation becomes
Maximize $z = 500x + 400y$ --------------------------1
Subject to
$x + 2y <= 531.31$ ------------------------------------2
$2x + y <= 117$---3

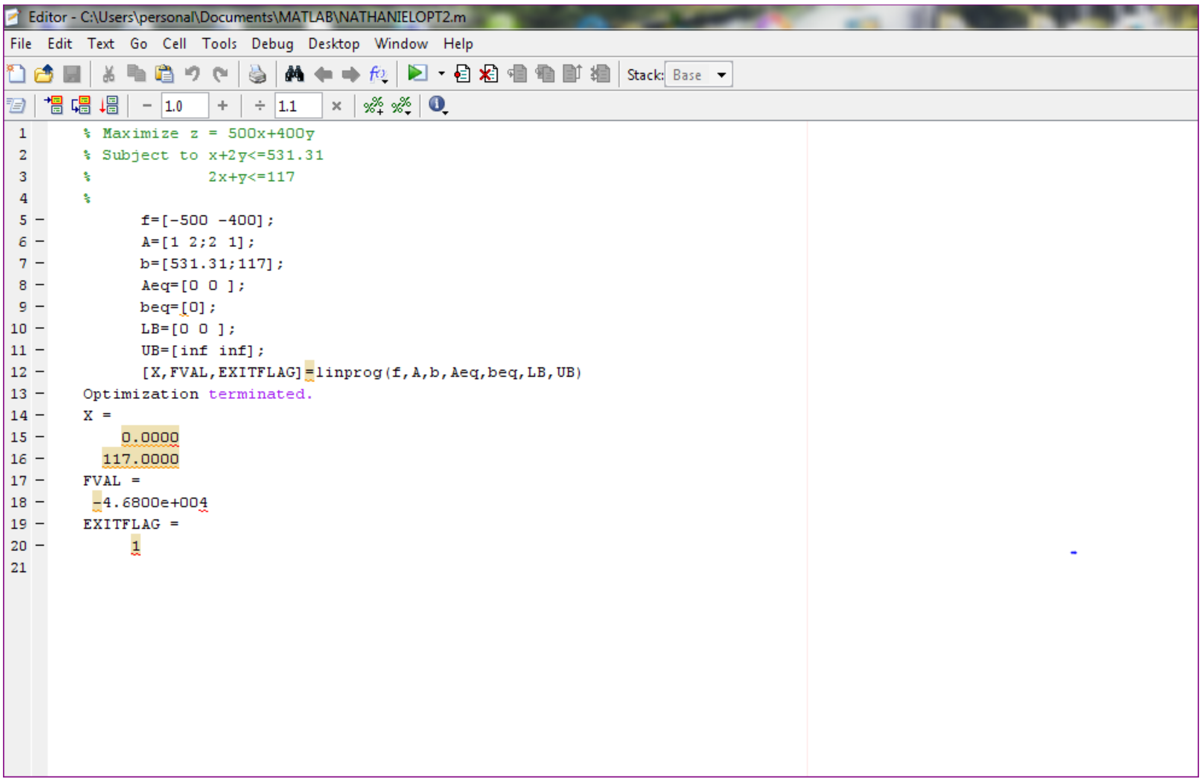


Fig. 4: Result of power loss optimization

To determine active power loss reduction in the buses
Power loss (mw)
The optimized values were used for the power loss reduction as shown on the table below

Table 2: power losses

Test system	Initial power losses in the Lines before using optimization	Final power losses in lines after using optimization
12 Bus	531.31	117
13 Bus	117	117

To calculate the active power loss reduction by transmitted generator TG
To find active power loss reduction PLR in Bus 12
Applying formula for active power loss reduction PLR

$$PLR_{12} = \frac{PL_{12}^{inital} - PL_{12}^{final}}{PL_{12}^{inital}} \times \frac{100}{1}$$

$$PLR_{12} = \frac{531.31 - 117}{531.31} \times \frac{100}{1}$$

$$PLR_{12} = \frac{414.31}{531.31} \times 100$$

$$PLR_{12} = 77.97\%$$

To design a model that reduces power losses in transmission network using optimization

