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MINIMIZATION OF POWER LOSSES IN 33/11KV DISTRIBUTION NETWORK USING GENETIC ALGORITHM AND SHUNT COMPENSATION TECHNQIUE

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Abstract

This paper presents the minimization of power losses in 33/11KV distribution network using genetic algorithm and shunt capacitor compensation. A technical study of the 15MVA, Thinker's corner 33/11KV injection feeder (testbed) was conducted with Gauss Seidal load flow analysis to read the transformer behaviour, while relationships between the active and reactive current components were used to read the losses. A Model of the testbed was developed with the loss problem formulated. To solve the problem, shunt capacitor was sized and then strategic algorithm for capacitor deployment using Genetic technique developed. This was demonstrated using Simulink and configuration parameters inspired from the testbed. The result after testing showed that the capacitor bank was able to induce reactive power to correct the power factors due to high loss rate. The algorithm was then integrated on the testbed and used to identify all the bus with poor power factor such as the 11.5MVA, 11KV Abakpa 1 and 0.7MVA5, 11KV GRA distribution transformers respectively. The result when tested showed that all the bus with poor power factor due to losses were corrected with an average power factor of 0.988019 as against 0.911649 without capacitor, thus presenting a percentage improvement of 7.7296%.

Keywords: Distribution Network; Gauss Seidal; Transformer; Genetic Algorithm;

1.0 INTRODUCTION

The distribution system is one of the most visible parts of the supply chain, and as such the most exposed to the critical observation of its users. It is, in many cases, the largest investment, maintenance and operation expense, and the object of interest to government, financial agencies, and associations of concerned citizens. About 30 to 40 % of total investments in the electrical sector go to distribution systems, but nevertheless, they have not received the technological impact in the same manner as the generation and transmission systems (Aggelos et al., 2016).

Many of these distribution networks work with minimum monitoring systems, mainly with local and manual control of capacitors, sectionalizing switches and voltage regulators; and without adequate computation support for the system's operators. Nevertheless, there is an increasing trend to automate distribution systems to improve their reliability, efficiency and service quality. Ideally, losses in an electric system should be around 3 to 6% (Aggelos et al., 2016). However, in developing countries like Nigeria for instance, the percentage of active power losses is around 20%; therefore, utilities in the electric sector are currently interested in reducing it in order to be more competitive, since the electricity prices in deregulated markets are related to the system losses (Ngang et al., 2021).

To manage a loss reduction program in a distribution system it is necessary to use effective and efficient computational tools that allow quantifying the loss in each different network element for system losses reduction. Generally, there are three techniques to mitigate losses and they are;

- ❖ Reducing the equivalent resistance in the distributive system
- ❖ The use of capacitors for power compensation and power factor correction
- ❖ Reconfiguring the distributive network

In the first technique which talked about mitigating resistance in the distributive system, the power in the conductor is presented as I^2R, where I is current, R is the resistance which is reduced proportionally to the power loss.

This can be achieved by replacing the small size conductors (overhead line and underground cables) with larger cross-sectional area as the resistance is inverse of the cross-sectional area or by installing auxiliary conductors to work in parallel with the existing ones. Although this technique could result to reasonable amount of loss reduction, it is on the other hand very expensive and requires special needs because the cost of the conductor cables and installation are in excess cost of energies saved (Komail et al., 2013).

The second technique which involves the use of compensating capacitors in the distribution system at a specific load point, the reactive power produces losses which can be reduced by any compensating capacitor to induce reactive power and hence compensate for losses of the inductive load. Using this technique, the power flow in the distribution system are reduced and hence the equivalent losses reduced (Doung et al., 2013).

As the compensating capacitors affects the losses due to reactive power components, their effects is more pronounced when the power system has low power factor. Additionally, the merit of installing capacitors is the increase in voltage capacity. This is to ensure the provision of feeders with the desired range of voltage for heavy and light load conditions respectively and thus improve the power factor. The optimize size and locations of the capacitors can be determined based on high cost of saving energy loss and peak power loss on the conditions that the voltage limit is not exceeded (Qasim and Xiangning, 2016). The third technique requires the reduction of power and loss of energy on the distributive system through the process of reconfiguration. The reconfiguration of the distributive system is employed in planning tool due to real time control tools.

In the conventional Enugu Electricity Distribution Company (EEDC) Feeders system, the distributive system is reconfigured radically to help control losses, however the limitation of this technique is the inability to control loss during peak period of loads (Juan and Antonio (2013); Kumar and Perumal (2016)). This has remained a very big problem as most of the distribution feeders suffer the problem of overloading due to constant increase in population which is proportional to load increase and hence losses. To solve this problem, this study proposes to develop a shunt capacitor bank and deploy on each of the feeders to control active and reactive power flow and hence reduce losses.

