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A THESIS REPORT ENTITLED

INVESTIGATING THE FREQUENT BURNOUT OF 33 kV/433 V DISTRIBUTION TRANSFORMERS OF ECG

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SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCEINCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

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TARKWA, GHANA
AUGUST, 2020

DECLARATION

I declare that this thesis is my own work. It is being submitted for the degree of Master of Science in Electrical and Electronic Engineering in the University of Mines and Technology (UMaT), Tarkwa. It has not been submitted for any degree or examination in any other University.

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(Signature of Candidate)

--------- day of --------------------, 2020

ABSTRACT

Transformers are one of the important devices in electric power transmission and distribution systems. These devices are used to control voltage and current levels on an electrical network by either stepping it up for transmission or stepping it down for utilisation. A distribution transformer provides the final voltage transformation in an electric power distribution system. Transformers, like many electrical devices, are prone to faults. These faults, regardless of their intensity can result in high financial implications. Failures of in-service distribution transformers not only limit system performance and reliability, but also have a serious social impact because of unscheduled outages of the electricity supply. The research focus on eliminating the lightning arrester leads length, which contributes to the total discharge voltage that is incident on a transformer during lightning surges. MATLAB Simulink (SimPowerSystems) is used to model the existing system and various simulations are performed to assess the effect of different lightning arrester configurations. The results indicate that when the lead length of the lightning arrester is reduced or eliminated, there is a higher margin of protection on the transformer, which implies that the frequent burnout of distribution transformers can be mitigated with the introduction of the Zero Lead Length configuration.

DEDICATION

I dedicate this study to the Almighty God for giving me good health, strength, wisdom and understanding for this research work. I also dedicate this study to my brother, Gerald Yiran, my wife and my daughters for their support. Besides, I dedicate this study to all sub-transmission protection and control engineers for their support and inspiration.

ACKNOWLEDGEMENTS

I will like to express my sincere gratitude to my Supervisor, Dr Solomon Nunoo for his support, guidance and contribution throughout the research work. Moreover, I would like to thank all Electrical and Electronics Engineering Department lecturers who in one way or another helped me to complete my research. I also thank Mr William Asihene for his support and help throughout the research work. God bless you all.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AC	Alternating Current
BDV	Breakdown Voltage
BIL	Basic Insulation Level
CSEB	Chhattigarh State Electricity Board
DC	Direct Current
DGA	Dissolved Gas Analysis
DoF	Drop Out Fuse
DP	Degree Polymerisation
ECG	Electricity Company of Ghana
EMF	Electromotive Force
GH₵	Ghana Cedis
GMT	Ground Mounted Transformer
HRC	High Rupturing Capacity Fuse
HT	High Tension
HV	High Voltage
IEEE	Institute of Electrical and Electronics Engineers
Kv	Kilo – Volts
kVA	Kilo-Volts Ampere
kVAR	Kilo - Volts Ampere Reactive

KW	Kilo-Watts
LV	Low Voltage
MATLAB	Matrix Laboratory
MCCB	Moulded Case Circuit Breaker
MCOV	Maximum Continuous Operating Voltage
MV	Medium Voltage
MVA	Megavolt Ampere
MOP	Margin of Protection
PESCO	Peninsula Energy Services Company
PMT	Pole Mounded Transformer
TAN	Total Acid Number
TOV	Temporary Over Voltage
WAPDA	Water and Power Development Authority

LIST OF SYMBOLS

Arrester discharge voltage	V_{sa}
Arrester lead length	L
Capacitance	C
Constant	K
Delta	D
Grounding resistance	R_E
Inductance of lead length	L
Lead length discharge voltage	V_L
Lightning discharge current	I_{dis}
Micro	µ
Number of turns in primary windings	N_P
Number of turns in secondary windings	N_S
Primary current	I_P
Primary voltage	V_P
Resistance	R
Resistance of non-linear arrester	R_{sa}
Secondary current	I_S
Secondary voltage	V_S
Star connection	Y

Star connection with neutral	Y_n
Time	t
Turns Ratios	N
Total discharge voltage across insulation	V_{total}

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Quantity	Unit	Symbol
Electric capacitance	farad	F
Electric current	ampere	A
Electric potential	volt	V
Electric resistance	ohm	Ω
Frequency	hertz	Hz
Inductance	henry	H
Length	kilometre	km
Power	kilowatt	kW
Time	seconds	s

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background to the Research

Transformers are devices that transfer electrical energy from one circuit to another by means of electromagnetic induction. These devices are primarily used to control voltage and current levels on a network, and form a major component of a typical power system. A distribution transformer provides the final voltage transformation in the electric power distribution system, stepping down the voltage in the distribution lines to the level used by the customer (Gomez-Exposito *et al*., 2018).

Transformers, like any other electrical devices are prone to faults. Statistics have shown that about 12% of faults experienced in a power system are due to transformer failures (Yazdani-Asrami *et al*., 2014).

Failure of in-service distribution transformers not only limit system performance and reliability, but also have a serious social impact because of unscheduled outages of the electricity supply. Power utility companies consequently incur high economic losses in replacing or repairing burnt transformers. These burnt transformers also have a great effect on the end user. Aside the inconvenience caused to the domestic user, companies will have to battle with reduction in productivity and security leading to high financial implications (Ndungu *et al*., 2017).

To maintain reliability and reduce the failure rate of distribution transformers, it is necessary to investigate and find solutions to the causes of failure. Harlow (2018) proposed that, a conjecture of cause must be established to determine the root cause of failure. Real time field data should then be collected, analysed, and conclusions drawn from the analysis.

According to Ali (2013), failure of a transformer is dependent on the life and exposure of its insulation. Failure of the transformer insulation is primarily caused by heat, oxidation, acidity and moisture, line surges such as lightning and switching surges. Dielectric strength is maintained until insulation is exposed to certain elevated temperatures. At that point the insulation becomes brittle and exhibits less mechanical strength, resulting in insulation failure and end of transformer life (Anon., 2016a).

Among the aforementioned causes of transformer insulation failure, this work will seek to identify the major cause of failure on transformers on the Electricity Company of Ghana's (ECG) network.

1.2 Problem Statement

Providing the final voltage transformation places the distribution transformer in a critical position in the power system. Failure of these devices goes a long way to threating the reliability and security of such systems.

In Ghana, it is much difficult to replace or repair damaged transformers due to the lengthy procedures in procurements and installation. The problem becomes even severe when the damaged device is in a rural community. It takes days and at times weeks to report the failure of these transformers. Also, some terrains are practically inaccessible during some times in the year, and this further delay restoring power to such communities.

Data taken from ECG further explains the need for a thorough research into the causes of transformer failure and provision of mitigating measures to reduce the frequent burnouts.

In 2019, ECG recorded 459 transformers damage nationwide. Out of these, 150 of the transformers were 100 kVA and that represents 33% of the total lost transformers in the year. The next in line was the 50 kVA transformers, where 144 representing 31% of such were lost in that same year. 106 (23%) of the 200 kVA was lost with the remaining 59 recorded on different sizes of transformers. Figure 1.1 shows a chart of the damaged transformers recorded in 2019. Consequently, the company spent GH₵ 11,907,329.57 as cost of replacing these damaged transformers in 2019. A breakdown of the total cost on the various sizes of transformers lost in 2019 is presented in Figure 1.2.

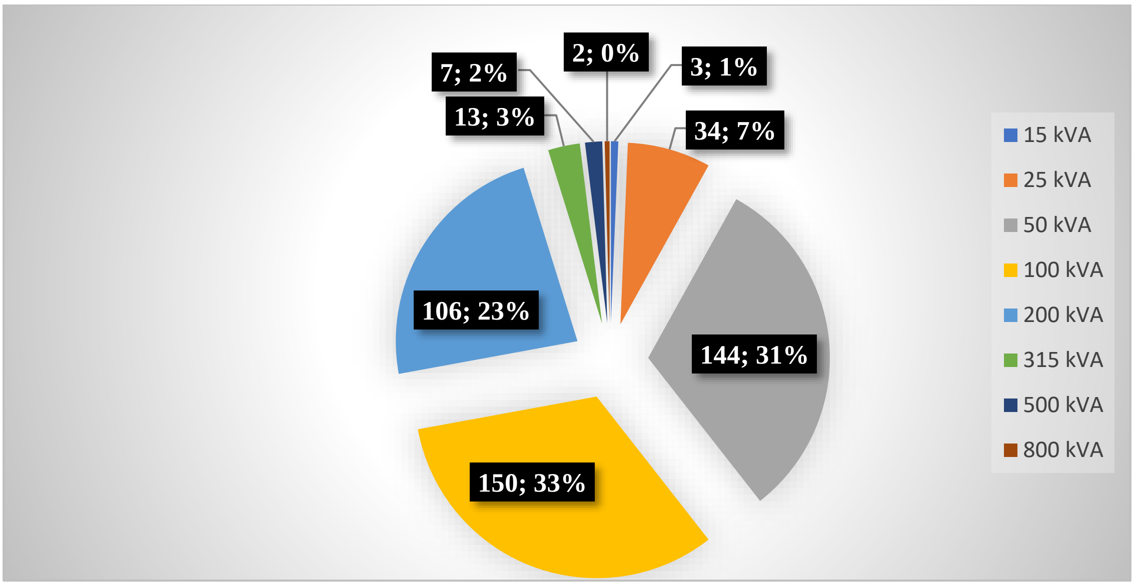


Figure 1.1 Data on Damaged Transformers Recorded by ECG in 2019

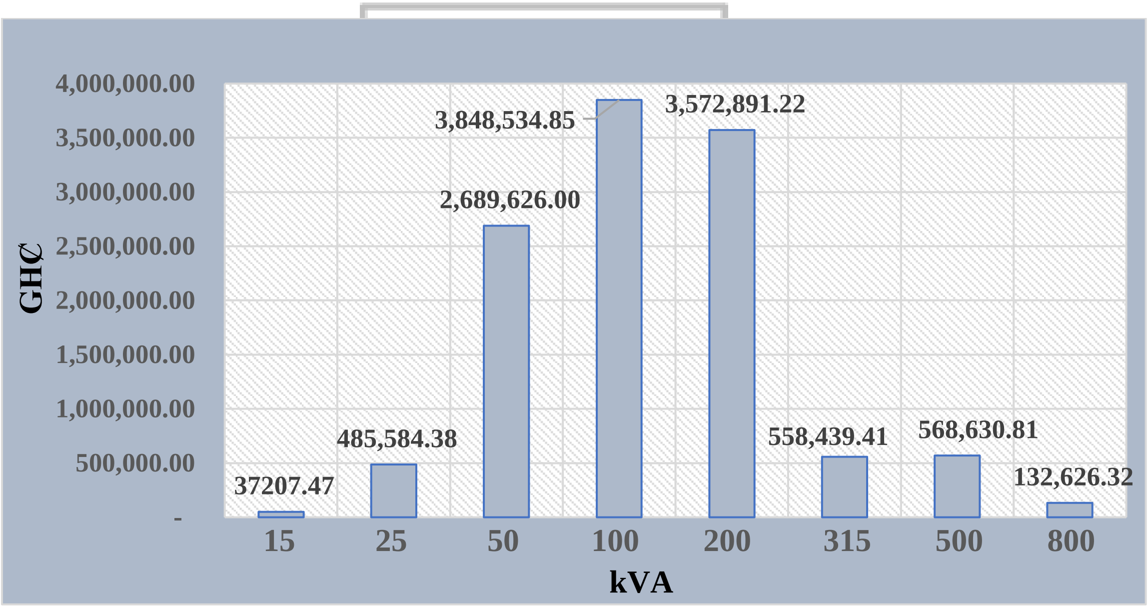


Figure 1.2 Cost of Replacement of Damaged Transformers Recorded by ECG in 2019

A similar situation is experienced in 2018, where a total of 500 transformers were lost in that year alone. Out of the total transformers damaged in 2018, 174 representing 35% were 100 kVA transformers. This is followed by 148 of the 50 kVA transformers which represents 30% of the total damaged. 98 of the 200 kVA transformers were lost and the remaining 80 which represents 15% were transformers of other sizes. Figure 1.3 shows a chart of the damaged transformers recorded in 2018. The company spent GH₵ 14,084,326.97 as cost of replacing these damaged transformers in 2018. A breakdown of the total cost on the various sizes of transformers lost in 2018 is presented in Figure 1.4.

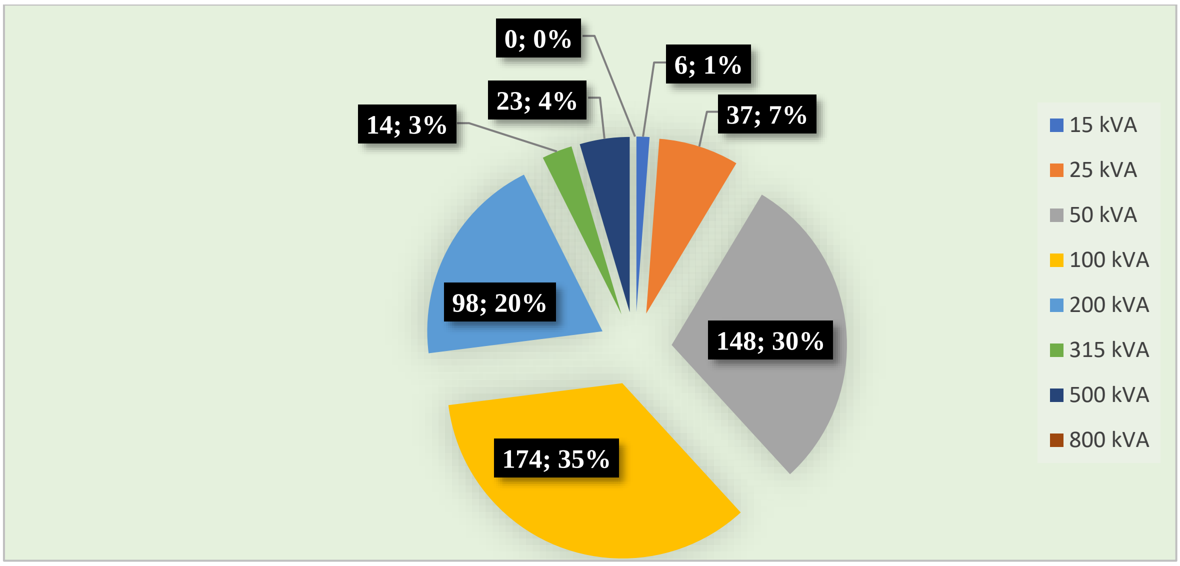


Figure 1.3 Data on Damaged Transformers Recorded by ECG in 2018

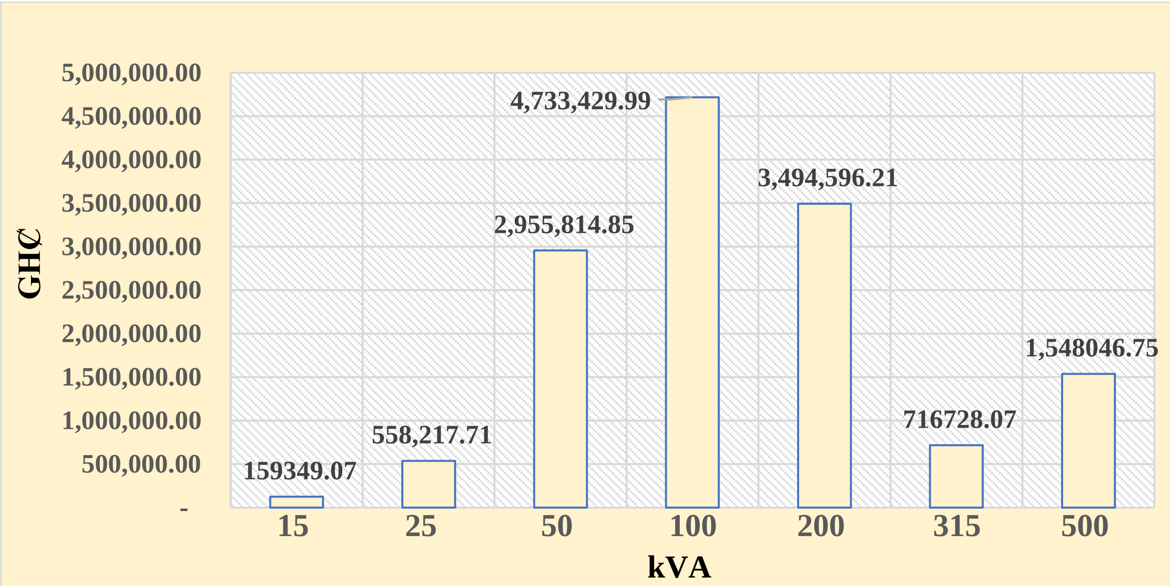


Figure 1.4 Cost of Replacement of Damaged Transformers Recorded by ECG in 2018

The Global ECG Damage Transformer Report for 2019 and 2018 can be found in Table A3 and A4 of Appendix A.

