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ELECTRICAL FAULT ASSESSMENT OF A 33KV DISTRIBUTION NETWORK A CASE STUDY OF ILE-OLUJI 33KV FEEDER

Adetunmbi, A.O.[1], Ebinowen, T.D. [2] & Akinnifesi A.F[3]

[1,2&3]Department of Electrical/Electronic Engineering, Federal Polytechnic, Ile-Oluji, Ondo State

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ABSTRACT

This work examines faults on a 33KV feeder network in Ile-Oluji. The town is one of the major towns in Ondo State that experiences epileptic power supply due to bad feeder network (bad terrain of the 33KV line), disrepaired and old-fashioned electrical power equipment. In this research work, diferent types of fault including overcurrent and earth faults were studied. These was as a result of the newly located higer institution (Federal Polytechnic, Ile-Oluji) in the town and the need for regular power supply to avoid student unrest. During the study, fault data on the feeder between the period of 2012-2016 were collated from Ondo 33/11KV Injection Substation's logbook of Benin Electricity Distribution Company. The data was analysed using SPSS 17.0 version. The research revealed that faults occurred oftent in the third quarter of the year (rainy season) due to thick vegetation along the feeder line while the least number of faults is usually recorded in the first quarter (Januray to March). Single Phase Earth fault was found to be the most occuring fault with an avegrage quarterly occurrence of 25.8125 while the Three Phase Overcurrent fault has the least with a quarterly average of 5.3125. Analysis of variance among fault types reveal a very high significant differences among the fault types. The Inter-fault Correlation showed that highest degree of relationship exists between Three Phase and Single Phase Earth faults. Other pairs of faults also revealed that considerable positive relationships with exception of Single Phase Overcurrent and Single Phase Earth faults. Based on these observations, it was deduced that for the town to enjoy regular power supply, a thorough rehabilitation must be carried out on the feeder by clearing all the thick vegetation along the feeder and replacing some bad equipment.

Keywords: 33KV feeder network, overcurrent fault, earth fault and Injection substation.

1. INTRODUCTION

Electric power system is a network of electrical components that deals with the generation, transmission, distribution and utilization of electric power [1]. The power system is also called the grid which is divided into three segments:Generation, Transmission and Distribution.

-Generation: This is the conversion of energy available in different forms in nature into electrical energy. Energy is available in various forms from different natural sources such as solar,pressure of water, chemical energy of fuels, nuclear energy, wind etc.

-Transmission System: This conveys the power generated from the generating centres to the load centres. The electric power at 132KV is transmitted by 3-phase, 3-wire overhead transmission line and terminates at a Receiving Station (RS). At the receiving station, the voltage is reduced to 33KV by step-down transformers. From this station, electric power is transmitted at 33KV also by a 3-phase, 3-wire overhead system to various Sub-Stations (SS) located at the strategic points in the city.

-Distribution System: that give power supply to residential homes, commercial homes and industries. The transmission line terminates at the sub-station(SS) where voltage is reduced from 33KV to 11KV, 3-phase, 3-wire. The electric power from 11KV distribution line is delivered to Distribution Sub-stations(DS). These sub-stations are located near the customers' areas and step down the voltage to 415V, 3-phase, 4-wire distribution system in Nigeria. It may be different in different countries. The voltage between any two phases is 415V and between any phase and neutral is 220V. The single-phase residential lighting load is connected between any one phase and neutral, whereas 3-phase, 415V motor load is connected across 3-phase lines directly.

Both developmental growth and econmical growth of a country is determined by the availabilty of steady power supply. Electric power supply is the most important commodity for national development. With electrical energy the people are empowered to work from the domestic level and the cottage industries, through the small-scale and medium industries to employment in the large scale manufacturing complexes [2]. In these days, depriving people of electric power is tantamount to castration. The Federal Government of Nigeria has tried all possible means to minimize power outages in the country and increase power avalability by building more generating stations. Gordon Clapp, a former General Manager of the Tennessee Valley Authority (U.S.A) once said: " If you would destroy a region, you destroy its power supply. If you would hold a region to a lower standard of living, you can do it by placing a limit on its supply of electric power'' [3].

Power outages in Ile-Oluji town has affected the development of the town particularly commercial activities. ''Any reliable electric power system should serve consumers without awkward interruptions in power supply voltage, but in Nigeria today, consumers of electric power sector are subjected to unplanned outages on a regular basis which influence customer satisfaction" [4].