2.0 METHODOLOGY

The methodology used for the study were technical investigation of the distribution system using load flow analysis to read the 15MVA, 33/11KV Thinkers corner feeder transformer (testbed) data and analyze to read out the problem statement (losses). The model of the testbed was then developed and the derivation of its loss model was achieved using mathematical method. Other models developed are the power factor model, model for the capacitor sizing and the smart deployment algorithm with Genetic technique. The models were implemented with Simulink, programmed with parameters inspired from the testbed.

2.1 THE TECHNICAL INVESTIGATION

This research characterized the Thinker's corner 15MVA, 11KV distribution transformer system. The parameters considered for the characterization are active power, reactive power, power factor, and losses. The source of data collection is the Enugu Electricity Distribution Company (EEDC) headquarters at Okpara Avenue, Enugu, State, Nigeria. The method of data collection employed load flow analysis which can be done using Newton Raphson and Gauss Seidal techniques respectively; however, Uzodife and Madueme (2009) revealed that the use of the later techniques for distribution system studies is preferred as it requires small memory and very simple to implement on a computer problem when compared to the Newton Raphson counterpart.

To perform the characterization process, the load flow software using ETAP was run on the computer system and the power factor for each of the 34-bus relationship between variation in active and reactive power flow was collected and then used to determine the impact of loss on the network. The single line diagram of the 15MVA, 11KV thinker's corner feeder was presented as figure 1.

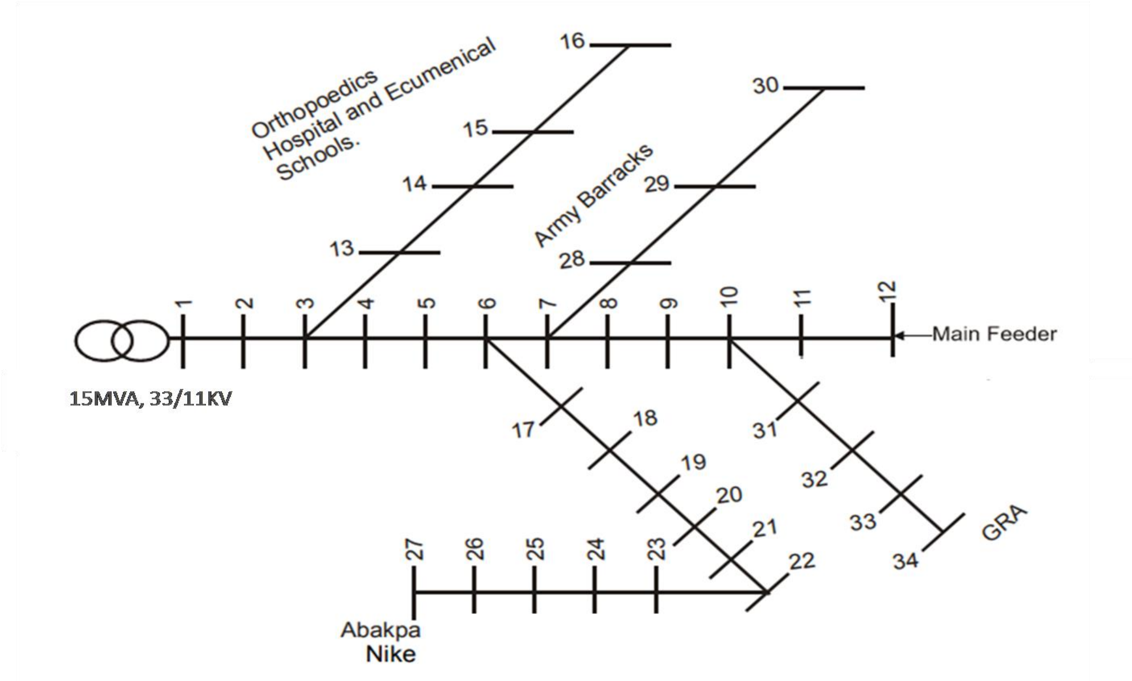

Figure 1: Single line model of the testbed (Image from EEDC File)

The figure 1 presented the single line diagram of the 15MVA, 33/11KV distribution transformer showing the 34 interconnected buses which were fed from the injection substation to supply the load with an average real and reactive power of 4636.5KW and 2873.5KVar. The loads are categorized as residential load with 60% of the bus, 25% with commercial loads and 15% presenting the industrial loads. To calculate the power factor of the transformer bus, the ratio between the active power and the reactive power was used as

$$\text{PF} = \frac{Real\ power\ (P)}{reactive\ power\ (Q)} \qquad 1$$

2.2 TRANSFORMER LOSS PROBLEM

Losses in the distribution transformers occurred due to copper and core losses in the transformers. These losses occur in the form of heat generated which vary current in the secondary and primary sides of the transformers through the winding process. The copper loss is formulated using the relationship between the transformer winding current (I) and resistance (R) as shown in the equation 2;

$$I^2R \qquad 2$$

Any facto which changes the behaviour of the parameters in equation 1 results to copper loss in the transformer.