Considering the alarming figures presented above, it is prudent to research into the cause of the high transformer damage experienced annually. From the data above, it is realised that 87% of the damaged transformers in 2019 are that of the 200, 100 and the 50 kVA, whereas 85% of the same was recorded in 2018. Since these transformer ratings fall under the distribution transformer category, the research will focus on finding the cause and remedy to the failure of transformers on the distribution network.

At Kasoa district where this research will be conducted, the distribution network is 33/0.433 kV. From 2014 to 2018, a significant number of transformer burnout has been recorded. Table 1.1 shows a total of 99 transformers burnt from 2014 to 2018.

Considering the data in Table A1 and A2 of Appendix A, the following are the causes of distribution transformers burnout:

a. Lightning overvoltage;
b. Insulation failure;
c. Short circuit;
d. Design and manufacturing defects (inherent faults); and
e. Overloading.

Table 1.1 Burnt Transformers at Kasoa District from 2014 to 2018

Year	Quantity
2014	18
2015	34
2016	4
2017	22
2018	21
Total	**99**

(Source: Anon., 2018a)

From Appendix A, lightning is one of the major causes of the burnout and ECG has installed surge arresters at various locations on the network. This is the common practice for the protection of the distribution transformers against lightning overvoltage that may cause serious damages to them, yet lightning overvoltage is still the major causes of distribution transformers burnout. The effective protection levels that surge arresters offer however depend on the following factors:

a. The installation position of the lightning arresters;
b. The lead length of the connecting conductors of the arrester; and
c. The effectiveness of the earthing resistance.

Therefore, this research work will investigate the causes and propose measures to minimise the burnout caused by lightning surge.

1.3 Research Questions and Hypothesis

The research questions to be answered are as follows:

a. What are the causes of distribution transformer burnouts?
b. What can be done to prevent or minimise the burnouts?

The research hypothesis is stated as follows: Insulation failures, overloading, poor earthing and lightning surges are the main causes of frequent transformer burnout at ECG substations

1.4 Objectives of the Research

The main objective of the research is to investigate the frequent burnout of distribution transformers of ECG.

The specific objectives of the research are to:

a. Determine the effectiveness of pole mounted transformer protection schemes;
b. Identify the optimum pole mounted substation configuration for ECG;
c. Propose measures to mitigate the burnouts.

1.5 Purpose of the Research

The purpose of this research is to carry out an investigation into the causes of 100 kVA, 33 kV/0.433 kV distribution transformer burnouts at Kasoa district of ECG and propose solutions to mitigate the problem

1.6 Research Methods Used

Research methods used are the following:

a. Review of related literature in the research domain.
b. Field visits, data collection and analysis.
c. Consultation of experts in the research area.
d. Earthing resistance tests.
e. Computer simulations.

1.7 Significance of the Research

ECG uses distribution transformer with capacities of 50 kVA, 100 kVA, 150 kVA, 200 kVA, 315 kVA, 500 kVA, 800 kVA and 1000 kVA. These transformers are very expensive to acquire and loss of them in service renders wide areas in total darkness. Apart from direct material costs incurred by the burnout of the transformer, there are costs such as transportation management, labour costs and revenue lost due to outages. The significance of this research is to be seen in mitigating these costs and avail more distribution transformers to active service.

1.8 Scope of the Research

The scopes of the research are:

a. The area of study of this research will consider 100 kVA, 33/0.433 kV distribution transformers at Kasoa district;
b. Data of quantity of burnt distribution transformers over the last five year period;
c. The causes of distribution transformer burnout that are studied in the world;
d. Field visit data collection and analysis;
e. Physical inspection of the burnt transformers;
f. Analyses data collected and find the roots causes of the burnt; and
g. Establish conclusions and recommendations base on the data analysed results.

1.9 Limitations of the Research

Due to financial constraints, time factor and other limitations of the research, the conclusions drawn from this research shall be based on the data from test results and proven academic models.

1.10 Facilities Used for the Research

Facilities used for the research are:

a. Library, Laboratory, Computer and Internet facilities at UMaT;
b. ECG research department;
c. Earthing resistance tester and megger;
d. 100 kVA, 33 kV/0.433 kV burnt and healthy transformers;

e. Power analyser; and
f. Multimeter.

1.11 Definition of Terms and Key Concepts

Distribution transformer: It is a transformer that provides the final voltage transformation in the electric power distribution system, stepping down the voltage used in the distribution lines to the level used by the customer.

Earthing: It is electrical circuit which connects the mechanical parts with the general mass of earth.

Transformer ratio: It is the ratio of Primary Voltage (V_p) to the Secondary Voltage (V_s).

Arrester leads length: It is a combine length of the line lead and the ground lead length in series with the arrester and in parallel with the device being protected.

1.12 Organisation of the Thesis

The rest of the thesis is organised as follows;

Chapter 2 gives the literature review of the research which discusses the effect of distribution transformer failures, the impact and the causes of distribution transformer burnouts. It continues with the review of related works on causes of transformer burnouts and their migration measures and finally, the statement of the gap that serves as the focus of this research.

Chapter 3 is on the methods used, which include data collection, field visits to perform tests that lead to burnout of distribution transformers such as earthing resistance test and measured ECG current pole mounted substation configuration arrester lead length. Determined protective margin of current ECG pole mounted substations configuration and zero lead length configurations. Also, modelled arrester lead length discharge voltages using Matlab simulation and simpowersystem.

Chapter 4 covers the results and discussions.

Chapter 5 summaries the findings, gives the conclusions and recommendations of the research, and future research directions.

CHAPTER 2

LITERATURE REVIEW ON DISTRIBUTION TRANSFORMERS

2.1 Introduction

Distribution transformer is a static electrical device which steps down the voltage by electromagnetic induction to feed distinct types of loads (Anon., 2018b). They are constructed to operate in distinct capacities. Distribution transformer is always the last in the chain of electrical energy supplied to industrial enterprises and households (Anon., 2014). Distribution transformer in Ghana steps down voltage from either 33 kV or 11 kV on the primary side to 415 V between lines and 240 V between line and neutral on the secondary side. Also, in Ghana the transformer windings configuration is Delta (D_{11}) on the primary and star (y_n) on the secondary. Both transformers can be identified by the height of their bushings. Figure 2.1 and 2.2 show 33 kV and 11 kV distribution transformers respectively.

Figure 2.1 33 kV Distribution Transformer

Figure 2.2 11 kV Distribution Transformer

Distribution transformers are rated in kVA and meant for distribution utilization of electric power. However, power transformers are rated in MVA and are meant for transmission purposes.

The capacity of the transformer is the extent of power in kVA that can be handled by the transformer while it does the voltage transformation at the pre-determined ratio (Suresh, 2014). The number of turns in High Voltage (HV) and Low Voltage (LV) windings determines the voltage ratio. Figure 2.3 shows the location of the distribution transformer in an electric power system.

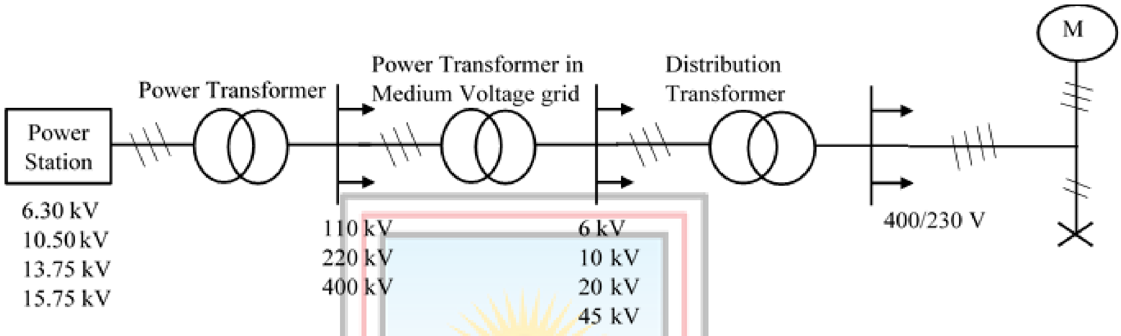


Figure 2.3 Distribution Transformer in Electrical Power Systems

Distribution transformers power ratings generally range from 50 to 1500 kVA. In Ghana, the power ratings of distribution powers used are 50,100, 150, 200, 250, 315, 500, 800, 1000 and 1500 kVA.

Generally, there are two types of mounting arrangements of outdoor distribution transformer, pole mounted and ground mounted as shown in Figure 2.4.

Figure 2.4 Pole Mounted and Ground Mounted Distribution Transformers

Figure 2.5 shows single line diagram for a typical distribution substation used at Kasoa district by ECG. In this arrangement, the surge arrestors mounted before Drop out Fuses (DoF) at primary side of the transformer to protect it from lightning and voltage surges. The DOF and High Rupturing Capacity (HRC) fuses are used to protect the distribution transformer against over current at primary and secondary.

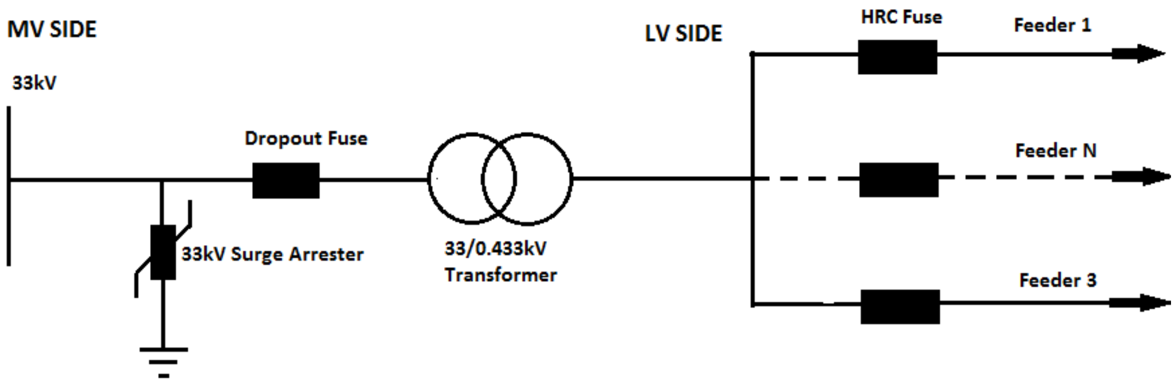


Figure 2.5 Typical Arrangement of Distribution Substation

2.2 Constructional Features of a Distribution Transformer

Distribution transformer has the following features; they are core, windings, off–load tap changer, tank and cover, bushings, paper insulation and insulation oil. Figure 2.6 shows a well labelled distribution transformer.

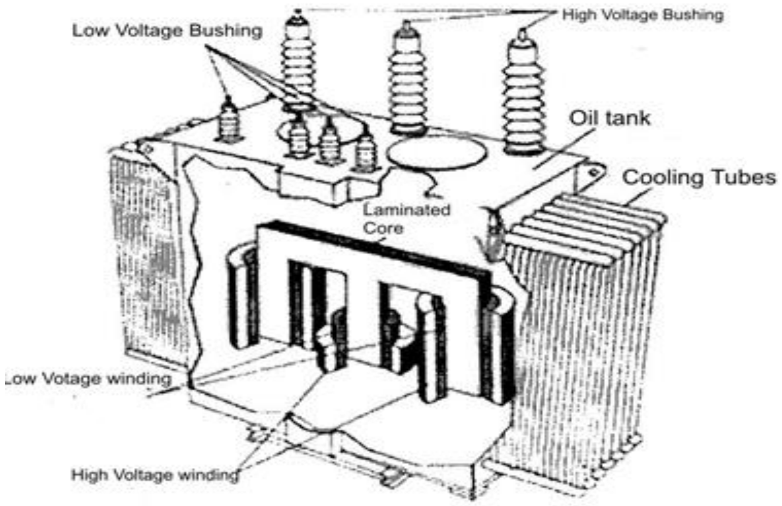


Figure 2.6 Constructional Features of Distribution Transformer

2.2.1 Transformer Windings

The windings are made of either copper or aluminium; they are insulated with either pure cellulose or double enamel. Furthermore, the complete columns are manufactured to withstand short circuit stresses. Windings are an important part of a transformer. In distribution transformers there are commonly two windings, the primary windings and the secondary windings (Jan *et al.*, 2015). Figure 2.7 shows a picture of the windings of three phase transformer

High voltage/low current flows in the primary side winding and through electromagnetic induction voltage is stepped down and current stepped up in the secondary side winding (Jan *et al.*, 2015).

These windings withstand dielectric, thermal and mechanical stress during this process. The faults that occur in the winding are due to these stresses. This causes the breaking of the windings or the burn-out. Dielectric faults occur in the winding due to turn-to-turn insulation breakdown. These are the insulation between the turns of the winding. Insulation breakdown commonly occur due to high current and voltage, which are above the rated values. The breakdown of the insulation results in the flashover of the winding turns and causes short circuit.

Figure 2.7 Three Phase Transformer Windings

2.2.2 Transformer Core

A magnetic circuit or core of a transformer is designed to provide a path for the magnetic field, which is necessary for induction of voltages between windings (Anon., 2015a). A path of low reluctance (i.e., resistance to magnetic lines of force), consisting of thin silicon, sheet steel laminations, is used for this purpose (Anon., 2015a). In addition to providing a low reluctance path for the magnetic field, the core is designed to prevent circulating electric currents within the steel itself. Figure 2.8 is an example of steel laminated core.

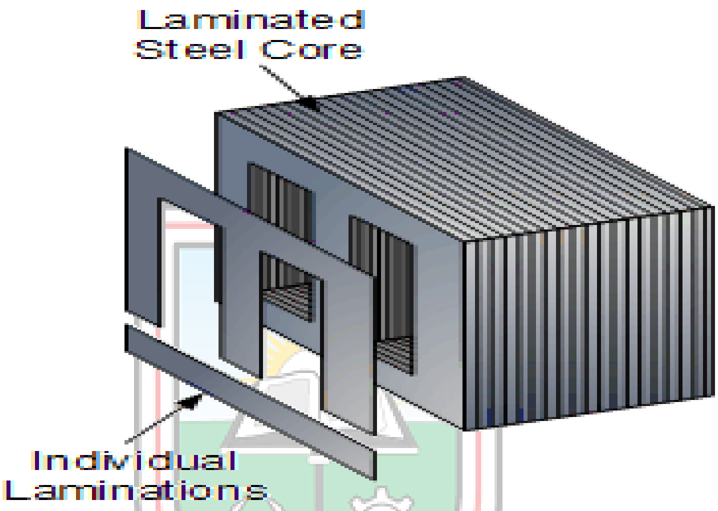


Figure 2.8 Sheet Steel Laminated Core

There are two basic designs of transformer cores; namely

Core type: In core type transformers, winding is positioned on two limbs of the core and there is only one flux path and windings are circumventing the core as shown in Figure 2.9a. These transformers are quite favourite in High voltage practical applications like Distribution, Power, and Auto-Transformers.

