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DESIGN OF AN ELECTRICAL DISTRIBUTION NETWORK WITHIN DAMATURU

(A case study of Damaturu town-Yobe State capital, Nigeria)

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ABSTRACT

This project presents a novel method for designing of an electrical power distribution network within Damaturu town with highly accurate-efficiency. The design involves the task of designing a new electrical power distribution network that will be efficient and reliable. The town is been supply by $2\ x\ 7.5MVA$ transformers which became grossly overloaded due to the frequent increases in demand because of the series of developmental projects. The capacities of all the transformers were taken and the percentage loading of the whole injections substation were calculated. Suggestion is being made as for the capacities of power transformers that can accommodate the future load to avoid any problem of power demand factor. The new design recommended to use $2\ x\ 7.5MVA$ transformers, one transformer will supply the Alimarami Feeder while the other one will serves the Maiduguri road feeder thereby, tackling the problems

of over loading on the installed injection substation transformers and the distribution transformers. The work recommended using $2\,x\,7.5MVA$ transformers at the injection substation. The project is designed in such a way that it has to be implemented at stages which gives wide choice of procedures.

1 Introduction

Energy is the basic necessary of the economic development of any country. Energy exists in different form in nature but the most important one is electrical energy. The power systems consist of three (3) principle divisions which are Generation, Transmission and distribution. In Nigeria the main generating power station generate between $11kV$ to $21kV$ which is step-up to $330kV$ and $132kV$ for primary and secondary transmission respectively and distributed at 33kV, 11kV and 0.415kV respectively. The Damaturu town distribution line network is connected to Potiskum $132/33kV$, the distribution lines is linked with some other local government and other villages around the town which has been exposed to harsh whether condition and difficult terrains, particularly from Buniyadi to Bukar Abba University where the line passed through bush and costive places which has become so hectic for the power holding company's officials to patrol the line in the event of any fault occurrence. Furthermore if any of those villages are vandalized due to lack of proper security on that portion of line accessories such that conductors, insulators, cross-arm and other transmission facilities, which may need an exigent attention for proper maintenance which will require an urgent turn around maintenance which is the to and fro movement of the staff along the line to detect an electric faults, trace it and carry out proper maintenance on it annually. The line has been existed over a decade. Due to ageing virtually all the poles (wooden ones) and cross arms have either collapse or are at this verge of collapsing and therefore persistent maintenance at a given time has to be given to the time and failure to do this it will cause a problem to the State capital Damaturu. Over a long period of neglect as a result of the above mentioned reasons, the $33kV$ line (feeder) hardly stays for 24 hours without experiencing tripping hence stability of power supply is highly compromised coupled with other reason such as lack of the existing transformers to cater for the existing load demand of these areas. Moreover, using inappropriate materials and substandard material add to difficulties for instead one will find out sometimes that where $33kV$ insulators are to be used instead of $11kV$ insulators which the result will not gives the required demand by the line which in turn will be of high impact on the transformers and consequently on the household electrical appliances too. Most consumers especially in Damaturu tend to dismiss with a wave of the hand the fact that electricity supply is highly subsidized. At the inception of the electrification of the town $1 \times 7.5\ MVA\ 33/11kV$ is used in 1995 and in 2002 the line was isolated from the Benisheik feeder and was linked to Potiskum transmission line due to breakdown of poles in the Benisheik transmission lines. Considering all the problems of power holding company of Nigeria at Damaturu town as it was elaborated in the later chapter the factors have contributed and the frequent growth of the town. Hence, there is a need to adopt this new design so as to tackle those problems. Upon all the problems enumerated, there are ways or solutions that will facilitate the effectiveness of designing of new distribution network within the town. These problems generally bring about the need for designing another distribution network within the town. There is a need to install bigger transformers for the two feeders that is Maiduguri road feeder and Alimarami road feeder, which can be feed up with $2 \times 15MVA$ transformers because of the problems encountered from the existing network which was design when the town was not development and poorly populated. Due to the increase of the consumers it is necessary to design

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new plans hence; it is the purpose of this project which is name design of electrical distribution network within Damaturu town.

2 Methods

2.1 Transformers Capacities

The town is divided into industrial, non -industrial and residential area. In terms of load survey, each feeder was carryout separately. This is done by summing up the load readings of all the substations in a particular feeder. The below relation was used to obtain the load demand of each feeder: In order to determine whether a particular substation is overloaded or more rated current of the various transformers size of capacity is considered by using the below relation:

$$P = \frac{KVA}{\sqrt{3}\times 0.415} - - - - - equation\ (1)$$

Where,

KVA,= transformer capacity

V_L, = 0.4I5kV

$\cos\emptyset = Power\ factor$

2.2 Percentage Loading of the Distribution Transformers

Transformer percentage loading is obtained from the expression

$$\%\ \text{Loading} = \frac{(I_R + I_Y + I_B)}{3\times I_L} \times 100\ \text{------}\ equation\ (2)$$

Where:

$I_{\mathrm{R}} = \mathit{Current\ in\ the\ red\ wire};$

$I_{\mathrm{Y}} = \mathit{Current\ in\ the\ yellow\ wire};$

$I_{\mathrm{B}} = \mathit{Current\ in\ the\ blue\ wire}.$

2.3 PRESENT LOAD OF THE DISTRIBUTION TRANSFORMERS.

To calculate the present load demand of the whole town, the individual real power of all the distribution substation have to be calculated. Using the formular of real power (3-phase).