Another function which can result to loss is the increase in load via active or reactive power changes leading to increase in current flow and hence more losses in the transformer. According to Uzodife and Madueme (2009), the eddy current losses are due to magnetically induced current in the core and hysteresis loss which occurred as a result of core permeability. The hysteresis loss occurred in the transformer due to due to requirement of energy to provide magnetic field in the core to guide the direction of magnetic flux and current. Now considering loss in the transformer based on a combination of active and reactive current, the total power loss is then given as (Uzodife and Madueme, 2009);

$$P_l = \sum_{i=1}^{M} I_{iri}^2 = \sum_{i=1}^{M} (I_{ai}^2\, ri + I_{ri}^2\, ri) \quad 3$$

Where M is the total of the system sections, Ii is the current flowing in the ithsection with active (ai) and reactive components (ri), while ri is the ith section resistance

2.3 TO CHOOSE SHUNT CAPACITOR SIZE AND DEPLOY ON THE POWER SYSTEM USING GENETIC ALGORITHM

This section is responsible for the solution to the problem formulation established after the characterization process. Shunt capacitor band which is a power system device with the capacity to inject reactive power into the bus when there is high loss was used. The intelligent deployment comes in to economize the cost required in the system implementation. The high cost of capacitor bank presents the need for the intelligent deployment only on weak bus. This is where the genetic algorithm comes in as it was used to perform fitness test in the bus stability margin within the distribution network and identify all the weak buses and update as point for the capacitor deployment. The capacitor sizing presents model which was used for the sizing of the capacitor.

2.4 SIZING OF THE CAPACITOR FOR THE LOSS MINIMIZATION

This section was used to determine the size of the capacitor which is necessary to compensate the losses formulated in the equation 3 at the feeder via the injection of reactive power for load flow compensation. To achieve this, the relationship between the existing power factors, desired power factor, total active power and transformer capacity was considered using the model Ohanu et al. (2020) in equation 4;

$$Q_c = \frac{P}{pf_1} sin\theta_1 - \frac{P}{pf_2}\, sin\theta_2 \qquad 4$$

Where Qc is the reactive power factor correction, Ɵ is phase angle, P is the total active power, pf_1 is the existing power factor of the load and pf_2 is the power factor desired to be used for correction. Where Ɵ is computed using equation 5 as;

$$\theta = cos^{-1}\,(pfn) \qquad 5$$

Where n is the number of bus-interconnected on the feeder transformer. The size of the capacitor (Q_{cB}) is therefore presented as equation 6;

$$Q_{cB} = \frac{P}{pf_1} sincos^{-1}\,(pf_n) \qquad 6$$

2.5 THE GENETIC ALGORITHM FOR CAPACITOR DEPLOYMENT

Many works have been done to develop strategic approaches for the deployment of capacitor in distribution transformers such as heuristic approaches in (Uzodife and Madueme, 2009; Ohanu et al., 2020) among others, however this approach is limited to only a fixed power factor value which do not changes as the load varies. These is need for a system which minimize loss considering the dynamic in load changes to main a reliable power factor value which will guarantee quality of service.

The approach used a fitness test integration which uses the least standard accepted for power factor based on the Nigerian Electricity Regulatory Commission (NERC) which is 0.900 as the reference fitness level to compute and check for bus below the standard which indicated loss in the active or reactive power and then apply the capacitor for correction. The fitness model was presented in the equation 7;

$$Ft = \frac{x_i}{\sum_{k=1}^{n} \; fitness\,(x_k)} \qquad 7$$

Where x_i is the least power factor values which is 0.9000. x_k is the number of bus below the ideal power factor values, n is the total number of bus with interconnected to the thinker's corner feeder. The fitness model was used to determine the next phase of chromosome which is the next phases of bus below the ideal power factors and then cross mutation to determine the weakest bus. This process continues iteratively until all the weak bus is identified and capacitor installed. The pseudocodia of the algorithm is presented below and the flow chart of the placement algorithm is presented as figure 2;

2.6 THE GENETIC PSEUDO CODE FOR CAPACITOR DEPLOYMENT

1. *Start*
2. *Identify all the chromosomes (bus in interconnected with the 33/11KV feeder)*
3. *Initialize the fitness function in equation 7*
4. *Select bus below the desired power factor*
5. *Cross over in pairs*
6. *Mutation*
7. *Get the next set of bus with poor power factor*
8. *Return to step (3)*
9. *Do*
10. *Until the bus with the poorest power factor is detected*
11. *Identify for capacitor placement*
12. *Return to step (2)*
13. *End*