Power failure occurs when there is disturbance in the electrical power transmission/ distribution line and Power Holding Company (as it was called then before the privatisation) will respond to the outage and make any repairs necessary to restore power supply [5]. When these faults occur there is an immediate demand for repairs of the electrical power line [6]. There are two types of power outages:

(1) Planned Power Outage
(2) Unplanned Power Outage

Planned Power Outage: This type of power outage occurs either when there is need to carry out routine maintenance on the substations/ line network to prevent perpersual breakdown or when there is need to carry out loadshedding at some areas due to poor energy generation. The commencement date, commecement time, duration day and duration time of this type of power outage is well specified before it occurs.

Unplanned Power Outage: This type of power outage occurs as a result of fault on the network. The duration of this type of power outage is unknown. The duration will last until the fault on the network is cleared. Unplanned power outages are due to different factors which include:

(i) natural factor like rain storms, transient lightning strikes etc
(ii) environmental factor eg untrimmed thick vegetation along the line, touching of line by birds (iii) faulty equipment factors eg shattered insulators, conductor cut down, dilapidated equipment.

1. 33 KV DISTRIBUTION NETWORKS IN ILE-OLUJI

The 33 kV and 11 kV distribution networks in Ile-Oluji is of radial distribution network system configuration. This pattern is the easiest and common-place in terms of usage but with its own demerits. It has separate feeders that radiates out of the substation with each feeder serving a particular area [7]. To provide alternate source when there is a fault on the other it is best suitable to use a ring distribution network system since the 33kV networks encompasses a substantial part of Ondo State. There is high presence of thick vegetation in this area which needs to be cleared often times to minimise the occurrence of earth fault on the network. Due to unpredictable weather condition in this area, rainfall season varies which also contribute immensely to electrical fault [6].

2. METHODOLOGY

A comprehensive study of electrical faults was carried out on Ile-Oluji 33KV feeder in Ondo State to ascertain the the number of occurrence of different types of fault within duration of five years (2012-2016). The faults on the feeder affected different types of consumers ranging from industrial, commercial and residential customers. Monthly data on five major fault types (Single Phase Overcurrent, Three Phase Overcurrent, Single Phase Earth, Two Phase Earth, and Three Phase Earth) were collected from 2 x 7.5 MVA Ondo 33/11KV Injection substation of Benin Electricity Distribution Company, Ondo, Ondo State from 2012 to 2016. These data were cummulated from montly observations to quarterly observations because of high frequency of zero fault (no fault) in many months (especially between November and February). SPSS ststistical software package version 17.0 which is now popular in other fields including sciences and engineering was used tabulate the report and analyze the data.

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Time plots for the quarterly observations were drawn for each fault type (Overcurrent and Earth faults). Component bar chart was also drawn for all the fault types for the entire period under review to present the quarterly distribution of fault types at a glance.

Correlations between pairs of faults are also examined to access the degree of relationship existing among fault types. Analysis of variance to examine significant difference among the fault types is also carried with the data layout below:

Table 1: Types of Fault

Year	Quarter	Fault Type				
		Singat lowest le Phase Overcurrent	Three Phase Overcurrent	Single Phase Earth	Two Phase Earth	Three Phase Earth
2013	Q1 . . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .
2016	. . . Q4	. . .	. . .	. . .	. . .	. . .

3. RESULTS AND DISCUSSION

Time plot for the two types of faults (figures 1 and 2) show that lowest number of fault is often recorded in the first quarter (January to March) of every year while the highest frequency of fault occurrence are usually observed on the third quarters (July to September). This may be due to change in weather condition (ie rainy season) and bad feeder network. Also, Single Phase Earth fault has the least frequency of occurrence while Two Phase Earth fault has the highest. Occurrence of Single Phase Overcurrent fault is lower compared to the Three Phase Overcuurent. At a glance, the component bar chart (figure 3) shows that the first quarter has the least occurrence of faults recorded while the third quarter has the highest.