Shell type: In shell type transformers, winding is positioned on the middle limb of the core while other limbs are utilized as the mechanical support as shown in Figure 2.9b. These transformers are quite favourite in Low voltage practical applications such as transformers employed in electronic circuitry as well as in power converters.

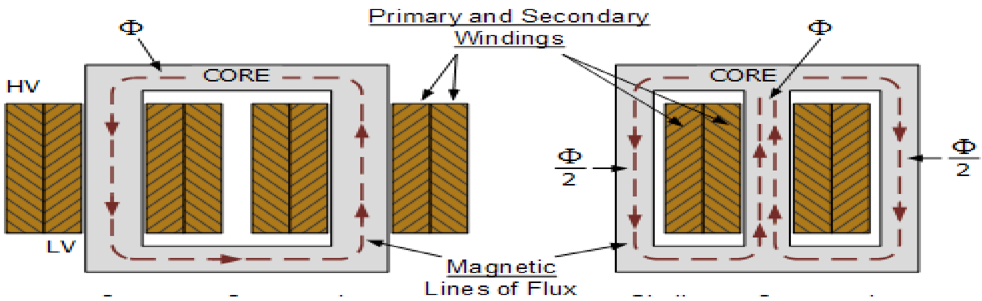


Figure 2.9 (a) Core type Construction (b) Shell type Construction

2.2.3 Bushings

The bushings are generally two type; solid and capacitance graded (Singh and Singh, 2016). Solid porcelain bushings consist of high grade porcelain cylinders that conductors pass through. Outside surface have a series of skirts to increase the leakage path distance to the grounded metal case (Feilat *et al.*, 2013). Capacitance graded bushing uses conducting layers at predetermined radial intervals within the oil-impregnated paper or some others insulation material that is located in the space between the central conductor and the insulator. Currently, this type is used for all voltage ratings above 25 kV system voltages (Anon., 2015b). Bushings of a transformer, as shown in Figure 2.10, is a type of porcelain or ebonite post insulator put on the top or side of the transformer tank through which connections are made to the external circuit both the primary and the secondary. Bushings facilitate the passage of an energised, current-carrying conductor through the grounded tank of the transformer. Figure 2.11 shows some types of transformer secondary bushings.

Figure 2.10 Types of Transformer Primary Bushings

Figure 2.11 Types of Secondary Transformer Bushings

2.2.4 Off-Circuit Tap Changer

The transformer voltage at the load side desired to be constant or as close to the design value. But the load voltage may vary according to current drawn by the load or supply voltage (Anon., 2016b).

$$V_2 = \frac{V_1 \text{ x } N_2}{N_1} \qquad (2.1)$$

where, V_2 = secondary voltage

V_1= primary voltage

N_1 = primary winding turns

N_2 = secondary winding turns

Base on the Equation (2.1), to maintain constant secondary voltage/load voltage or as close to the desired value it is needed to change the turn’s ratio. The tap changer of the transformer performs this task to change the turn’s ratio.

The tapping (±2 × 2.5%) of the HV winding, are connected to the off-circuit tap changer located horizontally between the yoke and tank cover. The handle is located on the cover and should be operated when the transformer is deactivated. A distribution transformer is off load tap changer and it has five tap positions with steps of ±2.5% (McDonald *et al.*, 2013). Figure 2.12 shows an example of offload tap changer mechanism.

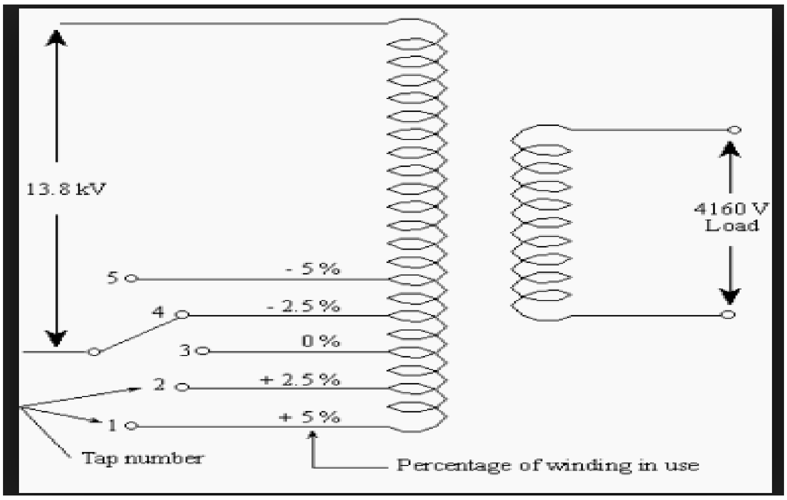


Figure 2.12 Offload Tap Changer Mechanisms

2.2.5 Transformer Tank and Cover

The sides of the tank are made of corrugated cooling surfaces. The bottom plate, side and frames are of a welded construction. The thermometer pockets, bushings, tap switch drive and lifting lugs are fitted on the tank cover. The cover is bolted to the tank frame. The undercarriage is welded to the bottom plate and rollers are suitable for either longitudinal or transverse movement (Anon., 2015c). The function of the tank in the transformer is to be as container for the oil used in it. The oil in the tank is used for insulation and cooling. The tank can also be used as a support for other equipment's of the transformer (Jan *et al*., 2015). Figure 2.13 is a picture of a transformer.

Figure 2.13 Transformer Tank

2.2.6 Insulation System

The insulation system in a transformer consists of two parts, a solid part (cellulose paper) and a liquid part (transformer oil). The liquid insulation also serves as a cooling medium to the windings (Abbasi, 2017).

Solid Insulation: The solid insulation in a transformer is of cellulose based products such as press board and paper. Its main function is to isolate the windings and Figure 2.14 displays solid insulation and windings of a transformer (Abbasi, 2017).

Figure 2.14 Transformer Windings Wrapped in Solid Insulation

Liquid Insulation: Transformer oil (also known as insulating oil) is a special type of oil which has excellent electrical insulating properties and is stable at high temperatures. Transformer oil is used in oil-filled electrical power transformers to insulate, stop arcing and corona discharge, and to dissipate the heat of the transformer (i.e. act as a coolant) (Salvi and Paranjape, 2017).

Transformer oil is also used to preserve the transformer's core and windings – as these are fully immersed inside the oil (Salvi and Paranjape, 2017). Another important property of the insulating oil is its ability to prevent oxidation of the cellulose-made paper insulation (Salvi and Paranjape, 2017).

2.3 Overview of Transformer Operation

Transformers are used to transform power from one voltage level to another voltage level. When the alternating current flows in the primary coils, a changing magnetic flux is generated around the primary coil; this changing magnetic flux is transferred to the secondary coil through the iron core (Rauff *et al*., 2016). The changing magnetic flux is cut by the secondary coil, hence induces an EMF in the secondary coil. Now if load is connected to a secondary winding, this EMF drives a current through it (Rauff *et al*., 2016). The magnitude of the output voltage can be controlled by the ratio of the number of primary coil and secondary coil as shown in Figure 2.15.

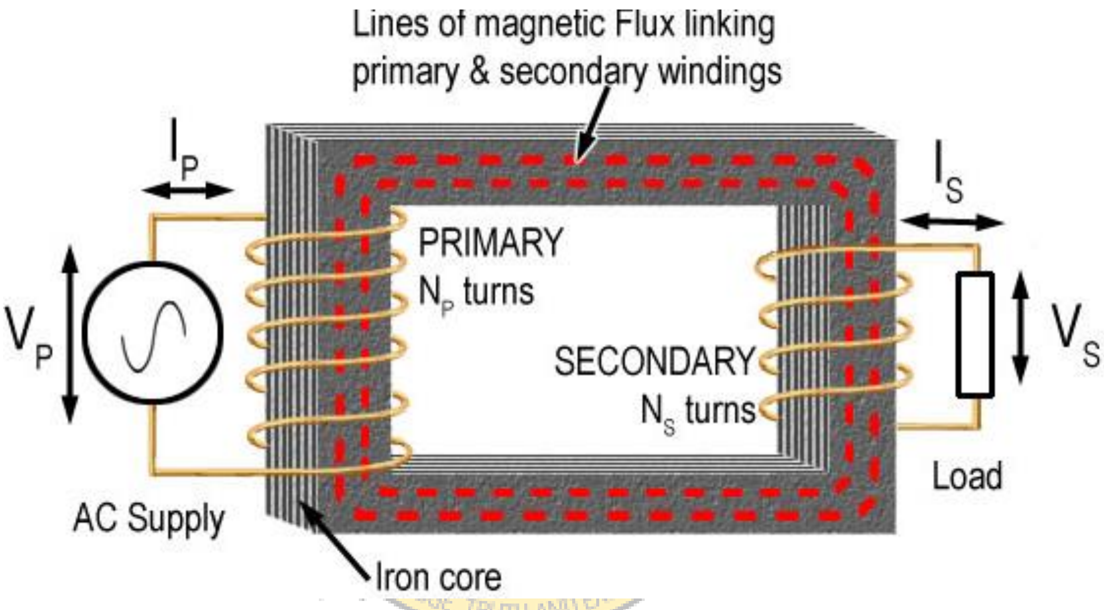


Figure 2.15 Coupling between a Transformer Coils and its Core

$$\text{Transformer Turns Ratio (TTR)} = \frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{I_S}{I_P} \qquad (2.2)$$

where, V_P = primary voltage

I_P= primary current

V_S= secondary voltage

I_S= secondary current

N_P= numbers of turns in primary winding

N_S= number of turns in the secondary winding

Figure 2.15 shows the coupling between a transformer coils and its core. The transformer coils are identified as primary coils and secondary coils. Power is applied to the transformer's primary coil and this is the input power and then output power is available at the transformer's secondary coils and it is also the load side the transformer (Rauff *et al*., 2016). The power output is equal to the power input less the losses of the transformer (power consumed by transformer). The efficiency of a transformer is the ratio of power output to power input (Kumrey and Mahobia, 2016). The power ratings of transformers are directly related to the voltage across the coils and the current through the coils. Equation (2.2) shows transformer voltage and current transformations ratios. Table 2.1 identifies some standard transformers and theirs associated current levels.

Table 2.1 Primary and Secondary Current of different Transformer Capacities

Transformer Capacity (kVA)	11 kV/433 V		33 kV/433 V	
	Primary Current (A)	Secondary Current (A)	Primary Current (A)	Secondary Current (A)
50	2.62	66.67	0.87	66.67
100	5.25	133.34	1.75	133.34
200	10.50	266.67	3.50	266.67
225	11.81	300.00	3.94	300.00
315	16.53	420.01	5.51	420.01
500	26.24	666.69	8.75	666.69
800	41.99	1,066.70	14.00	1,066.70

(Source: Udayakanthi, 2014)

2.4 Distribution Transformer Protection

Protection system's main function is to clear faults from the power system at high speed to ensure safety, minimise equipment damage and maintain power system stability (Hossain *et al*., 2014). Protective devices provided to distribution transformers are shown in Table 2.2.

Table 2.2 Protection Devices of a Distribution Transformer

No	Protective Device	Protection Given
1	Surge Arrester	Against lightning strikes or surges on primary side
2	Earthing System	Transformer neutral earthing provides a path for earth fault current.
3	HRC Fuse	Against over current on secondary side
4	DDLO Fuse	Against over current on primary side
5	MCCB	Against over current on secondary side

Protection method used for power transformers depends on the kVA ratings. IEEE standard C57.12.00-1993, general requirements for liquid-immersed distribution, power and regulating transformers, defines four categories of transformers based on the kVA rating. These categories are shown in Table 2.3.

Table 2.3 Transformer categories

Categories	Single Phase Transformer (kVA)	Three Phase Transformer (kVA)
I	5 to 500	15 to 500
II	501 to 1667	501 to 5000
III	1668 to 10000	5001 to 30000
IV	Above 10000	Above 30000

(Source: Anon., 2015d)

As per the Table 2.3, distribution transformers used by ECG belong to category I and category II. According to IEEE C57.12.00-1993, "Guide for liquid immersed transformer through fault duration, each of the categories has it short time thermal load capability and these are shown in Table 2.4.

Table 2.4: Short Time Thermal Load and Short Circuit Capability

Times rated current (I), (A)	Time in seconds (t)	I^2t
2	1800	7200
3	300	2700
4.75	60	1354
6.3	30	1190
11.3	10	1277
25	2	1250

(Source: Anon., 2015d)

2.4.1 Fuse Protection

A fuse is one type of over current device that is designed to be a sacrificial element in an electrical power system. Fuses are designed to open circuits when excessive currents are present due to overloads or faults to prevent equipment from damage (Kishore, 2014).The main protective device of ECG owned distribution transformer is a fuse. The DoF which is shown in Figure 2.16 are used for primary side of the transformer and High Rupturing Capacity (HRC) type current limiting fuse which is shown in Figure 2.17 are used for the secondary side of the transformer. A fuse contains a current-carrying element sized so that the heat generated by the flow of normal current through it does not cause it to melt the element; however, when an over current or short-circuit current flows through the fuse, the fusible link will melt and open the circuit to protect the transformer from damage (Kishore, 2014).

Figure 2.16 Drop Out Type of Fuse

Figure 2.17 HRC Type of Fuse

The performance of a fuse is depicted by means of the minimum melting and the total clearing curves: a fuse has an arcing time, which is the time needed to interrupt the current after the fuse melts, so the total clearing time curve is deduced by adding the arcing time to the melting time which shown in Figure 2.18. This is called Time Current Characteristic (TCC) curves and it is an important tool utilised in distribution transformer fuse application.

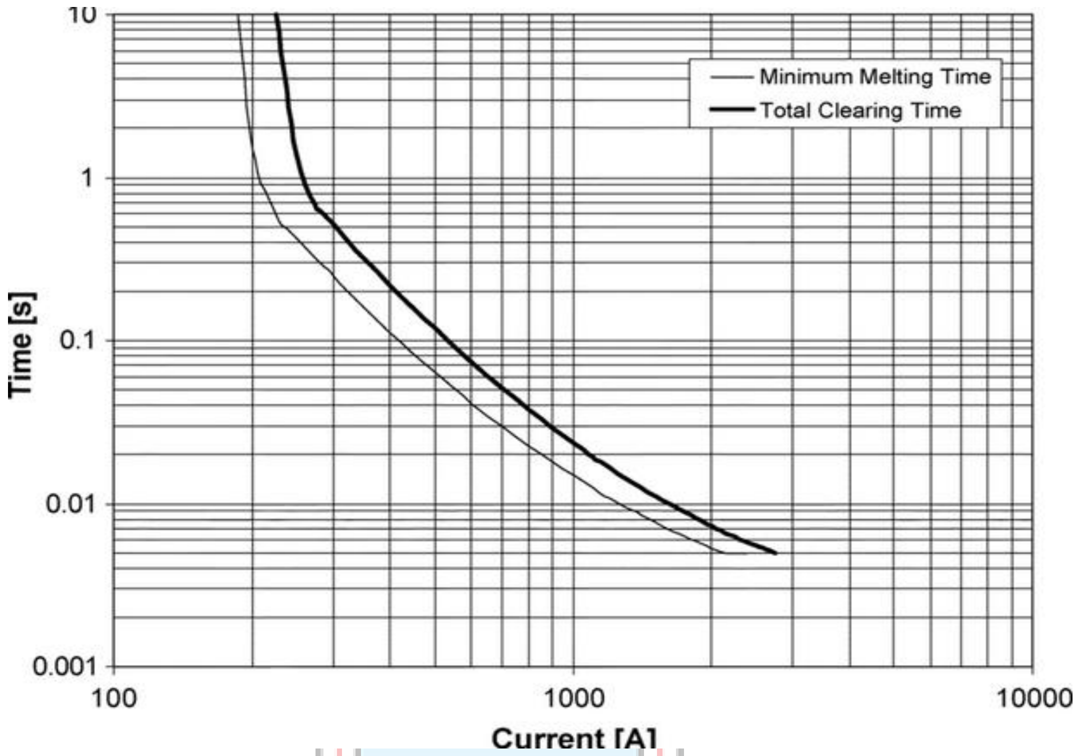


Figure 2.18 Example of TCC Curve

2.4.2 Moulded Case Circuit Breakers

Moulded case circuit breakers (MCCBs) are widely used in low voltage electrical distribution systems, the breaking technique of which is based on current limitation (Soon-Yong *et al*., 2013). When a fault current comes, if the electrodynamics' repulsive force exceeds the spring force, the contacts will separate first and the arc will appear. The primary functions of MCCB are to give a means to manually open a circuit and automatically open a circuit under short circuit or overload conditions. The following are some characteristics of MCCB:

a. The range of rated current us up to 2500 amperes;
b. Trip current can be adjusted; and
c. Thermal/thermal magnetic operation.