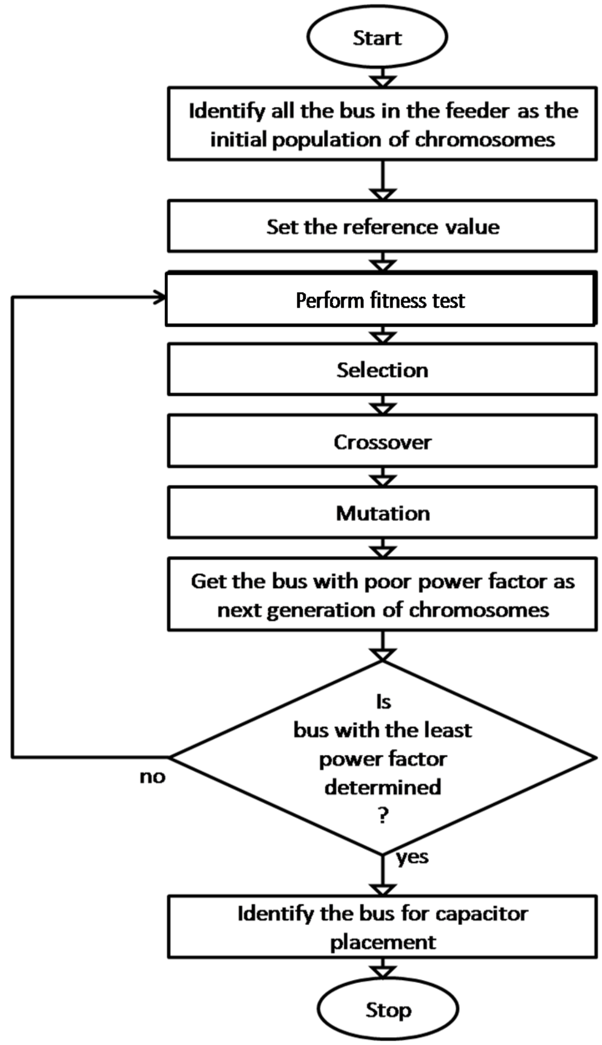

Figure 2: The Genetic algorithm for Capacitor Placement

The figure 2 presented the genetic algorithm developed for the placement of capacitors. The algorithm identified the bus interconnected on the feeder and then used the fitness model in equation 2 to determine the bus with poor power factor which was identified as the next generation of chromosomes (i.e number of bus which have poor power factor), then the fitness is used to compute the next bus with the poor power factors and the process continued iteratively until the bus with the poorest power factor is identified an then process returns. This algorithm was deployed at the thinker's cornet feeder using the model in figure 3;

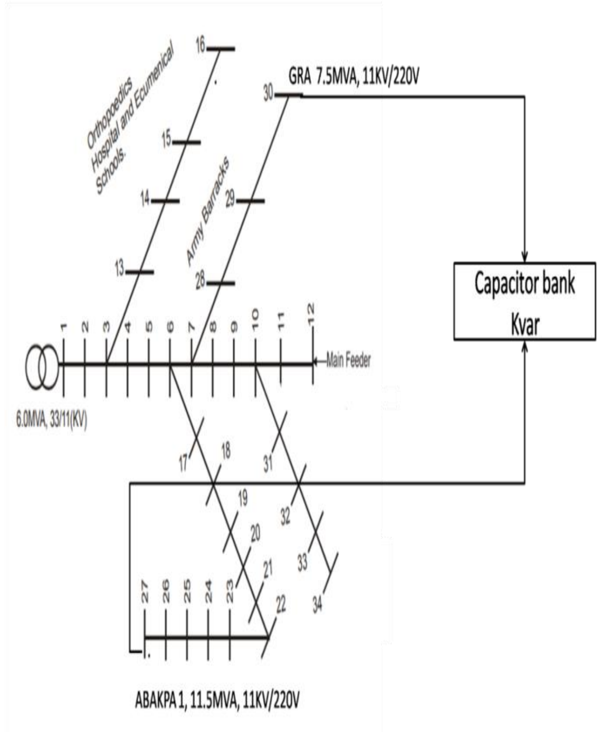

Figure 3: The algorithm integration on the Testbed

From the figure 3 the algorithm was used to detect the GRA and Abakpa1, 11KV feeder as the bus with poor power factor which occurred due to high losses in the active or reactive power. The size of the capacitor to be deployed on the bus is determined in the next section.