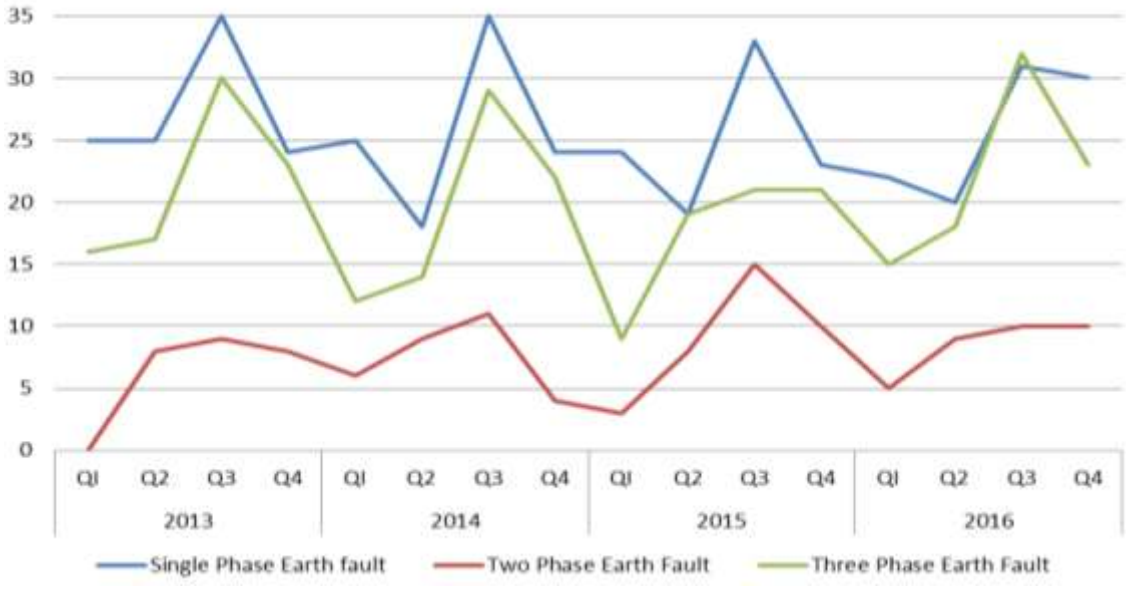

Figure 1: Quarterly Earth fault over the four year period

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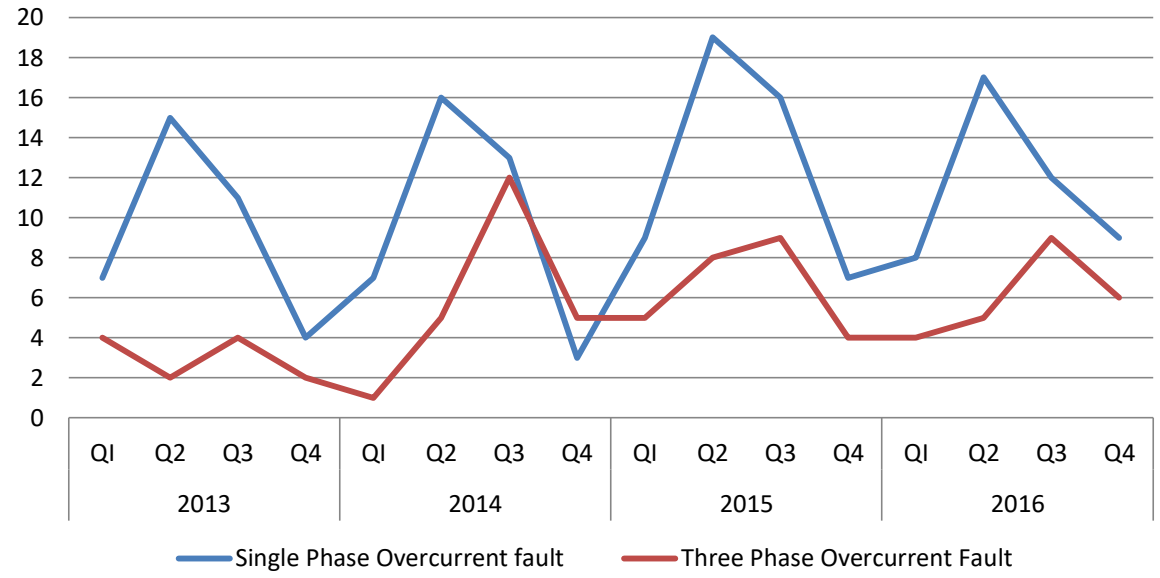