Figure 2.19 Examples of MCCB (single phase and three phase)

2.4.3 Surge Protection

A surge arrestor is a device which protects electrical equipment from transient over-voltage caused by external (lightning) or internal (switching) events.

Lightning strike on an overhead line, injects high current surge thereby creating over-voltage in a distribution system. The high voltage introduced in the system is capable of breaking down most distribution-class insulation unless protected by an arrestor, which diverts the transient over-voltage to ground.

Modern surge arrester are usually made up of metal-oxide resistor blocks which offers low resistance to high voltage surge and divert the high voltage surge to ground, thereby the insulation of protected installation is not subjected to the full surge voltage. The arrester responds to over-voltages by reducing the impedance on the metal oxide blocks, thereby allowing the surge to be diverted from the electrical equipment (Mabunwe and Gbasouzor, 2017).

The metal-oxide block is primarily zinc oxide with other materials added. This new model of the arrester has overcome many drawbacks of the earlier surge arrester designs and is currently being used in most distribution systems (Short, 2014).

Typical surge arrestors shown in Figure 2.20. In ECG distribution substations, surge arresters are fixed at source before DoF in the case of Figure 2.20.

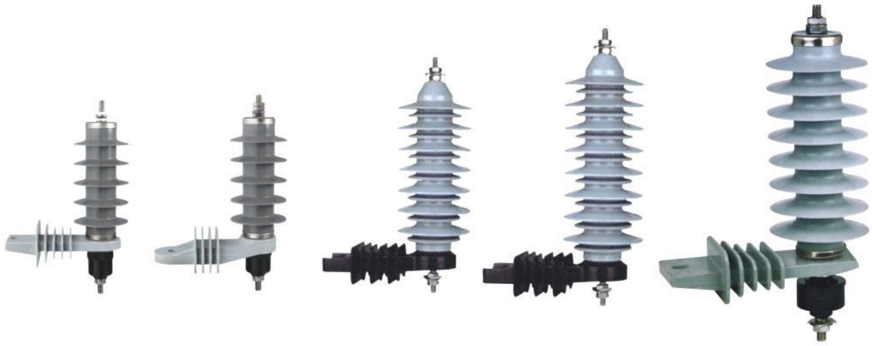


Figure 2.20 Surge Arrester

Selecting an arrester for a distribution system depends on the voltage under normal conditions and possible Temporary Over-Voltages (TOVs). Temporary over-voltages during line-to-ground faults on the healthy phases are the main concern therefore; system grounding plays a large role in arrester application. The most important rating of a metal-oxide arrester is the Maximum Continuous Operating Voltage (MCOV). Arresters also have another voltage rating called the duty-cycle rating (this rating is commonly used to refer to a particular arrester). The duty-cycle rating is about 20% higher than the MCOV rating. Within a given rating class, arresters may have different performance characteristics (such as the discharge voltage and the energy-handling capability) (Short, 2014).

2.4.4 Earthing of Substation

Substation earthing system is essential not only to provide the protection of people working in the vicinity of earthed facilities and equipment against danger of electric shock but to maintain proper function of electrical system (Rahi *et al.*, 2012). The purpose of a grounding system at a substation includes the following:

a. To provide the ground connection for the grounded neutral for transformers;
b. To provide the discharge path for lightning rods, surge arrestors, spark gaps etc;
c. To ensure safety to operating personnel by limiting potential differences that can exist in a substation;

d. To provide a sufficiently low resistance path to ground to minimise rise in ground potential with respect to remote ground.

In ECG, the earthing arrangement of distribution substation is as follows:

a. Neutral of the transformer is connected to one earth electrode;
b. The transformer tank and surge arresters are separately earthed with another electrode.

Separation of minimum 5 m is maintained between earth electrodes. The connection of the transformer to earth should be as directly as possible for discharge of high currents. The discharge of high currents requires earth connections of low resistance. IEEE standard 142, recommended earth resistance limits for different electrical power installations are shown in Table 2.5. In ECG distribution substations, the earthing resistance limit is 5 Ω.

Table 2.5 Recommended Earth Resistance Limits for Different Electrical Installations

System Installations	Earth Resistance Limits (Ω)
Power Stations	0.5
EHV Substations	1.0
33 kV Substations	2.0
Distribution Transformers	5.0
Surge Arresters	5.0
Tower Foot Resistance	10.0

(Source: Shad and Bhasme, 2014)

2.5 Burnout Modes and Causes of Transformer

Transformer failure modes relate to the faults that causes the transformer to fails or burn. These faults may occur in different parts and components of the transformer due to mechanical, electrical or thermal stress caused due to different conditions (Jan *et al.*, 2015). The cause of a failure can be internal or external as shown in Table 2.6.

Table 2.6 Typical Causes of Transformer Burn Out

External Causes	Internal Causes
Lighting Strokes/Temperature	Overheating
System overload	Moisture
System Faults (short circuit)	Insulation deterioration
System Switching	Oxygen
Frequent Operations/Thermal	Partial discharge
Poor Workmanship	Designing and manufacturing defects
High Voltage Disturbance	Improper Cooling

(Source: Pandit and Chakrasali, 2017)

2.5.1 Bushing Failure

The function of the bushing is to insulate the windings from the tank and also to connect the winding to the power supply system to energise the transformer (Singh and Singh, 2016). The main failure mode of bushing is short circuit. Damage of porcelain of the bushing can occur due to sabotage such as throwing stones and bad handling. Damages, such as cracks in the porcelain and bad gaskets, provide ingress of water inside insulation of the bushing leading to its failure (Jan *et al.*, 2015). Table 2.7 shows some causes and modes of failure in transformer bushings.

Table 2.7 Failure Causes and Failure Modes of Bushing

<table>
<tr><th>Causes of Failure</th><th>Failure Event</th><th>Mode of Failures</th></tr>
<tr><td>Sabotage</td><td rowspan="2">Damage on bushings</td><td rowspan="4">Short Circuit</td></tr>
<tr><td>Bad Handling</td></tr>
<tr><td>Aging (bad gasket-water penetration)</td><td rowspan="2">Fault in insulation material</td></tr>
<tr><td>Lack of Maintenance (water or dirt)</td></tr>
</table>

(Source: Udayakanthi, 2014)

2.5.2 Winding Failure

Transformer winding is the active part which provides electrical circuit for current to flow in the transformer. The windings are kept as the cylinders around the core, where every stand is wrapped with protection paper (Kaur and Bhangu, 2017). In addition to dielectric stress and thermal requirements the windings have to withstand mechanical forces that may cause winding displacement and those forces can appear during short circuit and transient over voltage (Singh and Singh, 2016). Table 2.8 shows some causes and modes of failure in transformer windings

Table 2.8 Failure Causes and Failure Modes of Winding

Causes of Failure	Failure Event	Mode of Failures
Low Oil Quality	Failure in insulation material	Short Circuit
Short Circuit in the Network	Mechanical Damage	
Aging of Cellulose		
Lightning (transient over voltage)		

(Source: Udayakanthi, 2014)

2.5.3 Core Failure

The function of the core is to concentrate the magnetic flux and provides mechanical strength to the transformer. The core fails due to DC magnetisation or displacement of the core steel during the construction of transformer and can also lead to reduction of the transformer efficiency (Singh *et al.*, 2019). Table 2.9 shows some causes and modes of failure in transformer core.

Table 2.9 Failure Causes and Failure modes of Core

Causes of Failure	Failure Event	Mode of Failures
DC Magnetisation	Mechanical failure	Loss of efficiency

(Source: Udayakanthi, 2014)

2.5.4 Tank Failure

Transformer tank is an enclosed container that provides physical protection for active parts and also serves as a container for the coolant oil (Jan *et al.*, 2015). The tank has to withstand environmental stresses such high humidity, corrosive atmosphere and sun radiation (Singh *et al.*, 2019). Table 2.10 shows some causes and modes of failure in transformer tanks.

Table 2.10 Failure Causes and Failure Modes of Tank

Causes of Failure	Failure Event	Mode of Failures
Sabotage or Accident	Tank Damage	Oil Leakage
Careless Handling		
Aging		
Lack of Maintenance(corrosion)		

(Source: Udayakanthi, 2014)

2.5.5 Oil Insulation Failure

Transformer oil (also known as insulating oil) is a special mineral oil which has excellent electrical insulation properties and stable at high temperatures. Transformer oil is used in oil filled transformers to insulate, stop arcing and corona discharges and to dissipate heat of the transformer (act as a coolant) (Anon., 2019a). The quality of the oil greatly affects the insulation and cooling properties of the transformer. Moisture and oxygen coupled with heat are major causes of transformer oil failure (Singh *et al.*, 2019). Table 2.11 shows some causes and modes of failure in transformer oil insulation.

Table 2.11 Failure Causes and Failure modes of Oil Insulation

Causes of Failure	Failure Event	Mode of Failures
Over Heating	Conducting Particles in oil	Short Circuit
Oil Aging (water in oil)		

(Source: Udayakanthi, 2014)

2.5.6 Solid Insulation Failure

The solid insulation in a transformer is cellulose based products such as press board and paper. Its main function is to isolate the windings. Cellulose consists of long chain of glucose rings which degrades with time leading to shorter chains (Singh *et al.*, 2019). Degree of Polymerisation (DP) is the average number of these rings in the chain and indicates the condition of the paper. New paper has DP between 1200 and 1400 and DP less than 200 means that the paper has a poor mechanical strength and may no longer withstand short circuit and other mechanical forces (Singh *et al.*, 2019). Table 2.12 shows some causes and modes of failure in transformer solid insulations.

Table 2.12 Failure Causes and Failure Modes of Solid Insulation

Causes of Failure	Failure Event	Mode of Failures
Over heating	Fault in insulation material	Cannot supply insulation
Aging of Cellulose (Short Circuit)	Mechanical damage	Cannot supply insulation

(Source: Udayakanthi, 2014)

2.6 Review of Related Works on Burnt out Distribution Transformers

Christina *et al*. (2018) presented a reviewed on the sources of transformer failure in a substation. The paper identified transformer bushing failure as one of the main causes of transformer malfunction. Further test and analysis revealed that the high voltage bushing had the highest rate of failure. The paper indicated that insulation breakdown of the HV bushing led to the failure. However, the inability of lightning arresters to operate on time, especially when the supply is connected to the bushing before the arrester can lead to faster degradation of the bushing insulating material and consequently transformer failure (Florkowski *et al*., 2018).

Singh *et al*, (2019) presented the failure modes, effects and criticality analysis of distribution transformers in India. Detailed analysis was conducted on 348 distribution transformers between 2010 and 2015. The paper presented Figure 2.21 as the component failure analysis chart.

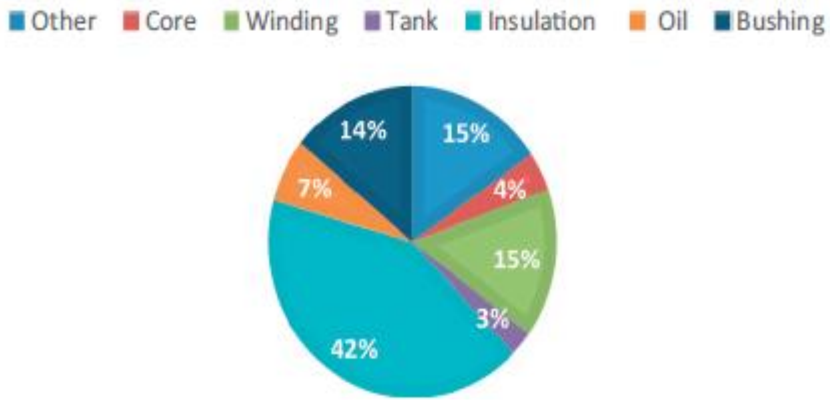


Figure 2.21 Transformer Component Failure Analysis

From Figure 2.21, the major failure occurred as a result of insulation breakdown, followed by winding and bushing failure. With all three-component failure, transient overvoltage due to lightning or other line surges was identified as a major root cause of the Failure.

Ravi *et al*. (2019) performed an in-depth analysis on determining the cause of transformer failure, with data collected over a 5-year period. Text mining was used to determine the trip occurrences. The results as shown in Figure 2.22 indicate that leak, lightning and animal interference were the major cause of the failure.

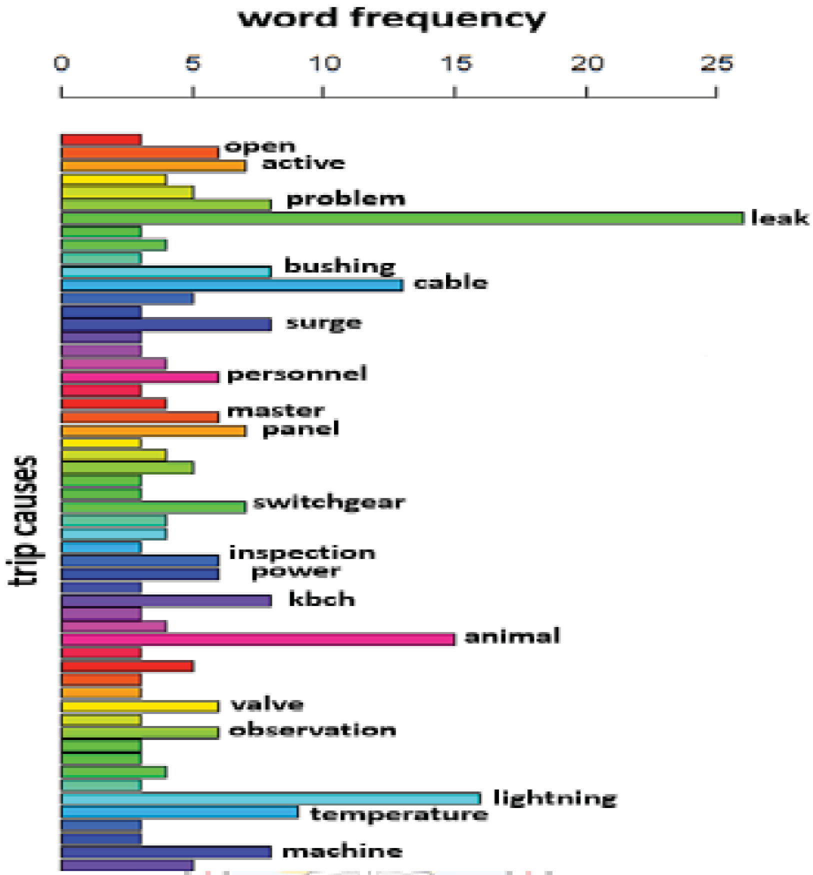


Figure 2.22 Word Frequency Bar Plot

The paper however did not propose any counter measures in dealing with the aforementioned problems.