3.0 SYSTEM IMPLEMENTATION

The system was implemented using power system toolbox, optimization toolbox and Simulink. The power system toolbox was configured with the model of the testbed while the optimization toolbox was configured with the model of the genetic algorithm developed to determine the bus with poor power factor for correction and loss minimization.

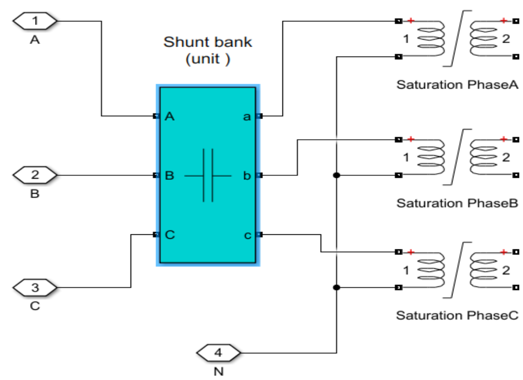

Figure 4: The electrical configuration of the capacitor bank to the transformer

The figure 4 presented the configuration of the transformer identified with the algorithm with poor power factor value. This was placed at the primary side of the testbed transformer which was feed by 60MVA, 132/33KV incoming from the Newhaven 120MVA, 330/132KV Transmission network as shown in the Simulink model in figure 5;

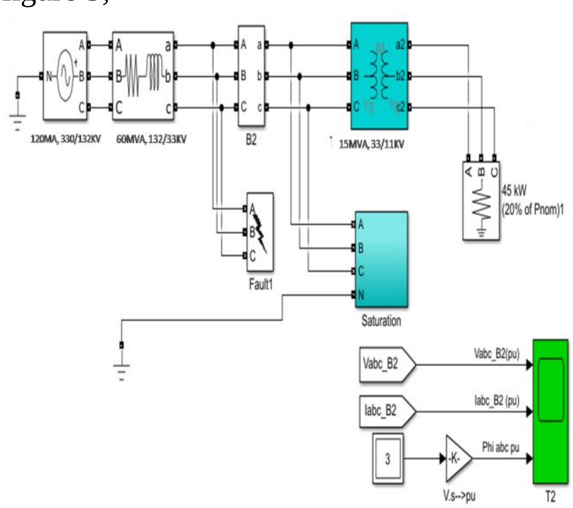

Figure 5: The model of the improved bus system with the capacitor bank

The figure 5 presented the Simulink model of the improved thinker's corner injection feeder transformer with the capacitor banks. To simulate the model, the parameters inspired from the testbed presented in table 1 were used and the result evaluated.

Table 1: Simulation Parameters

.

Parameters	Values
Active power rating	2674KW
Capacitor rating	1343KVar
Capacity of transformer	15MVA
Power factor	0.79
Base voltage	11KV
Frequency	50Hz

4.0 RESULTS AND DISCUSSION

This section presents the result of the technical investigation to read the impact of losses on the 15MVA, 33/11KV Distribution transformer. Capacitor bank was sized and then deployed on the transformer through simulation and the result also presented. The new result o the system integration on the testbed was also presented and comparative analysis was performed to validate the result.

4.1 Results of the Technical Investigation without Capacitor bank

The result of the characterization which was generated using the Gauss Seidal model which iteratively read the load flow phasor characteristic of the 15MVA, 33/11KV distribution transformer, then the loss model was used to compute the losses due to active and reactive current components on the transformer with consideration of the power factor implications. These data collected were presented in the table 2;

Table 2: Data of Thinkers Corner 33/11KV Feeder (Source: EEDC)

Bus No.	Load Power		Line current			Power Loss Data			
	P(KW)	Q(KW)	Active	Reactive	Line (R)	Loss due to active current	Loss due to reactive current	Total power losses (KW)	Power factor (pf)
1-2	166	235	254.9	-154.3	0.117	22.819	8.350	31.169	0.709199
2-3	230	165.9	242.8	-146.8	0.107	18.972	6.927	25.899	0.721454
3-4	87.4	125	230.6	-139.2	0.164	26.241	9.557	35.798	0.698886
4-5	230	142.5	218.3	-131.6	0.149	21.375	7.769	29.143	0.716571
5-6	230	142.5	205.9	-124.0	0.149	19.014	6.898	25.911	0.716362
6-7	148	154	070.3	-41.5	0.314	4.655	1.707	6.363	0.961932
7-8	126	128	57.90	-34.8	0.209	2.113	0.763	2.875	0.982098
8-9	230	1425	45.30	-27.2	0.314	1.942	0.698	2.639	0.983483
9-10	230	142.5	32.70	-19.6	0.209	0.674	0.240	0.914	0.990865
10-11	240	241	20.20	-12.2	0.131	0.160	0.058	0.218	0.996048
11-12	230	142.5	07.50	-4.5	0.105	0.018	0.006	0.024	0.998429
3-13	137	84	12.20	-7.5	0.157	0.070	0.027	0.097	0.997328
13-14	72	45	08.30	-5.2	0.209	0.044	0.018	0.061	0.998694
14-15	72	45	04.50	-2.8	0.105	0.007	0.002	0.009	0.999047