The optimized power loss reduction Simulink model was designed as shown in fig 5

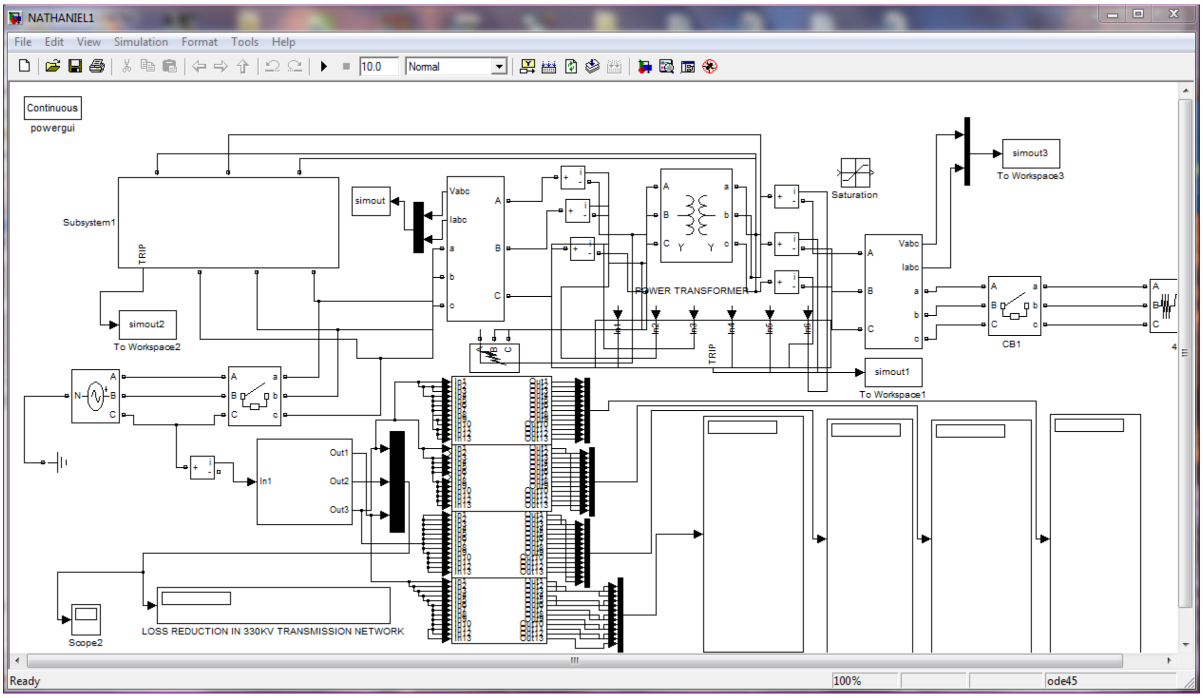


Fig 5 Designed model that reduces power losses in transmission network using optimization

Fig 5 shows the designed model that reduces power losses in transmission network using optimization method only. The power loss reduction when implemented is shown in fig 6