Bala (2014) carried out performance test on faulty distribution transformers along the streets and roads of Port Harcourt. The series of tests include; voltage transformation ratio test, step-up voltage ratio test, insulation resistance test with XLPE cable and earthing (ground resistance test) and dielectric oil test. The findings revealed poor earth system, absent lightning arrester and loose connections among others as the major cause of equipment failure. The paper therefore recommended routine inspection and maintenance of transformers to avert the problem.

Rawal *at al.* (2017) carried out a research on distribution transformer failure in Gujarat DISCOM. The paper carried out failure analysis using the following methods: Gujarat DISCOM failure analysis, circle data analysis, fault tree for core failure, fault tree for windings failure, fault tree for insulation failure, fault tree for oil insulation deterioration and capacity wise failure analysis. The paper concluded on insulation failure as the major cause of burnout, whereas load unbalancing, inadequate protection system, improper earth system and improper maintenance was the major cause of transformer failure for rural communities with transformer ratings below 100 kVA. The paper then proposed that proper maintenance strategy should be put in place by Distribution Company for rural areas because they were mainly remote areas which lead the failure rate due to lack of maintenance as well as negligence.

Nunoo and Sey (2018) analysed lightning caused distribution transformer failure in Ghana. Data between 2011 and 2016 was considered and 477 distribution transformers failed caused due to lightning. The methods used for the research were computer simulation for both the existing and proposed lightning protection configuration and instrumental test such as tear down analysis, insulation resistance test, breakdown voltage test and bushing test. After these tests, the paper revealed five causes of distribution transformers failure. They were lightning related surges, insulation failure, and short circuit in low voltage (LV) system, overloading and others. Also, the paper analysed the data collected and concluded that, protection integrity at the distribution substations was riddled with indiscriminate used of copper links to replace blown fuses and high ground resistance. The paper also revealed that the proposed lightning protection system design for distribution transformers which has surge protection at primary and secondary has an improved lightning protection however, the inclusion of the improved surge protector adds additional cost to the distribution system thereby increasing the cost of power delivery to the consumers.

Dewangan and Patel (2017) carried out a research to prevent premature failures of distribution transformer. This research considered three types of distribution transformer failure test to determine the condition of distribution transformer oil. The three methods carried out were: Conventional oil test, Furan derivatives test and Marko models' criteria. The conventional oil test determined the gas concentration in the oil samples and analysed the defect by considered the ratio of two suitable gasses. Furan derivative was carried out in the distribution transformer oil sample to determine the Furan derivatives present which was used to decide distribution transformer insulations condition. The paper also presented a computer program for the hidden Markor model which was used in finding out the fault probability of the distribution transformer. These three methods were demonstrated on a 132/ 33 kV, 15 MVA distribution transformers from CSEB substation. The paper revealed some important reasons distribution transformer failed, there are: Overloading, Lightning strike, loose connection, Oil contamination, Moisture ingress, Line surges and other issues. The paper concluded that, distribution transformer failed due to a number of prolong faults. It therefore proposed proper inspection/testing of transformers on routine maintenance or preventive maintenance to avert the causes of transformers failure.

Ndungu *et al*. (2017) carried out a study which investigated the root causes of premature failure of distribution transformers in Kenya. The data collected showed that the failure rate of the transformers was approximated as 10-12%, which was far above the recommended level of 1-2% of international standard. After the data analyses, the paper revealed that line surges and switching transient over voltages were among the main causes of the transformers failures as this accelerated deterioration of the insulation materials. The paper therefore, concluded that ; the failure rate of distribution transformers in Kenya was 10% against 1-2% annually as per international standard, distribution transformers were poorly protected from lightning, switching surges and faults/flashover, vandalism of earthing system both for HT and LV side of the transformer exposed to high voltage surges that led to insulation breakdown resulting to early failure of the transformers and lastly but not the least was high harmonic current as a result of transformer overload especially triples harmonics (that circulate within delta windings causing HV insulation breakdown. The paper recommended the following; utilities companies should avoid transformer overload by properly grading the LV fuses and discourage the use of direct link, transformers should be properly protected by installing correct fuse rating and earth lightning arresters and also proposed the use of concrete poles with earth wire appended inside to prevent vandalism of the earthing system.

Jan *et al.* (2015) carried out a research that investigated transformers failures, causes and impact. The transformers that studied were step down transformers (11/0.22 kV) used by WAPDA in the distribution sectors. Data about the transformer's failures for the last 5 years were collected from PESCO for two locations of Peshawar district. The paper considered failure causes, failure events and failure modes of every part and component of the failed transformers and analysed the data. After the data was analysed, the paper concluded that every component of a transformer has different faults which causes different failures, some are severe than others, some occur more frequently while were hard to detect. The paper also concluded that, fault occurred in the transformer does not affect a particular component alone but affected others.

Zadgaonka *et al*. (2014) investigated the premature failure of distribution transformers in some of the regions of the state of Madhaya, India. They revealed that premature failure rate of distribution transformers was above 25% in some of the regions investigated. They presented case studies of four (4) distribution transformers which failed within their warranty period of three years. After the investigation, the paper found that, the main causes of the transformer failure were overloading and unbalanced loading. These findings were verified by Dissolved Gas Analysis (DGA) and found that transformer oil degraded due to thermal aging caused by continuous overloading. The oil samples of 27 distribution transformers of different ratings, which failed within the warranty periods, were taken for further studies. Breakdown Voltage (BDV), Total Acid Number (TAN) and viscosity of oil samples were measured and analysed. The results obtained showed that, TAN and Viscosity increased significantly due to thermal aging and Breakdown Voltage decreased substantially. Therefore, the paper found that most failures of distribution transformers occurred before the life of three years due to overloading. The paper also stated that the causes of overloading distribution transformers are different for rural and urban areas. The paper proposed that deliberate overloading for long duration must not be encouraged. The paper also found low maintenance and monitoring of distribution transformers and considered two main reasons for that. Firstly, a large number of distribution transformers were installed at remote rural areas and secondly, insufficient skilled man power to carryout Dissolved Gas Analysis test which is widely recommended for evaluating the health of oil filled transformers.

2.7 Summary of Chapter

This chapter is on literature review of distribution transformers by definition and where it is located in an electrical network. The various types of distribution transformers, which are classified by either voltage level or mounting configuration is also discussed. The constructional features of a typical distribution transformer and their functions are reviewed and the major components that make up the transformer are explained. An overview of the principle of operations of a typical transformer is discussed with an explanatory diagram presented in Figure 2.15. Some examples of distribution transformer rating, primary voltage level, and current in both the primary and secondary are also presented. Further on, the types of protection devices for distribution transformers are discussed and the most relevant protective schemes are enumerated. The chapter also presented IEEE recommended earth resistance limits and typical causes of transformers burnout for both external and internal causes. The literature also discussed failure causes and failure modes of every component of a distribution transformer.

The chapter further presents literature on works relating to causes of transformer burnouts and their possible remedies. From the related works, it is evident that majority of burnout experienced is as a result of insulation failure. Failing of transformer insulation over a lengthy period of time can occur due to aging. However, an insulation failure, which occurs within a short period like the warranty period, is normally as a result of voltage surge, which was described by Florkowski *et al*. (2018). These surges can either be from switching or lightning. Papers like Ravi (2019), Nunoo and Sey (2018), and Bala (2014) identified the cause of insulation failure to be lightning. The protection schemes discussed earlier in the chapter indicated that transformers can be protected from lightning by using surge arresters. A lot of improvements have been made in arrester design and the Metal oxide Varistor provides the best protection for distribution transformers. However, even with these improvements, transformers installed with functioning surge arresters still fail.

The thesis therefore seeks to determine the optimal placement of the lightning arrestor in order to provide a zero-lead length for lightning surges to ground thereby limiting the cause of lightning-related transformer burnouts. The research will be conducted using data taken from ECG along with computer simulations, which will be further discussed in Chapter 3.

CHAPTER 3

MODELLING AND SIMULATION OF THE ZERO LEAD LENGTH CONFIGURATION

3.1 Introduction

The chapter elaborates on the methods used in arriving at the proposed solution. It commences by introducing the software used in modelling and simulation of the proposed system. The model is achieved by implementing the data taken from ECG in MATLAB SIMULINK to depict the actual system. The various lightning arrester mounting configurations is discussed briefly to identify the trend in substation configuration, the configuration employed by ECG and the proposed configuration. The placement of the lightning arrester to achieve optimum protection will be determined using Margin of Protection (MoP). Finally, various simulations will be performed to further identify the best protection to reduce the transformer burnouts due to lightning.

3.2 Overview of MATLAB SIMULINK

MATLAB has been identified as a tool used by Engineers and Scientists for the analysis and design of systems to achieve desired results. The program contains built in graphics which helps in visualizing and gaining insight on a proposed project. MATLAB incorporates a library with a wide range of tool boxes, which helps to identify systems and models that are relevant to our required field of study (Anon., 2019b).

SIMULINK is a branch of MATLAB that extends its capabilities by the numerous toolboxes. A number of blocks set further extend SIMULINK into various disciplines such as aerospace, communications, signal processing, mechanics and power systems. The power systems toolbox enables the modelling of electrical, mechanical, and control systems. An electrical power system comprises various electrical circuit elements such as transformers, motors, resistors and generators, which are interconnected to represent an existing system. This enables engineers to build models in a user friendly environment in order to constantly improve their performance. Simulations are performed on the modelled system and the best results can then be implemented on the actual system.

The configuration of the distribution substation for the proposed system will be modelled using SIMULINK, and various simulations will be performed to determine the most appropriate configuration for the minimisation of transformer burnouts due to lightning.

3.3 Presentation of Collected Field Data

To determine the cause of the most frequent burnout, the transformer failure data sheet is taken from ECG's Central Region network. The data is presented graphically in Figures 3.1 and 3.2.

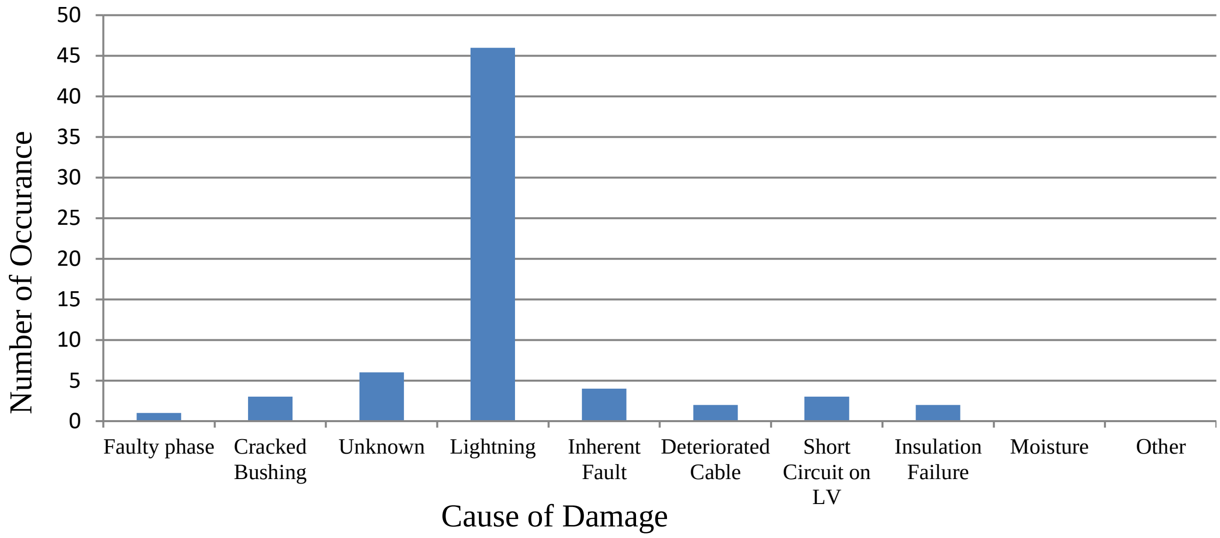


Figure 3.1 Causes of Transformer Burnout for the Year 2017

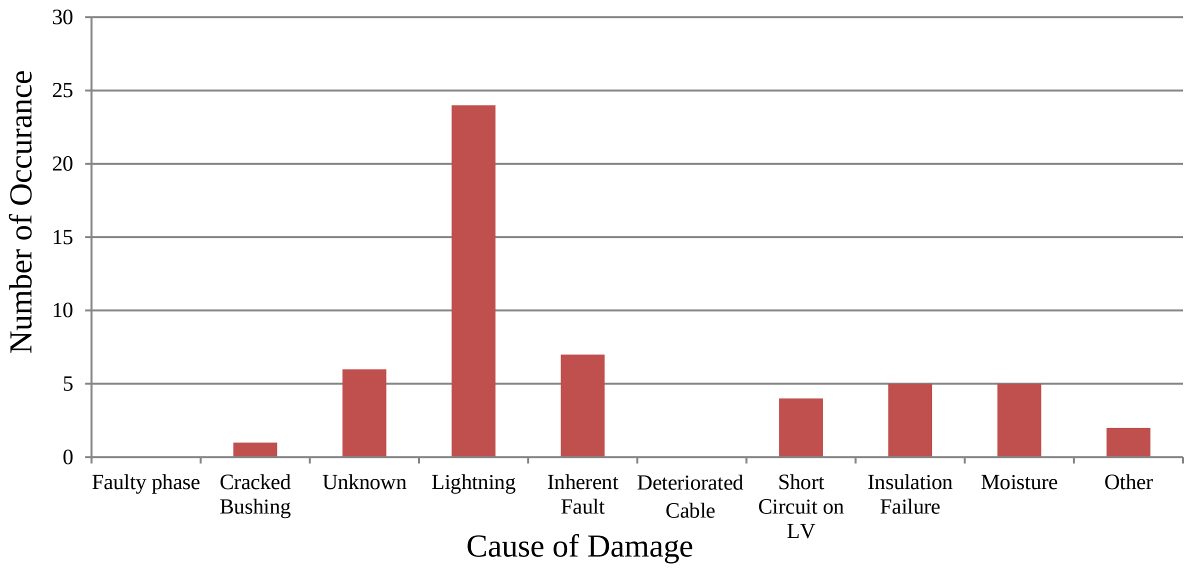


Figure 3.2 Causes of Transformer Burnout for the Year 2018

According to Figure 3.1 and 3.2, most burnouts experienced by distribution transformers in the central region were mainly due to lightning. For 2017 alone, 68.7% of distribution transformer burnouts were as a result of lightning. Whereas lightning caused 44.4% of the total burnout experienced in 2018. In both years, lightning was the major cause of the burnout.

3.4 Description of the Pole - Mounted Substation Configuration

A pole mounted substation primarily consists of a combination of fuses, surge arresters, transformers and electrical earthing systems. Generally, distribution transformers are protected against lightning by installing lightning arresters between the phases and the ground at the primary side of the transformer to reduce the magnitude of lightning below the Basic Insulation Level (BIL) of the transformer. In order to reduce the magnitude of lightning strikes below the BIL, the following factors should be considered:

a. The installation position of the lightning arrestor;
b. The lead length of the connecting conductors of the arrestors; and
c. The effective earthing resistance.

The effective protection level can hence be achieved by determining the optimum position of the lightning arrester to arrive at a reduced lead length and therefore a reduced resistive path to ground for the surge current. A typical pole mounted substation configuration is shown in Figure 3.3.