15-16	72	45	00.70	-0.4	0.052	0.001	0.002	0.001	0.999887
6-17	13.5	7.5	135.7	-81.5	0.179	9.904	3.573	13.475	0.896099
17-18	230	142.5	123.1	-73.8	0.164	7.474	2.689	10.163	0.887453
18-19	230	142.5	110.5	-66.2	0.207	7.610	2.732	10.342	0.883407
19-20	230	142.5	97.80	-58.5	0.189	5.421	1.941	7.363	0.960935
20-21	230	142.5	85.00	-50.8	0.189	4.101	1.464	5.567	0.961993
21-22	230	142.5	72.30	-43.1	0.262	4.104	1.464	5.567	0.961994
22-23	230	142.5	59.40	-35.5	0.262	2.776	0.988	3.763	0.982543
23-24	230	142.5	46.54	-27.7	0.314	2.043	0.726	2.769	0.990271
24-25	230	142.5	33.62	-20.0	0.209	0.711	0.252	0.963	0.998949
25-26	230	142.5	20.68	-12.3	0.131	0.168	0.059	0.228	0.998999
26-27	230	142.5	7.72	-4.6	0.105	16.019	9.007	25.992	0.722454
27-28	137	85	12.55	-7.7	0.157	26.741	9.251	35.992	0.691235
28-29	75	48	8.19	-5.1	0.157	0.031	0.012	0.044	0.999576
29-30	75	48	4.09	-2.5	0.157	26.992	9.511	36.503	0.673251
10-31	75	48	12.55	-7.4	0.157	0.074	0.026	0.100	0.999932
31-32	57	34.5	9.41	-5.55	0.209	0.056	0.019	0.075	0.999798
32-33	57	34.5	6.27	-3.70	0.157	0.019	0.007	0.025	0.999399
33-34	57	34.5	3.14	-1.85	0.105	0.003	0.001	0.004	0.999835
Total	4857.0	4371.3	2397.7	-1441.8	6.1526	246.4339	92.0012	339.453	31.9077

The table 2 presented the result of the load flow analysis performed on the testbed to read the phasor characteristics of the transformer and determine the loss rate and power factor implication due to load variation. From the data recorded, the total loss is 339.453KW. The data were analyzed using the standard of $\pm$5% (0.95) for tolerable transformer power factor according to NERC, then computer aided software engineering methodology.

The data was achieved using the summation of losses in the reactive and active current components of each line based on equation 3 to produce the losses recorded in the feeder. The result showed that bus27 and 30 experienced the greatest loss. From the result, it was observed that the power factor of the transformers determined with the model in equation 1 varied based on the loss analysis behaviour o the transformers. The result indicated that 8 transformers fall below the standard tolerable power factor recommended by NERC and hence is a problem to be addressed.

The implication of this poor power factor result is the poor quality of power supply received by the consumers and also unstable power flow which are all a major problem that has to be addressed. This problem has been addressed in this research using intelligent deployment of shunt capacity bank. The result of the simulated transformer with the deployed system was presented in the next section.

4.2 Simulation Results

This section presented the power factor of the simulated transformer selected with the genetic algorithm developed for capacitor placement and power factor correction. The simulation was done configuring the power system Simulink model with the parameters inspired from the testbed and then the result presented in the figure 6;