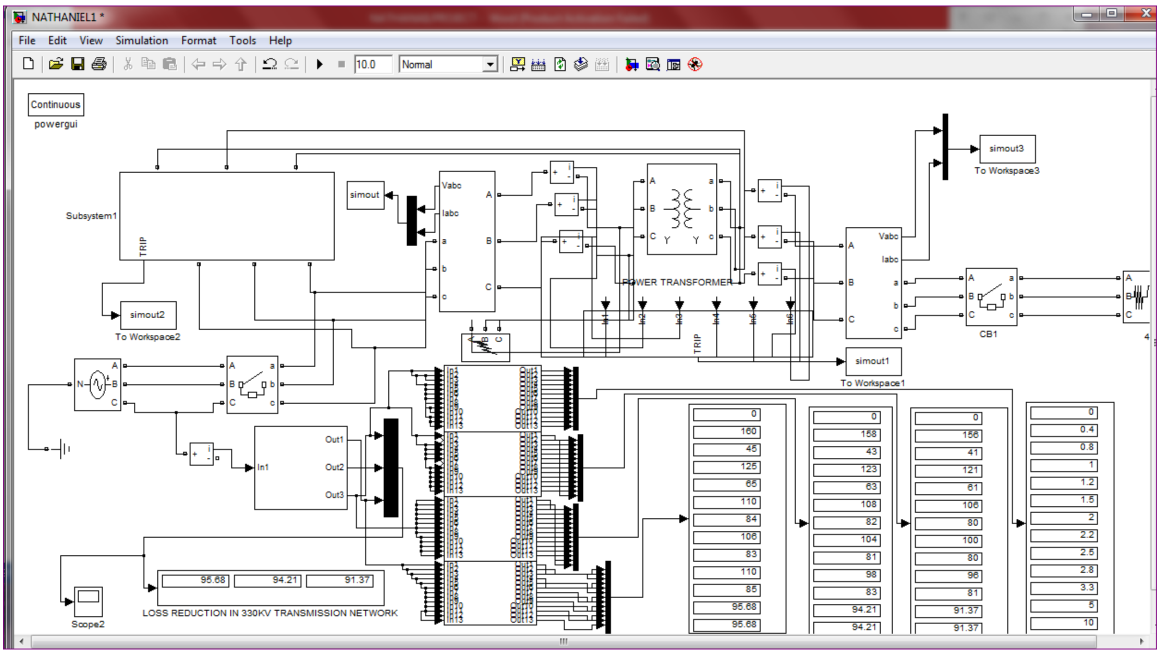


Fig 6 Implemented Designed model that reduces power losses in transmission network using optimization

Fig 6 shows an implemented designed model that reduces power losses in transmission network using optimization. Fig 6 reduces the losses in transmission network from 95.68Kw to 91.37kw when simulated.

III. RESULT ANALYSIS

Loss Reduction in Transmission Power System

Active Power Loss Reduction	Final power loss in the lines after using optimization
PLR_{12} = 91.37%	PL_{12}^{final} = 12.94mw
PLR_{23} = 94.21%	PL_{23}^{final} = 6.94mw
PLR_{13} = 95.69%	PL_{13}^{final} = 6.64mw