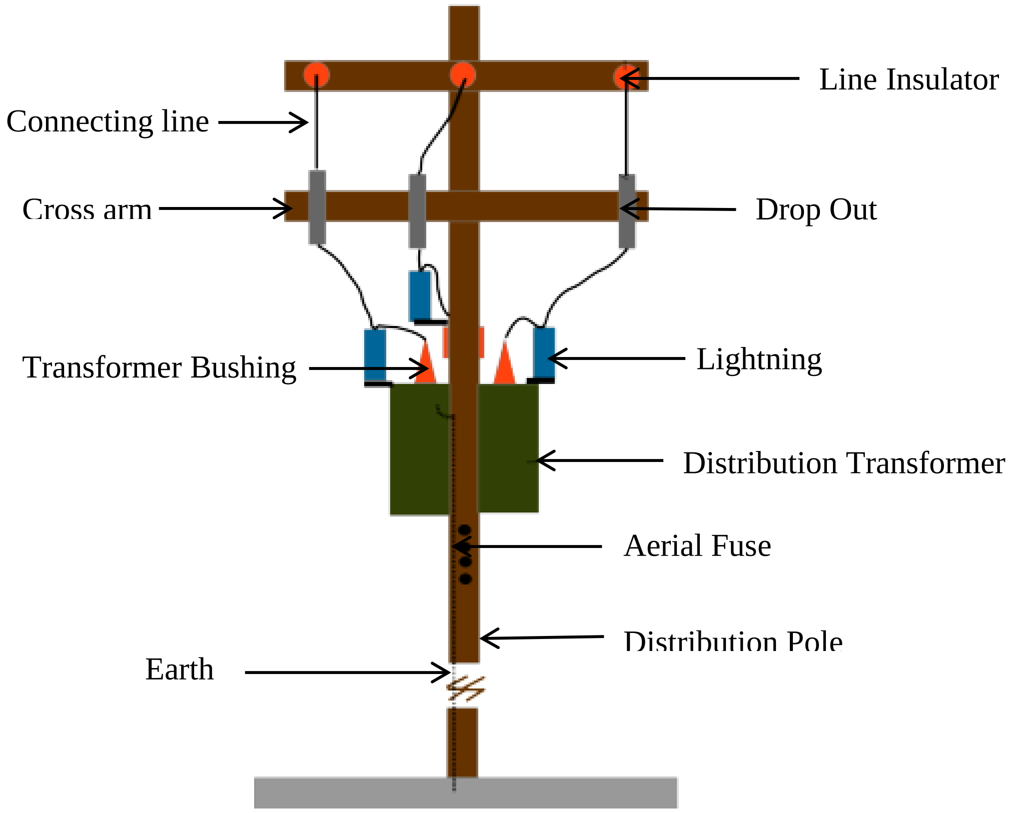


Figure 3.3 Typical Pole Mounted Substation Configuration

The pole mounted substation configuration is prone to numerous faults, especially lightning surges. From the configuration of Figure 3.3, a lightning strike on the line will first go through the fuse and then to the arrester. If the drop out fuse is designed to withstand transient over voltages, then the arrester encounters the lightning surge, which then must ideally operate to send the fault current to ground. Most often, the inability of the arrester to conduct the fault current can be attributed to a damaged arrester or high resistance offered by the connecting leads.

3.5 Current Configuration Employed by ECG

ECG adopts a unique configuration which tends to prevent frequent operation of drop-out fuses during lightning strikes on overhead lines. In this regard, the construction is such that the surge is first intercepted by the arrester which then acts to divert the high current to ground. The arrester after conduction opens to allow normal flow of current through the drop out fuse to the transformer. Figure 3.4 shows the current configuration employed by ECG.

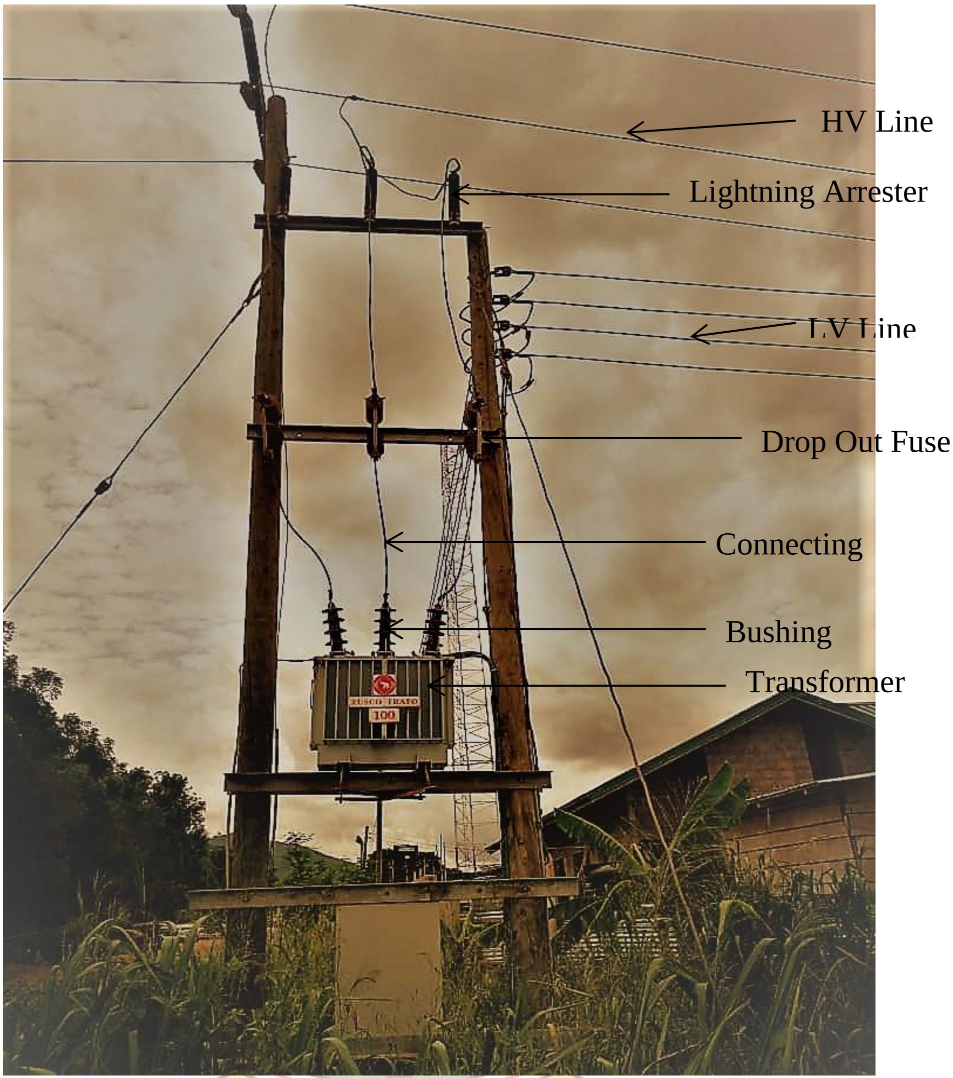


Figure 3.4 ECG Pole Mounted Substation Configuration Employed by ECG

From Figure 3.4, the channel iron serving as base for the arrester is placed 1.5 metres from the high voltage line. The Drop-out fuse is then placed 3.5 metres from the line and the transformer is at a distance of 6.5 metres from the line. Table 3.1 shows some data collected on the field about Transformer burnouts due to lightning and their measured arresters lead length from some selected distribution substations at Kasoa district.

3.1 Lightning Caused Transformer Burnout in the Kasoa District with their Lead Length and Earth Resistance Measured

No	Location of Substation	Rating (kVA)	Voltage Level (kV)	Date of Commis sion	Date of Damage	Arrester Lead Length (m)	Earth Resistance (Ω)
1	Domeabra	100	33/0.433	2015	10/08/2017	12.59	32.50
2	Nkwantanan	100	33/0.433	2009	11/04/2017	11.11	3.90
3	Johovah Witness	100	33/0.433	2015	13/06/2017	10.45	7.60
4	Nyamenadom	100	33/0.433	2010	17/07/2018	10.51	6.86
5	Tema House	100	33/0.433	2013	26/03/2018	10.79	4.44
6	Fetteh Kakraba Park No.3	100	33/0.433	2017	20/07/2018	11.28	6.78
7	Opeikuma No.10	100	33/0.433	2015	13/11/2018	10.45	8.49
8	Appiah Junction No.2	100	33/0.433	2013	11/11/2018	10.67	6.62
9	Opeikuma D - Square	200	33/0.433	2014	13/05/2018	14.12	6.80
10	Ofaakor MTN	200	33/0.433	2016	13/10/2018	10.56	4.45

With the current configuration, even though customer interruptions due to lightning are minimised, there is a high possibility of transformer failure since the lightning strike can incident on the connecting leads between the lightning arrester and the transformer bushing. Also, the arrester lead length contributes to the total voltage surge encountered by the transformer during such faults as will be explained in the next section.

3.6 Determining the Optimum Placement of Lightning Arrester for a Pole - Mounted Substation

The position of the lightning arrester on a pole mounted substation has resulted in different configurations worldwide. The most effective operation of the arrester can only be achieved by finding the optimal location of the device. The optimum placement of lightning arresters for a pole mounted transformer can be determined using Margin of Protection as proposed by Short (2014).

3.6.1 Margin of Protection

Margin of Protection (MoP) is defined as the margin between the maximum allowable surge arrester voltage (protective level) and the insulation withstand that of the transformer (Short, 2014). Most electric power equipment are rated for a travelling wave voltage surge capability by the impulse test. This is used to determine the crest value to the insulation of the equipment involved. The crest value of the wave is called Basic Insulation Level (BIL).

The level of equipment protection provided by an arrester depends on:

a. The magnitude of surge and the current wave rise time; and

b. Discharge voltage of the arrester, giving by Equation (3.1).

$$V_{sa} = i_{dis} \times (R_{sa} + R_{E}) \tag{3.1}$$

where, V_{sa} = arrester discharge voltage (kV)

i_{dis} = discharge current (kA)

R_{sa} = resistance of the non-linear resistor of the arrester (Ω)

R_E = grounding resistance (Ω)

c. Arrester lead length discharge voltage.

$$V_L = l \times L \times \frac{di_{dis}}{dt} \times k \tag{3.2}$$

where, V_L = discharge voltage of lead length in volts

l = lead length of the connection conductors in meters

L = per-unit-length inductance of the connection conductors

k = constant = 2

The total discharge voltage (V_{total}) at the terminals of the transformer can hence be determined by the sum of arrester discharge voltage and the arrester lead length voltage (Christodoulou *et al*., 2017):

$$V_{total} = V_{sa} + V_L \tag{3.3}$$

The MoP is determined based on the total discharge voltage and the transformers' BIL.

$$\mathrm{MoP}=\left(\frac{\mathrm{BIL}}{V_{\mathrm{total}}}-1\right)\times 100\% \tag{3.4}$$

3.6.2 Calculating Margin of Protection for Typical Arrester Lead Lengths

This section focuses on finding the Margin of Protection from the various lead length values measured on ECG's distribution network. This will help determine the security of the 100 kVA transformers at the various substations. A typical lightning arrester employed by ECG has a discharge voltage (Vsa) of 90 kV with a discharge current of 10 kA at 8/20 µs rise time. The 33/0.433 kV, 100 MVA transformers have a BIL of 170 kV. The arrester lead inductance (*L*) is approximately 1.3 µH/m or 0.4 µH/ft (Short, 2014).

The following lead lengths are taken from Table 3.1:

a. Average of (10.45, 10.51, 10.45, 10.67, 10.56 and 10.79) = 10.57 m;

b. Average of (11.19 and 11.28) = 11.24 m; and

c. 12.59 and 14.12 m

Using the above data and Equation (3.2) to (3.4), the MoP is calculated for lead lengths: 10.57, 11.24, 12.59 and 14.12 m

a. Lead length of 10.57 m;

$$V_L = 10.75 \times 1.3 \times 10^{-6} \times \left(\frac{10}{8 \times 10^{-6}}\right) \times 2 = 34.94 \text{ kV}$$

$$V_{total} = V_{sa} + V_L = 90 + 34.94 = 124.94 \text{ kV}$$

Therefore,

$$\mathrm{MoP} = \left(\frac{170}{124.94} - 1\right) \times 100\% = 36.07\%$$

b. Lead length of 11.24 m;

$$V_L = 11.24 \times 1.3 \times 10^{-6} \times \left(\frac{10}{8 \times 10^{-6}}\right) \times 2 = 36.53 \text{ kV}$$

$$V_{total} = V_{sa} + V_L = 90 + 36.53 = 126.53 \text{ kV}$$

Therefore,

$$MoP = \left(\frac{170}{126.53} - 1\right) \times 100\% = 34.36\%$$

c. Lead length of 12.59 m;

$$V_L = 12.59 \times 1.3 \times 10^{-6} \times \left(\frac{10}{8 \times 10^{-6}}\right) \times 2 = 40.92 \text{ kV}$$

$$V_{total} = V_{sa} + V_L = 90 + 40.92 = 130.92 \text{ kV}$$

Therefore,

$$MoP = \left(\frac{170}{130.92} - 1\right) \times 100\% = 29.85\%$$

d. Lead length of 14.12 m;

$$V_L = 14.12 \times 1.3 \times 10^{-6} \times \left(\frac{10}{8 \times 10^{-6}}\right) \times 2 = 45.89 \text{ kV}$$

$$V_{total} = V_{sa} + V_L = 90 + 45.89 = 135.89 \text{ kV}$$

Therefore,

$$MoP = \left(\frac{170}{135.89} - 1\right) \times 100\% = 25.10\%$$

The arrester lead length can contribute a high lead voltage, since the length of wire has self-inductance. A fast rising current therefore induces high voltage across this inductance. From the calculations, it is realised that the lower the lead length, the higher the Margin of Protection, this means that a lower or no lead length will provide a better protection of the transformer against lightning. According to Short (2014), even though IEEE recommends a Margin of protection of above 20%, the transformer is best protected with an MoP of 50% or better due to the current rise time and arrester aging. The optimal placement of the lightning arrester can hence be determined as the location with Zero Lead Length.

Considering the Zero Lead Length configuration, the MoP can be calculated as follows:

Lead length of 0 m;

$$V_L = 0$$

$$V_{total} = V_{sa} + V_L = 90 \text{ kV}$$

Therefore,

$$\text{MoP} = \left(\frac{170}{90} - 1\right) \times 100\% = 88.89\%$$

A MATLAB code is written to graphically analyse the effect of various lead length on lead voltage, arrester voltage and total discharge voltage

3.7 Comparisons on the ECG Current Configuration and the Zero Lead Length Configuration

3.7.1 Configuration Employed by ECG

With ECG's current configuration of lightning protection of distribution substations, the configuration is as follows:

a. The Arrester is placed 1.0 m from the MV line;
b. Line connectors are used to connect a 120 mm^2 All Aluminium Conductor (AAC) from the MV line to the top of the arrester;
c. A lead is connected from the top of the arrester to the top of a DoF placed 1.5 m from the base of the arrester;
d. The DoF is then connected to the transformer bushing. The transformer is mounted on an angle iron which is at a distance of 3m from the base of the DoF;
e. A 35 mm copper wire is connected from the base of the arrester to the earthing point of the transformer tank. The transformer tank is then connected to the earth rods to complete the ground loop;
f. The phase lead length is taken from the top of the arrester to the top of the transformer bushing. It is typically measured at least 3.5 m; and
g. The ground lead length is taken from the bottom of the first arrester to the earthing point of the transformer tank, which is also measured at least 6.5 m. Hence the total lead length measures at 10 m.

Figure 3.5 shows typical ECG current pole mounted substation and lightning protection configuration.