$\mathit{Real\ power} = \sqrt{3} \text{ x } I_{\mathrm{L}} \text{ x } V_{\mathrm{L}} \text{ x } \cos\emptyset - - - - - \mathit{equation}\ (3)$

$\mathit{Where},$

$V_{\mathrm{L}} = \mathit{Line\ voltage}$

$I_{\mathrm{L}} = \mathit{Line\ current}$

$\mathit{Cos}\emptyset\ = \mathit{power\ factor}\ (0.8\ \mathit{under\ normal\ condition})$

2.4 Load Analysis

The method used in getting the present load demand of the whole town is obtained by summing up the real power of the individual distribution transformers of each feeder.

3 RESULTS

In order to determine whether a particular substation is overloaded or more rated current of the various transformers size are considered as shown in the table 3.1

Table 3.1: Current capacities of different distribution transformers

INSTALLED CAPACITY (KVA)	RATED CURRENT (A)
100	139
200	278
300	417
500	696

Application of equation 1 gives 139A as rated current of 100KVA transformer. And for 200KVA, 300KVA, and 500KVA give 278A, 417A, and 696A respectively.

3.1 Percentage Loading of the Distribution Transformers

Transformer percentages loading of the transformers of all the feeders of the sub-stations were obtain using equation (2).

Table 3.2: Shows a loading percentage of some of the distribution transformers

S/No	Substation name	Capacity (KVA)	Red	Blue	Yellow	Neutral	% loading
1	3bedroomb/h	100	180	100	150	60	103.1
2	A Medical center	300	270	350	300	15	74.0
3	Low cost Alim.	200	210	240	230	60	82.0
4	250housess/s	200	210	240	250	52	83.9
5	40housess/s2	100	100	180	100	25	91.1

Transformers capacities is said to be overloaded when the current drawn is more than the rated current. It can be seen from Table 3.2 that all the transformers are overloaded there are more than 200 transformers located in the town's distribution sub-stations and their percentage loading showed that they are overloaded. In an ideal situation a transformer will not withstands beyond it rated current and if it does so it exceed it saturation limit which can lead to sudden damage or tripping of the transformer

3.5 PRESENT LOAD OF THE DISTRIBUTION TRANSFORMERS.

To calculate the present load demand of the whole town, the individual real power of all the distribution substation have to be calculated. Using equation (3)

Considering the I_R I_Y, and I_B of the distribution transformers from table 3.2 and 3.3, the real power of the distribution transformers is calculated in the table 3.4 and table 3.5 respectively.

Table 3.4: shows a real power of some of distribution transformers

S/no.	Substation names	Capacity (KVA)	Percentage loading
1	N.T.A. Substation	300	132.2
2	250 houses estate s/s 1	200	105.4
3	250 houses estates/s 2	500	162.9
4	250 houses estate s/s3	200	134.2
5	A.P substation	300	134.2

3.6 Load Analysis

The present load demand of the whole town was obtained using equation (3) by summing the real power of the individual distribution transformers of all the transformers.

Below are the grand total of the entire town's distribution network.

Therefore,

$$Maiduguri\ road\ feeder = 8028.3KW$$

$$Alirnarami\ road\ feeder = 7776.0KW$$

$$TOTAL = 15804.5KW$$

$Approximately = \ 16MW$

$The\ present\ load\ stands\ at\ approximately\ equal\ to\ 16MW.$

$Future\ load\ is\ estimated\ to\ be\ 8MW.$

Therefore, the total load expectation is

$$= \ (16 + 8)MW$$

$$= \ 24MW$$

In a normal condition the power factor is 0.8 hence,

$$24\ MW \ = \frac{24}{0.8}MVA$$

$$30MVA$$

Going by this design, the town should first and foremost be feed with $2 \ \times 15MVA$ transformers one serving Alimarimi road feeder and the other one Maiduguri road feeder. This implies that there should be $2 \ \times 15MVA$transformers at the injection substation instead of $2 \ \times 7.5MVA$.

4 DISCUSSIONS OF RESULTS

The town has been surveyed in order to estimates the demand and study its conditions and actual situation of existing facilities to the demand and study load characteristics of the town, the size, population and various other data relevant in the successful conduct of the load assessment. The analysis of the present load demand shown that the total load of the whole town plus the future load demand stands at $30MVA$ and the town is divided into two feeders. Therefore the new design recommended using $2 \ \times 15MVA$ transformers, one transformer will serves Alimarami road feeder (T_1) while the other one will feed Maiduguri road feeder (T_2) thereby, tackling the problems of over loading on the install transformers and the distribution transformers, if there is fault at any of the feeder a bus coupler will be use to couple T_1 or T_2 to allow maintenance on the faulty feeder since capacity of any of the transformer can carry the whole town. The work recommended using $2 \times 15MVA$ transformers at the injection substation. The project is designed in such a way that it has to be implemented at stages which gives a wide choice of procedures.

5. Conclusions

It is concluded that the project examined critically the condition of Damaturu $33/11kV$ distribution network problems, by finding a proper ways of solving the problems. The system has been designed to meet the present requirements of consumers and can conveniently carry loads which come in the near future. It is very simple to operate and maintain. The routine maintenance can be carried with minimum interruption of supply.

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