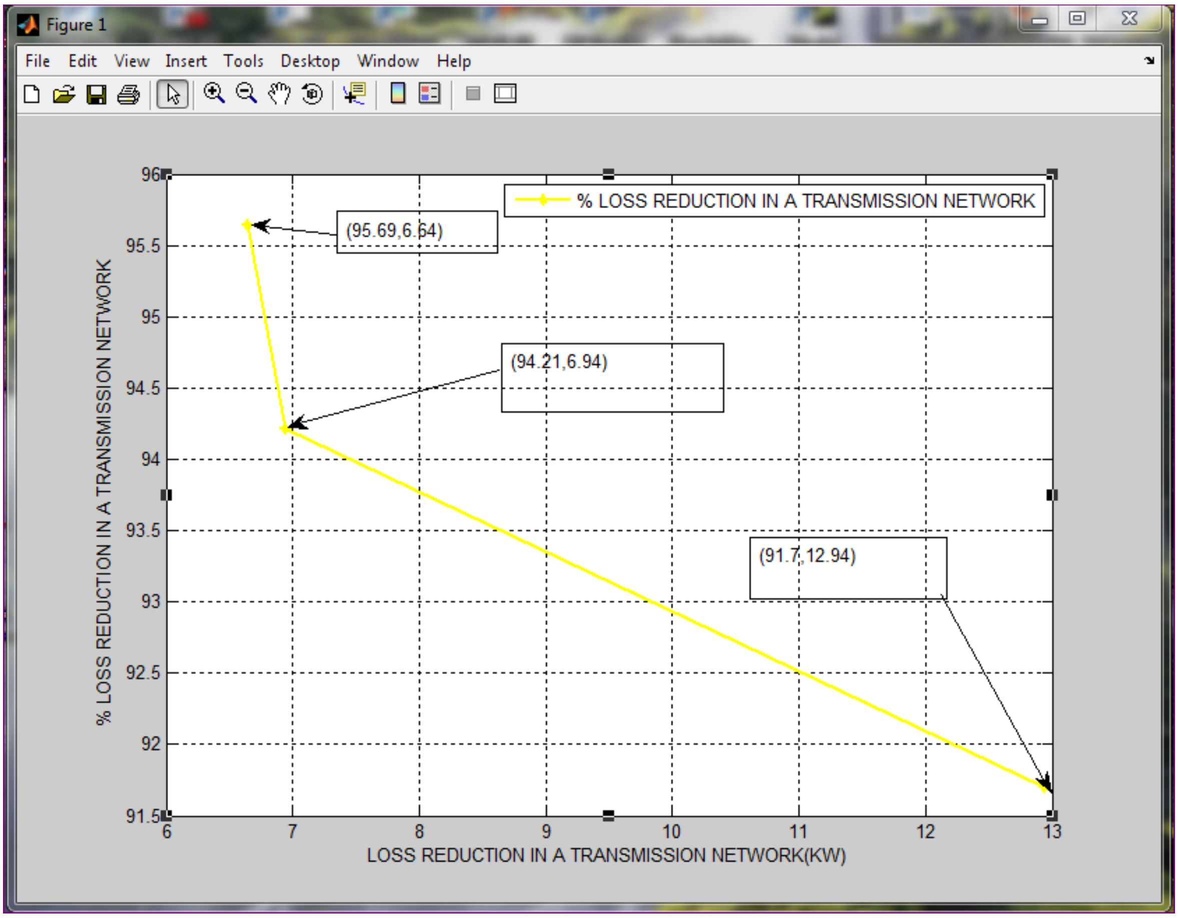


Fig 7 power losses in transmission network using optimization

Fig 7 shows the power losses in transmission network using optimization. Fig 7 shows that the highest loss reduction in a transmission network occurred at a coordination percentage loss reduction at (95.69%,6.64(KW)), while the least loss reduction is at (91.37%,12.94(KW)).

Table 2 Simulated data for designed model that reduces power losses in transmission network using optimization

P1	P2	P3	TIME
0	0	0	0
160	158	156	0.4
45	43	41	0.8

125	123	121	1
65	63	61	1.2
110	108	106	1.5
84	82	80	2
106	104	100	2.2
83	81	80	2.5
110	98	96	2.8
85	83	81	3.3
95.68	94.21	91.37	5
95.68	94.21	91.37	10