Figure 2: Quarterly Overcurrent fault over the four year period

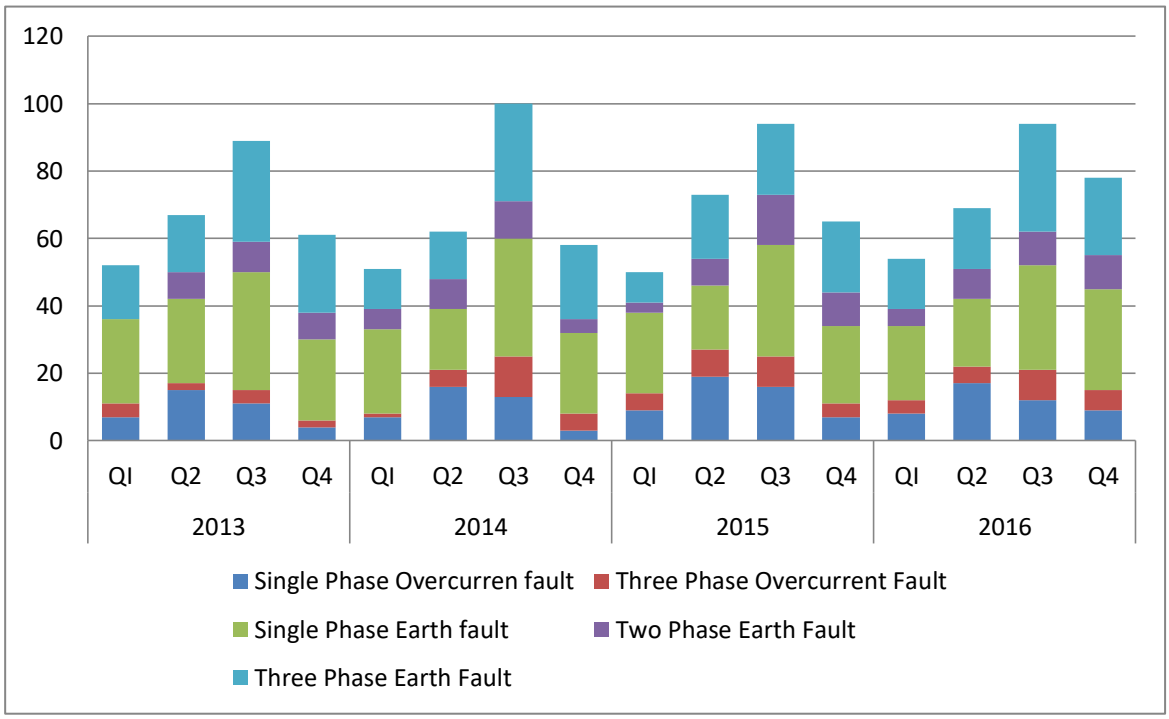

Figure 3: Component Bar Chart showing different fault types over the four years

Descriptive statistics of the frequency of occurrence of faults (table 2) reveal that Single Phase Earth fault is the most occuring fault with an avegrage quarterly occurrence of 25.8125 over the period under review while the Three Phase Overcurrent fault has the least with a quarterly average of 5.3125.

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Table 2: Descriptive Statistics

Groups	*Sum*	*Average*	Std. Dev	Std. Error	95% Conf. Interval	
Single Phase Overcurrent fault	173	10.8125	4.8197	1.2049	8.2443	13.3807
Three Phase Overcurrent fault	85	5.3125	2.9148	0.7287	3.7593	6.8657
Single Phase Earth fault	413	25.8125	5.4187	1.3547	22.9251	28.6999
Two Phase Earth fault	125	7.8125	3.5631	0.8908	5.9138	9.7112
Three Phase Earth fault	321	20.0625	6.4547	1.6137	16.6231	23.5019
Total	1117	13.9625	9.0951	1.0169	11.9385	15.9865

Table 3: (Inter-fault Correlation) reveal that highest degree of relationship exists between Three Phase and Single Phase Earth faults. Other pairs of faults also show considerable postive relationships with exception of Single Phase Overcurrent and Single Phase Earth faults. The implication of this relatively positive and moderate relationship is that a single measure to reduce a particular fault occurrence will go a long way in correcting for others.