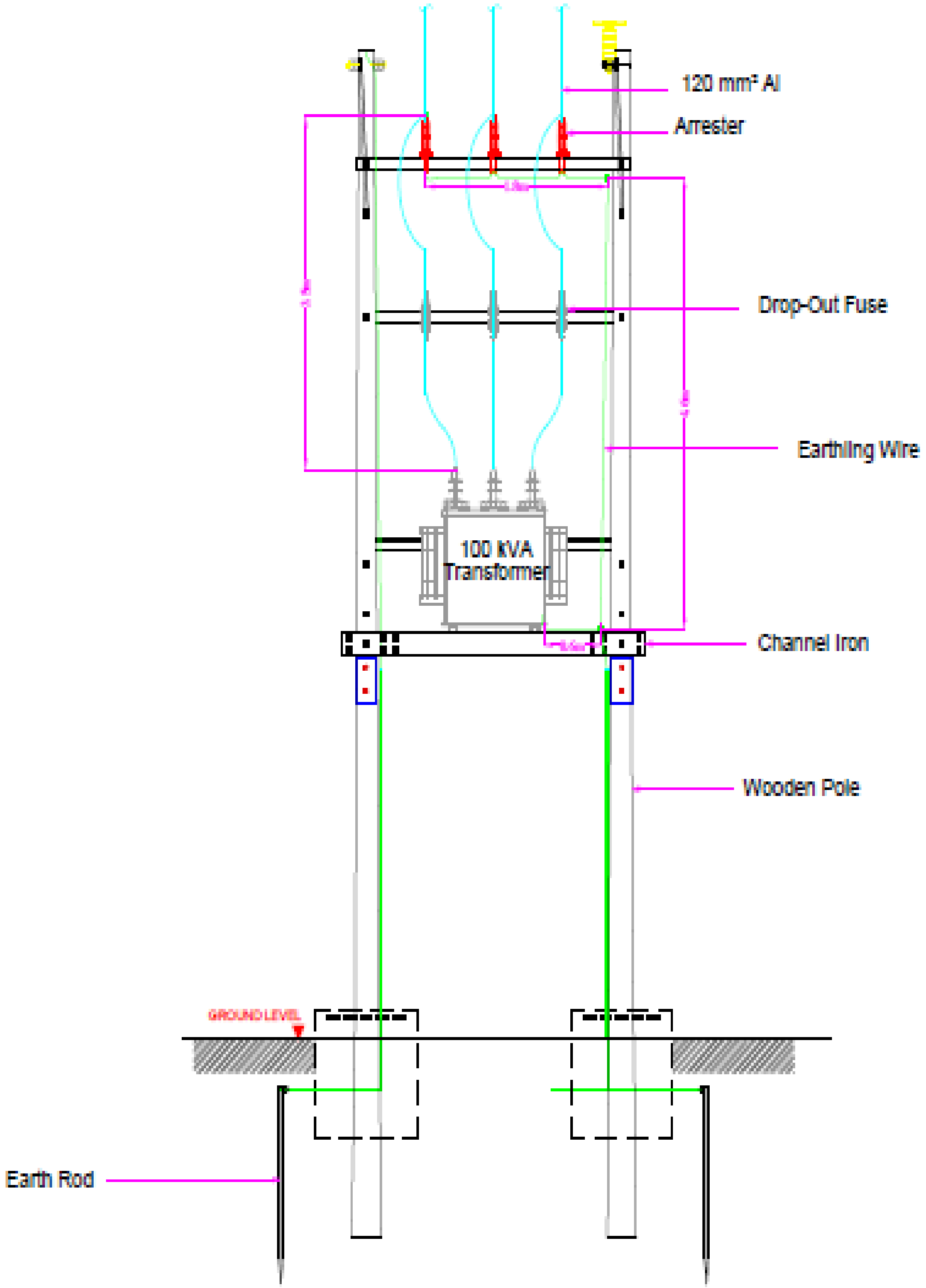


Figure 3.5 Typical ECG Current Lightning Protection Configuration

3.7.2 The Zero Lead Length Configuration

The Zero Lead Length Configuration is also derived with the following method:

a. In this configuration, the drop out fuse (DoF) is placed ahead of the arrester. The DoF is placed 2.5 m from the MV line;
b. A 120 mm^2 AAC is connected from the MV line to the top of the DoF;
c. The arrester is mounted on top of the transformer together with its bushings;
d. The transformer is also placed 3 m from the base of the DoF;
e. Another connecting lead connects the bottom of the DoF to the top of the arrester. This helps to avoid the phase lead length;
f. The top of the arrester is then linked to the top of the transformer bushing;
g. The bottom of the arrester is then connected straight to ground, which helps to avoid the grounding lead length. The connection is done using a 35 mm^2 copper conductor; and
h. The transformer tank is then linked to the bottom of the arrester.

Figure 3.6 shows pole mounted substation and proposed zero lead length configuration

There has always been a debate on the position of the arrester and fuse assembly. Placing the fuse ahead of the arrester causes nuisance interruptions during faults. On the other hand, even as placing the arrester ahead of the fuse prevents the frequent interruptions, the lead length of the arrester increases and hence the level of protection for the transformer is reduced.

The evolution of the Dual-Link (D-Link) fuse can help resolve the problem on the frequent operation of the DoF if it is placed ahead of the arrester. The D-Link fuse is constructed with two different fuse elements, where one element is designed to conduct transient overvoltage. In this regard, the DoF is able to allow the transient fault current to flow to the arrester, which then diverts the fault current to ground and bring the system back to normal operating conditions. The other fuse element is designed to operate on high current loading of the system.

By implementing the above fuse scheme, the DoF can be placed ahead of the arrester and the latter placed as close as possible to the transformer.

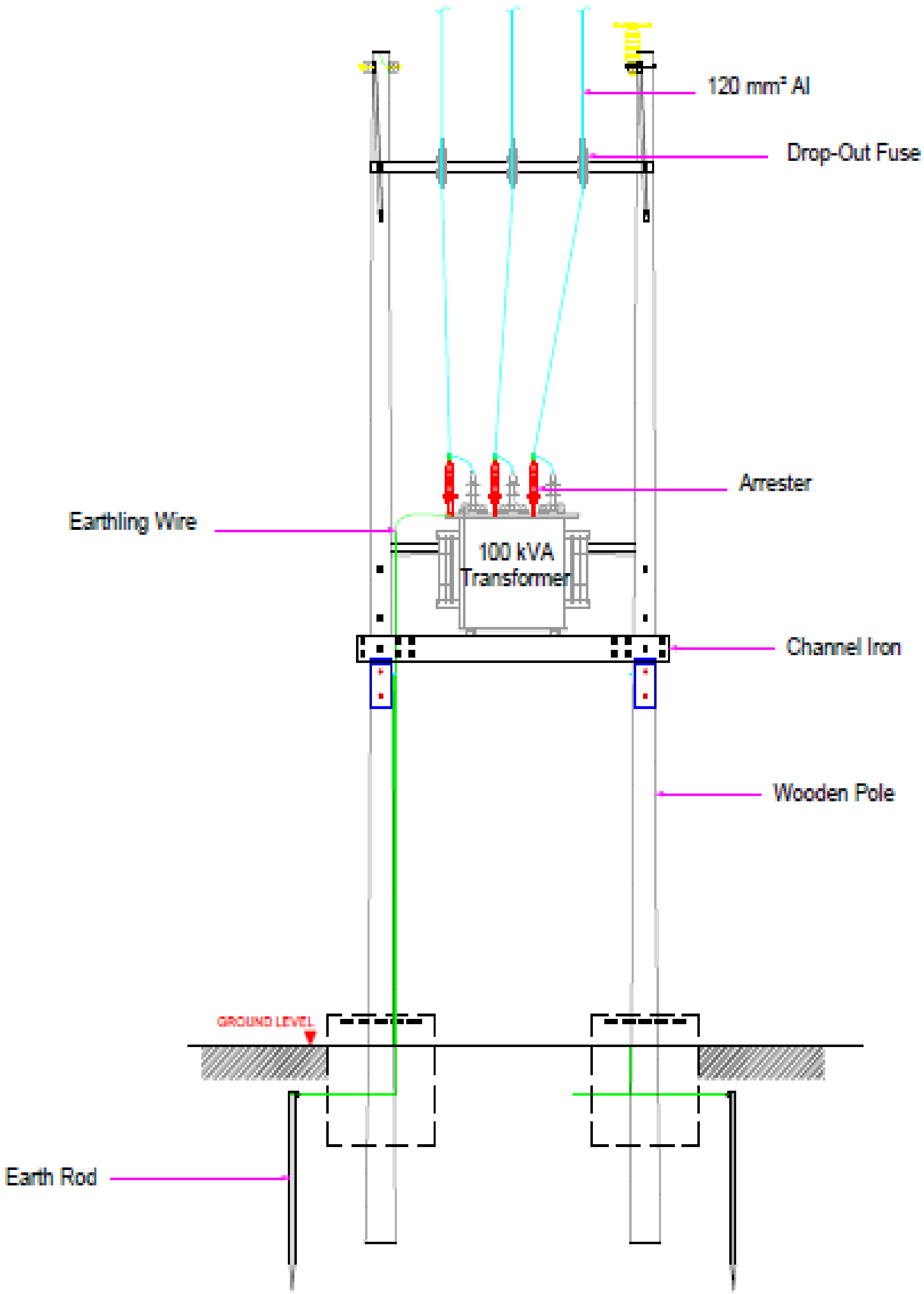
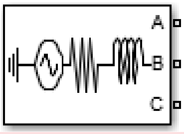
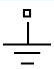
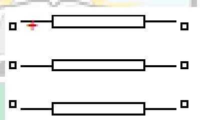
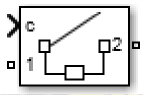
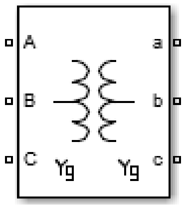
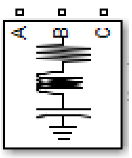


Figure 3.6 Proposed Zero Lead Length Configurations

3.8 Modelling the Current and Proposed Pole Mounted Substation Configuration in MATLAB Simulink

The model of the pole mounted substation configuration is implemented in MATLAB Simulink using SimPowerSystem blocks. The block sets representing the various components of the substation is selected and its parameters entered according to the collected data from ECG. The symbols and functions of the various blocks are presented in Table 3.2.

Table 3.2 SimPowerSystem Block Sets in Simulink Library and their Functions

Block	Symbol	Function
Three-Phase Source		Implement a three-phase source with internal R-L impedance
Ground		Provide a connection to the ground
Distributed Parameter Line		Implement an N-phases distributed parameter line model with lumped losses
Breaker		Implement a circuit breaker opening at current zero crossing
Surge Arrestor		Implement a metal-oxide surge arrester
Three-phase Transformer (2 windings)		Implement a three-phase transformer with two windings
Three-phase Series RLC Load		Implement a three-phase series RLC load with selectable Connection

The voltage source of the system is derived from the three-phase voltage source block. This block implements a balanced three-phase voltage source with internal R-L impedance. Double clicking the block opens a dialog box, where our field data can be entered. The winding configuration is selected as Yn in order to provide a neutral for grounding. The phase-phase voltage is selected at 33 kV with a frequency of 50 Hz. Since only the voltage source is required, the internal impedance of the block is ignored.

The ground block provides a connection to ground. It is implemented at various stages of the model. The neutral of the three-phase block is connected to ground, also for the arrester to conduct to ground; the bottom of the implemented arrester is also given a ground connection. A third ground is provided to the transformer for linking the neutral and also for protection.

The Distributed parameter Line block Implements an N-phase distributed parameter transmission line model with lumped losses. The block is used to determine the medium voltage line from the source to the distribution substation. Its dialog box helps to specify the resistance, inductance and capacitance of the line. The frequency is selected at 50 Hz and a line length of 70 km is chosen.

The three-phase breaker block Implements a three-phase circuit breaker opening at current zero crossing. This breaker is used to determine the time for injecting the fault current into the system. The switching time of the bock is selected as 3.5/60 s and a breaker resistance of 0.01 Ω.

A three-phase source block is used to model the lightning surge. The phase to phase voltage of the block is chosen as 180 kV with a frequency of 100 Hz. This presents a high system disturbance with a characteristic similar to a lightning surge.

The surge arrester block Implements metal-oxide surge arrester with a highly nonlinear resistor used to protect power equipment against overvoltage. The parameters of the block are specified according to the surge arrester datasheets of ECG. The protection voltage is selected as 90 kV with a reference current per column of 10 kA. The arrester segment characteristics are also chosen as per the data sheet.

The lead length is presented using the distributed parameter block with length 10 m and frequency 50 Hz. This helps to differentiate the model with and without lead length. Other parameters of the block are selected similarly to that of the MV line.

The three-phase transformer block presents three-phase transformer using three single-phase transformers. Modelled with reference to the typical system, a nominal power of 100 kVA and frequency of 50 Hz at a transformation voltage of 33/0.433 kV is used. D11 is selected as the primary winding configuration, which implies that delta leads Y by 30 degrees. The secondary winding configuration is chosen as Yn to enable a neutral line for distribution.

The three-phase series RLC load block is used to indicate the load on the secondary side of the transformer. It implements a three-phase balanced load as a series combination of RLC elements. At the specified frequency, the load exhibits constant impedance. The active and reactive powers absorbed by the load are proportional to the square of the applied voltage. The voltage is 0.433 kV at 50 Hz with an active and reactive power of 90 kW and 42.26 Var, respectively.

Scopes are connected at the primary and secondary stages of the network to display the various waveforms of the model.

Figure 3.7 presents the model with lead length. The model without lead length is achieved by removing the lead length parameter from the circuit.

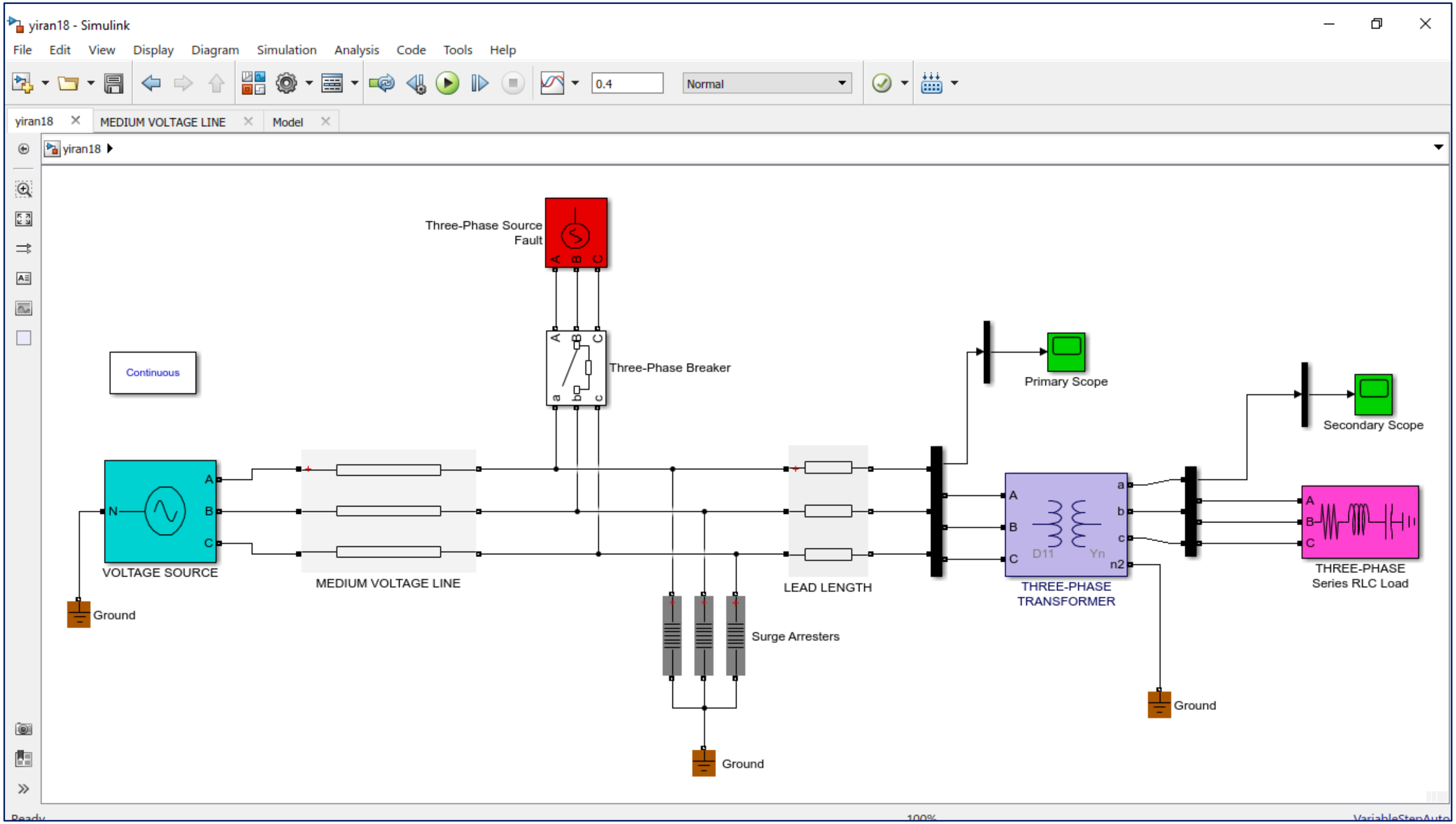


Figure 3.7 MATLAB Simulink Model of a Pole Mounted Substation

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the result of the various simulations performed on ECG's pole mounted substation. The first set of analysis outlines the effects of arrester discharge voltage, lead length voltage and the total discharge voltage on the transformer. The next analysis focuses on simulations performed on the Simulink model. The normal operating conditions of the system without the fault is first analysed. The fault is introduced into the system with lead length and simulated. Finally, the simulation on the system with the fault present but with no lead length is analysed.