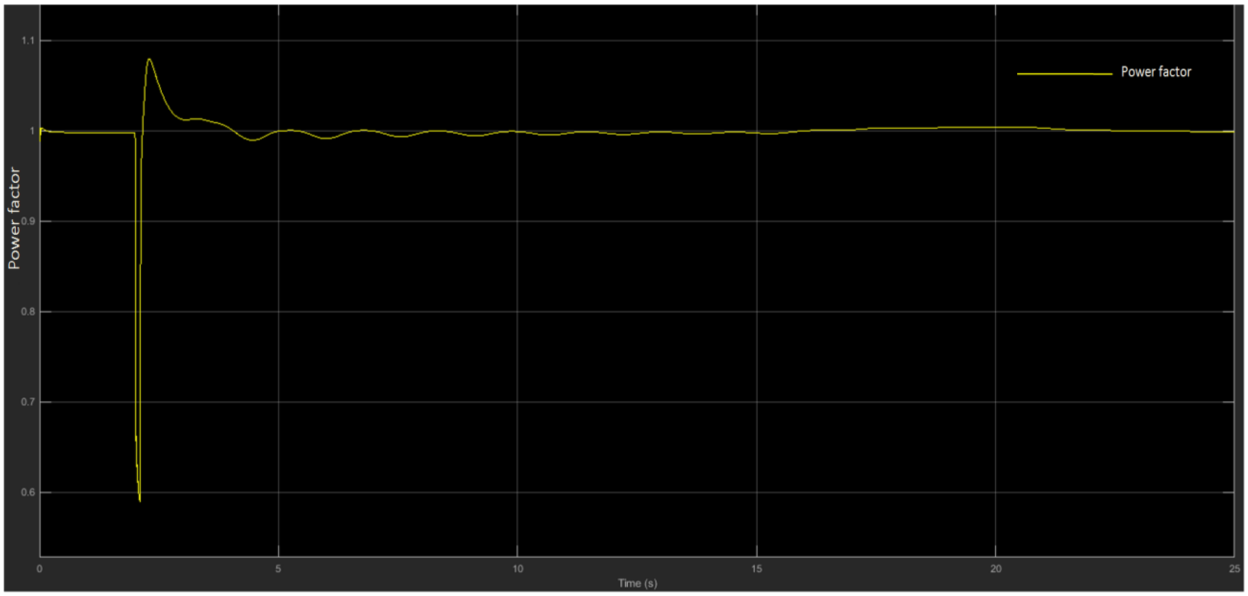

Figure 6: The power factor of the 11KV transformer with Capacitor Bank

From the result of figure 6, the transformer performance with capacitor integration was presented. The result showed that the power factor maintained a range within the standard tolerable value of ±5% (0.95). Even at the point in the graph where it dropped rapidly due to high loss due to reactive load as described in equation 3, the capacitor band immediately induced reactive power compensation to boast load flow and stabilize the power factor as shown in the result.

4.3 SYSTEM INTEGRATION AT THE EEDC 33/11KV FEEDER

Having tested the system developed and uncovered its ability to automatically correct power factor changes due high loss in the transformer; the genetic algorithm developed was used to identify the necessary bus which need placement of capacitor and then result when tested was presented in the table 3;

Table 3: Thinker's Corner feeder Data with Capacitor

Bus No.	Load Power		Line current			Loss Data			
	P(KW)	Q(KW)	Active (A)	Reactive (A)	Line (R)	Loss due to active current	Loss due to reactive	Total power losses (KW)	Power factor (pf)

							current		
1-2	225	235	254.9	-154.3	0.117	6.942	0.698	7.639	0.963483
2-3	230	220.6	242.8	-146.8	0.107	5.674	0.240	5.914	0.959085
3-4	250	251	230.6	-139.2	0.164	0.160	0.058	0.218	0.996048
4-5	230	142.5	218.3	-131.6	0.149	0.018	0.006	0.024	0.998429
5-6	230	142.5	205.9	-124.0	0.149	0.070	0.027	0.097	0.997328
6-7	211	220	070.3	-41.5	0.314	4.655	1.707	6.363	0.961932
7-8	230	234	57.90	-34.8	0.209	2.113	0.763	2.875	0.982098
8-9	230	1425	45.30	-27.2	0.314	1.942	0.698	2.639	0.983483
9-10	230	142.5	32.70	-19.6	0.209	0.674	0.240	0.914	0.990865
10-11	250	251	20.20	-12.2	0.131	0.160	0.058	0.218	0.996048
11-12	230	142.5	07.50	-4.5	0.105	0.018	0.006	0.024	0.998429
3-13	137	84	12.20	-7.5	0.157	0.070	0.027	0.097	0.997328
13-14	72	45	08.30	-5.2	0.209	0.044	0.018	0.061	0.998694
14-15	72	45	04.50	-2.8	0.105	0.007	0.002	0.009	0.999047
15-16	72	45	00.70	-0.4	0.052	0.001	0.002	0.001	0.999887
6-17	13.5	7.5	135.7	-81.5	0.179	1.942	0.698	2.639	0.983483
17-18	230	142.5	123.1	-73.8	0.164	0.674	0.240	0.914	0.990865
18-19	230	142.5	110.5	-66.2	0.207	0.160	0.058	0.218	0.996048
19-20	230	142.5	97.80	-58.5	0.189	5.421	1.941	7.363	0.960935
20-21	230	142.5	85.00	-50.8	0.189	4.101	1.464	5.567	0.961993
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22-23	230	142.5	59.40	-35.5	0.262	2.776	0.988	3.763	0.982543
23-24	230	142.5	46.54	-27.7	0.314	2.043	0.726	2.769	0.990271
24-25	230	142.5	33.62	-20.0	0.209	0.711	0.252	0.963	0.998949
25-26	230	142.5	20.68	-12.3	0.131	0.168	0.059	0.228	0.998999
26-27	230	142.5	7.72	-4.6	0.105	1.942	0.698	2.639	0.983483
27-28	137	85	12.55	-7.7	0.157	0.674	0.240	0.914	0.990865
28-29	75	48	8.19	-5.1	0.157	0.031	0.012	0.044	0.999576
29-30	75	48	4.09	-2.5	0.157	1.942	0.698	2.639	0.983483
10-31	75	48	12.55	-7.4	0.157	0.074	0.026	0.100	0.999932
31-32	57	34.5	9.41	-5.55	0.209	0.056	0.019	0.075	0.999798
32-33	57	34.5	6.27	-3.70	0.157	0.019	0.007	0.025	0.999399
33-34	57	34.5	3.14	-1.85	0.105	0.003	0.001	0.004	0.999835