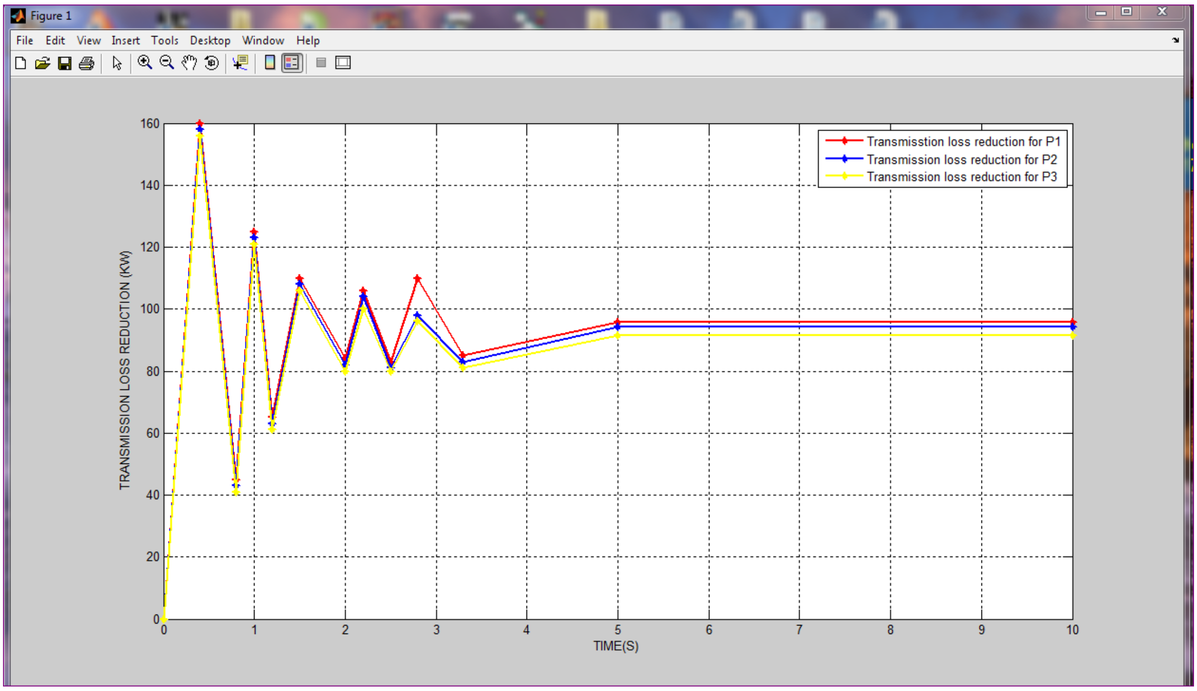


Fig 8 Simulated result for designed model that reduces power losses in transmission network using optimization

Fig 8 shows the simulated result for designed model that reduces power losses in transmission network using optimization. The loss reduction in transmission network becomes constant at P1 in a coordination of loss reduction in transmission network and Time of (95.68,5) to (95.68,10). On the other hand, the loss reduction in transmission network becomes constant at P2 in a coordination of loss reduction in transmission network and Time of (94.21, 5) to (94.21, 10).

Meanwhile the loss reduction in transmission network becomes constant at P3 in a coordination of loss reduction in transmission network and Time of (91.37, 5) to (91.37, 10). This shows that loss reduction in a transmission network reduces from 95.68 to 91.37 Kw

IV. CONCLUSION

The impact of proper calculation of power loss in transmission network using optimization is very significant. Power loss in transmission system increases overall system cost and has a major impact in power system management. From our analysis, we can come to know that power loss in transmission network when optimization method is used is lower than when other techniques of power reduction are used. That is to say, optimization method provides higher reduction of losses when compared to other methods like Gausidal method. Therefore, an effective loss reduction in a transmission network of a power system (optimization method) has to be implemented.

REFERENCES

[1]. Rizy D, AdhikariF,Li,H.Li and Kueck J "propelling understanding the impacts of distributed resources on transmitted system", in power and energy society general ting. IEEE, 2010.

[2]. Acharya N, Mahat P, Mithulananathan N, (2006). An analytical approach for TG allocation in primary transmission network, international journal of Electrical power and Energy Systems, Vol. 28, No. 10, Pp 669 – 678.

[3]. R. Arritt and R. Dugan, "Distributed generation interconnection trans-former and grounding selection," in Power and Energy Society General Meeting, IEEE, July 2008.

[4]. N. Acharya, P. Mahat, and N. Mithulananthan (2006), "An analytical approach for DG allocation in primary distribution network," International Journal of Electrical Power & Energy Systems, vol. 28, no. 10, pp. 669–678.

[5]. "Behavioral models of DR technologies for feeder-level analysis," in Power Energy Society General Meeting, IEEE, July proceedings.

[6]. Wang and M. Nehrir, (2004) "Analytical approaches for optimal placemen of distributed generation sources in power systems,"IEEE Transactions on Power Systems, vol. 19, no. 4, pp. 2068–2076 .

Aneke N.E, et. al. "Reduction of Power System Losses in Transmission Network Using Optimization Method." *International Journal of Engineering Science Invention (IJESI)*, Vol. 10(04), 2021, PP 58-66. Journal DOI- 10.35629/6734