Table 3: Inter-fault Correlations Analysis

Single Phase Overcurrent fault	1				
Three Phase Overcurrent fault	0.4600	1			
Single Phase Earth fault	-0.0525	0.4514	1		
Two Phase Earth fault	0.5141	0.4875	0.4228	1	
Three Phase Earth fault	0.0240	0.5127	0.6884	0.5165	1

Analysis of variance (table 4) among fault types reveal a very high significant differences among the fault types. This is observed at a glance from the mean plots (figure 5)

Table 4: Analysis of variance result for faults

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4803.200	4	1200.800	52.007	6.71396E-21	2.494
Within Groups	1731.688	75	23.089			
Total	6534.888	79				

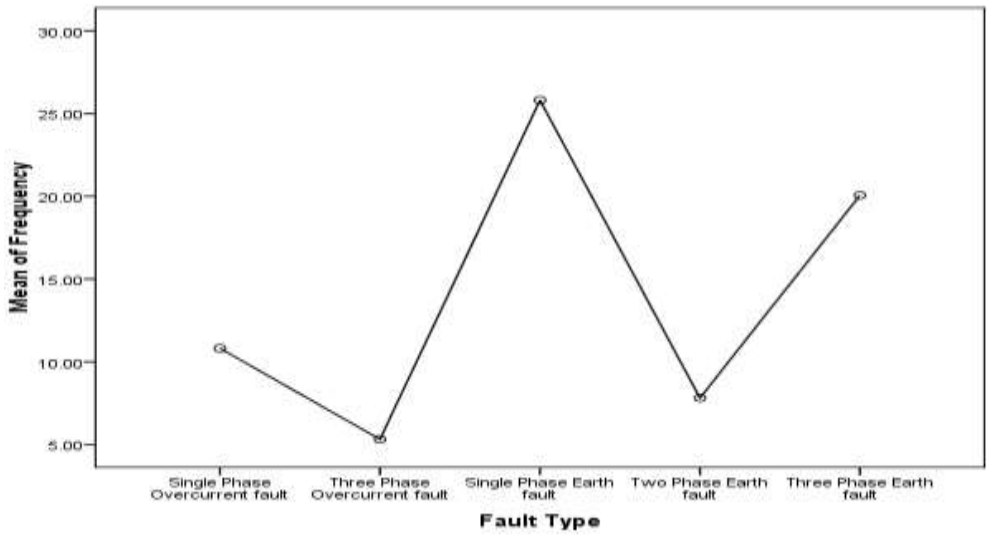

Figure 5: Mean Plots for all the faults over the four year period

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Turkey HSD Post Hoc test of homogeneous subsets (table 5) reveal that:

(i) there is no significant difference between Three Phase Overcurrent and Two Phase Earth faults.

(ii) occurrence of Two Phase Earth fault is not significantly different from the occurrence of both Three Phase Overcurrent and Single Phase Overcurrent faults.

(iii) frequency of occurrence of Three Phase Earth fault and Single Phase Earth fault is significantly different from any pair of fault occurrences.

Table 5: Tukey HSD Post Hoc Tests of Homogeneous Subsets

Fault	Subset for alpha = 0.05			
	1	2	3	4
Three Phase Overcurrent fault	5.3125			
Two Phase Earth fault	7.8125	7.8125		
Single Phase Overcurrent fault		10.8125		
Three Phase Earth fault			20.0625	
Single Phase Earth fault				25.8125
Sig.	.584	.401	1.000	1.000

4. CONCLUSION

This paper has presented an analysis of a 33KV distribution network in Ile-Oluji, Ondo State from year 2012 to 2016 which among other things investigated the occurrences of fault on this feeder using SPSS version 17.0 statistical software. Five different fault types were examined from 2 x 7.5 MVA Ondo 33/11KV injection substation of Benin Electricity Distribution Company. Analysis revealed that lowest number of fault is often recorded in the first quarter of every year while the highest frequency of fault occurrence are usually observed on the third quarters. The high frequency of fault in the third quarter may be attributed to change in weather condition (rainy season) and bad feeder network. Single Phase Earth fault is the most occuring fault with an average quarterly occurrence of 25.8125 over the period under review while the Three Phase Overcurrent fault has the least with a quarterly average of 5.3125. Analysis of variance among fault types reveal a very high significant differences among the fault types.

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