The Table 3 presented the performance of the feeder when integrated with capacitor. The result showed that the total loss recorded is 63.524KW.

This capacitor placement bus was determined with the genetic algorithm developed to identify bus with the weakest power factor and then compute the size of the necessary capacitor with equation 6. From the result it was observed that all the bus has a power factor value within the acceptable tolerance. This was due to the ability of the capacitor to induce reactive power when losses are recorded and then balance the load flow which the resultant effect is on the new power factor result recorded.

4.4 The Comparative Analysis

This section compared the performance of the new system and then characterized system without the capacitor. This was achieved using the result collected from the empirical study and then result of the system integration and compared as shown in the table 4;

Table 4: Comparative Analysis

Bus	Total power losses (KW)	Power factor (pf)	Total power losses (KW)	Power factor (pf)
BusNo.	Without Capacitor		With Capacitor	
1-2	31.169	0.709199	7.639	0.963483
2-3	25.899	0.721454	5.914	0.959085
3-4	35.798	0.698886	0.218	0.996048
4-5	29.143	0.716571	0.024	0.998429
5-6	25.911	0.722362	0.097	0.997328
6-7	6.363	0.961932	6.363	0.961932
7-8	2.875	0.982098	2.875	0.982098
8-9	2.639	0.983483	2.639	0.983483
9-10	0.914	0.990865	0.914	0.990865
10-11	0.218	0.996048	0.218	0.996048
11-12	0.024	0.998429	0.024	0.998429
3-13	0.097	0.997328	0.097	0.997328
13-14	0.061	0.998694	0.061	0.998694
14-15	0.009	0.999047	0.009	0.999047
15-16	0.001	0.999887	0.001	0.999887
6-17	13.475	0.896099	2.639	0.983483
17-18	10.163	0.887453	0.914	0.990865
18-19	10.342	0.883407	0.218	0.996048
19-20	7.363	0.960935	7.363	0.960935
20-21	5.567	0.961993	5.567	0.961993

21-22	5.567	0.961994	5.567	0.961994
22-23	3.763	0.982543	3.763	0.982543
23-24	2.769	0.990271	2.769	0.990271
24-25	0.963	0.998949	0.963	0.998949
25-26	0.228	0.998999	0.228	0.998999
26-27	25.992	0.722454	2.639	0.983483
27-28	35.992	0.691235	0.914	0.990865
28-29	0.044	0.999576	0.044	0.999576
29-30	36.503	0.673251	2.639	0.983483
10-31	0.100	0.999932	0.100	0.999932
31-32	0.075	0.999798	0.075	0.999798
32-33	0.025	0.999399	0.025	0.999399
Average	63.524	0.988018	320.056	0.911649

The table 4 presents the result of the comparative analysis of the testbed with capacitor and without capacitor. The result showed that with the capacitor the average loss recorded is 63.524KW as against 320.056KW in the characterized testbed.

The result showed that the buss which has poor power factor was corrected by the capacitor via the injection of reactive current and the power factor was improved.

The result showed that with capacitor, the power factor was fairly constant and satisfied the NERC requirements and tolerance standard for optimized transfer performance. The average power factor with capacitor is 0.988019 as against 0.911649 without capacitor. The percentage improvement in the power factor is 7.7296%.

5.0 CONCLUSION

This study has successfully developed a smart algorithm for the detection of bus with poor power factor and then corrects it with capacitor bank connected at the primary side of the transformer for optimization. This was deployed at the Thinkers corner 15MVA, 33/11KV distribution feeder and the result showed that the losses was reduced due to the ability of the capacitor to inject reactive power and hence maintained good power factor result. The system was implemented with Simulink and tested. The result showed that the power factor of the bus was corrected to tolerable standard of the NERC. The performance of the feeder was compared with the original performance without capacitor and the result showed that the percentage power factor improvement is 7.7296%.

6.0 REFERENCES

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