4.2 Analysis of the Results using Margin of Protection

As stated in Chapter 3, the protective level of transformers from lightning or overvoltage surges can be determined by using margin of protection. It is used to check whether there are enough margins between the lightning discharge voltage across the insulation and the insulation's capability.

Equations (3.1) to (3.4) are used to develop a MATLAB code to assess the results on the various parameters of Margin of protection. Figure 4.1 presents the results used to select the arrester discharge voltage. The reference current selection per column is also shown in the results.

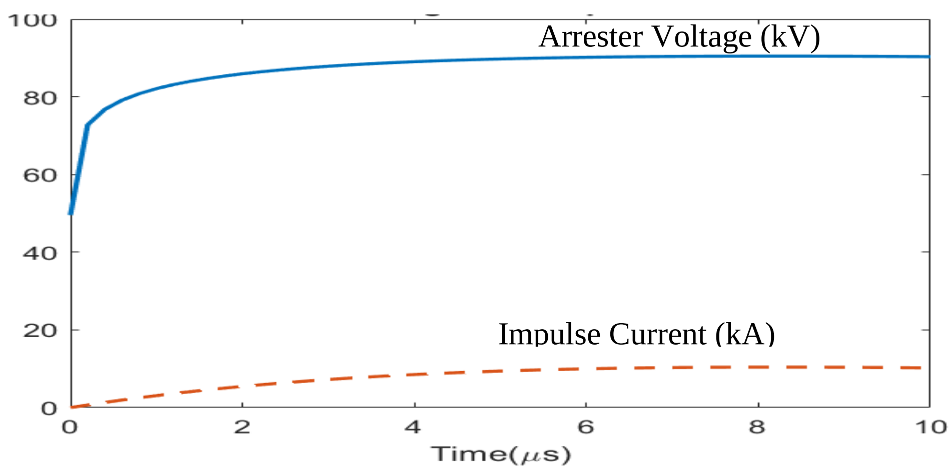


Figure 4.1 33 kV Arrester Discharge Voltages

From Figure 4.1 the arrester discharge voltage varies with the rate of rise time. As the time increases, the arrester discharge voltage suddenly increases from 50 kV to 80 kV within a rise time of 0.1 µs. The voltage then taps to 90 kV and remains steady throughout the whole of the simulation. The rise time however increased steadily and settled on 10 kA throughout the simulation time. An arrester chosen with a voltage of 90 kV and reference current of 10 kA will be ideal for the system.

Figure 4.2 presents results on various lead voltages with regards to the lead length. The lead length used in the analysis ranges from 0m to 20m.

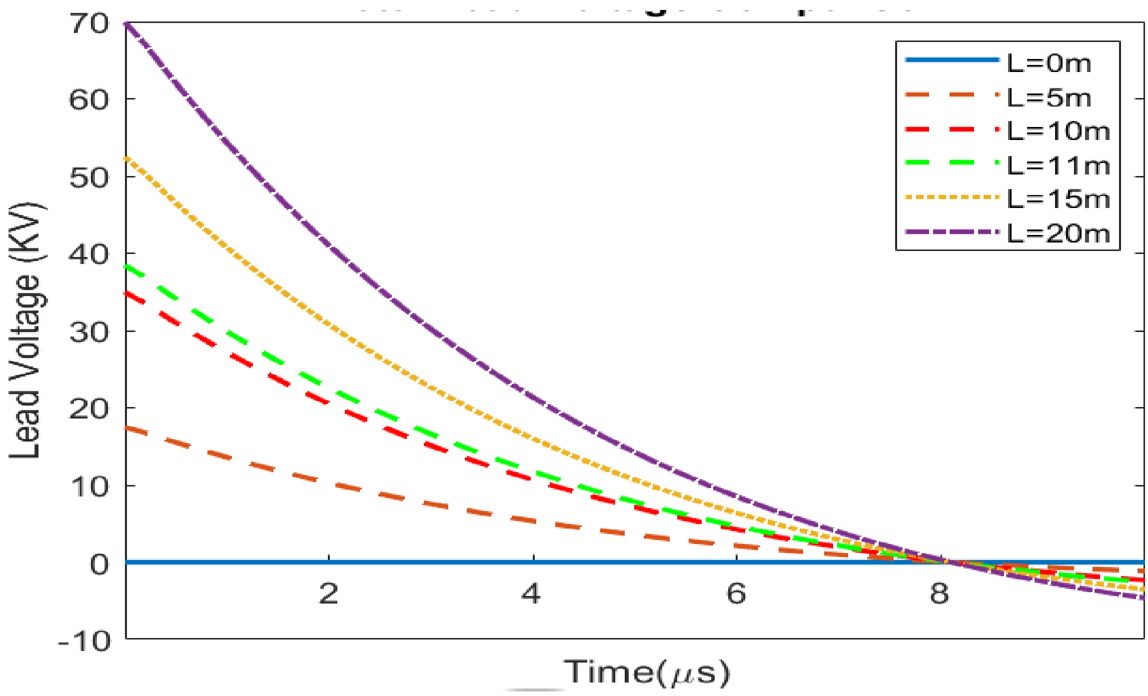


Figure 4.2 Total Lead Voltage Comparisons

From Figure 4.2, the voltage contribution of each scenario is shown. The length with the highest value contributes the most voltage to the system and the zero lead contributing no voltage to the lightning surge.

Figure 4.3 presents a sum of arrester discharge voltage and arrester lead lengths discharge voltages across the Insulation. Similar to the lead voltage graph, the system with lead length contributed a higher discharge voltage in the system.

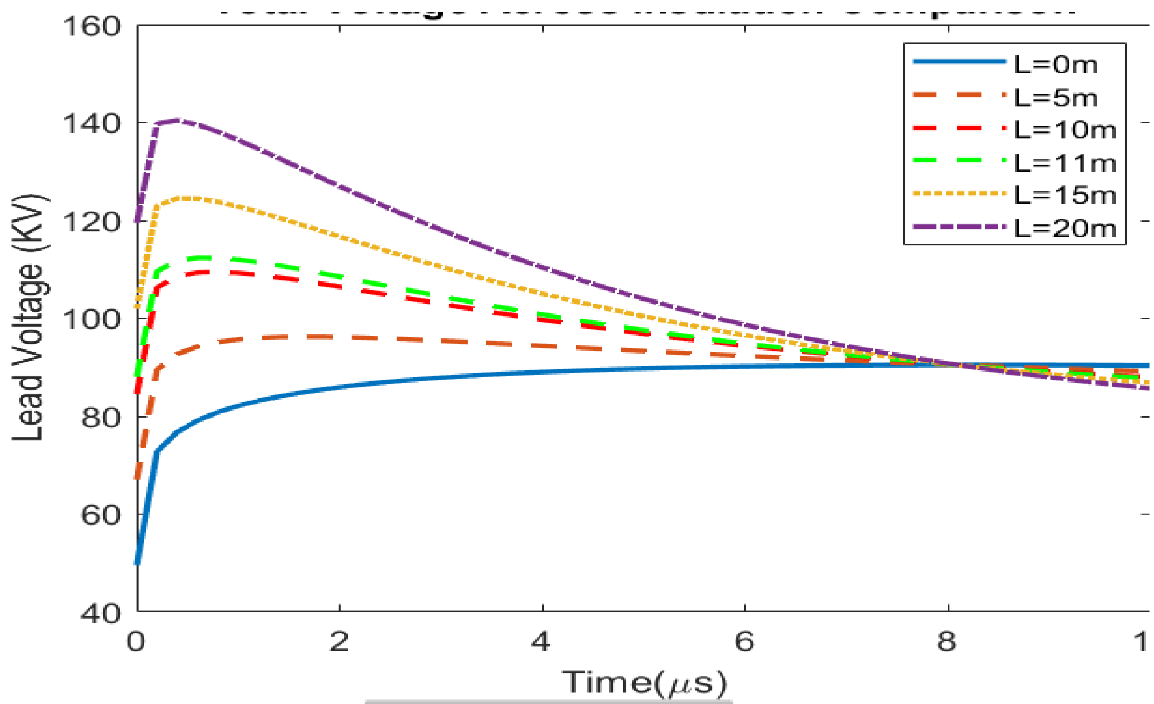


Figure 4.3 Total Discharge Voltages

From Figure 4.1 to Figure 4.3, the graphs show that arrester lead length increases the discharge voltage during lightning or voltage surge. It also shows clearly that, the longer the lead length of surge arresters, the higher the discharge voltage across the insulation of the transformer. Also, the higher the discharge voltage across the insulation, the smaller the margin of protection (protective level) putting the transformer at risks and a possibility of transformer damage

4.3 Analysing the Simulation Results of the Modelled System

This section provides detail analysis of the results obtained from the Simulink model. Three scenarios are presented, that is the results on the normal operating condition of the system, the system with fault and lead length as well as the system with fault but without lead length.

Figure 4.4 provides a graph of the simulated system with normal conditions. The graph shows that when there is no lightning or voltage surge on the line, the arrester provides a high resistance to the normal system voltage and act as an open circuit to ground. From the graph, the primary voltage remains constant at 33 kV.

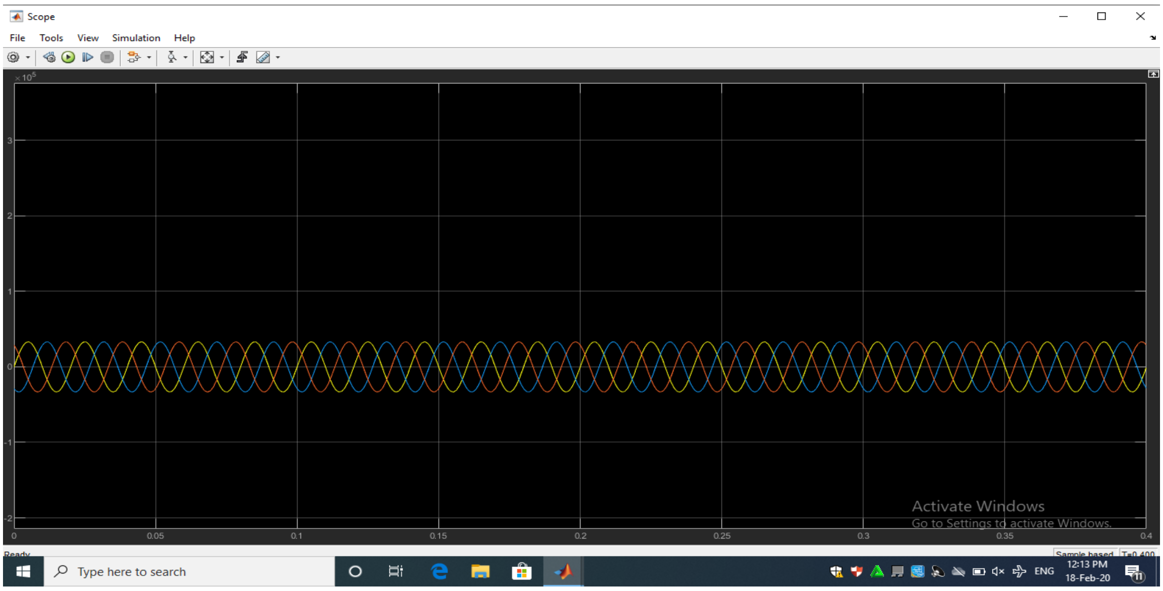


Figure 4.4 Simulation Result of Normal System Condition

Figure 4.5 presents the results of the simulated model with the fault condition initiated. The system had a lead length of 10 m present during the simulation.

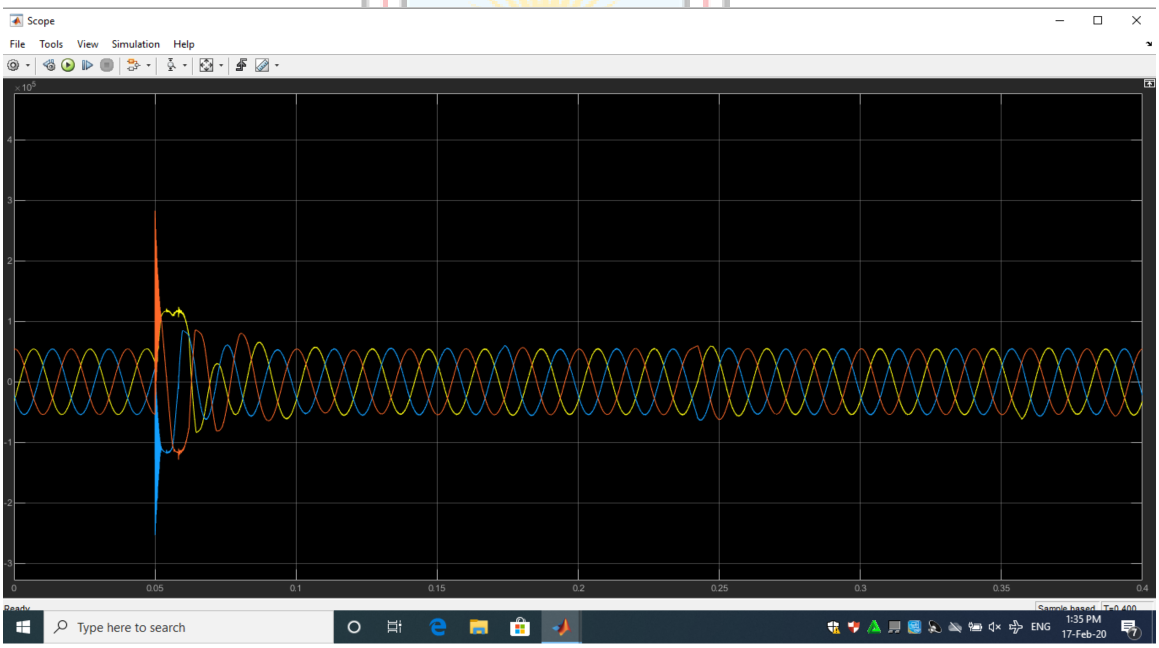


Figure 4.5 Simulation Results on Lightning Condition of Current Configuration

From Figure 4.5, the magnitude of the surge discharge voltage across the transformer insulation before the arrester operated was about 120 kV compare to the arresters discharge of 90 kV. This means that the arrester lead length has contributed a discharge voltage of 30 kV.

Figure 4.6 shows the simulation results on lightning condition of the proposed zero lead length configurations. Here the system is protected against lightning and overvoltage surges by the arrester. The configuration is without lead length and with a very high voltage injected as lightning surge.

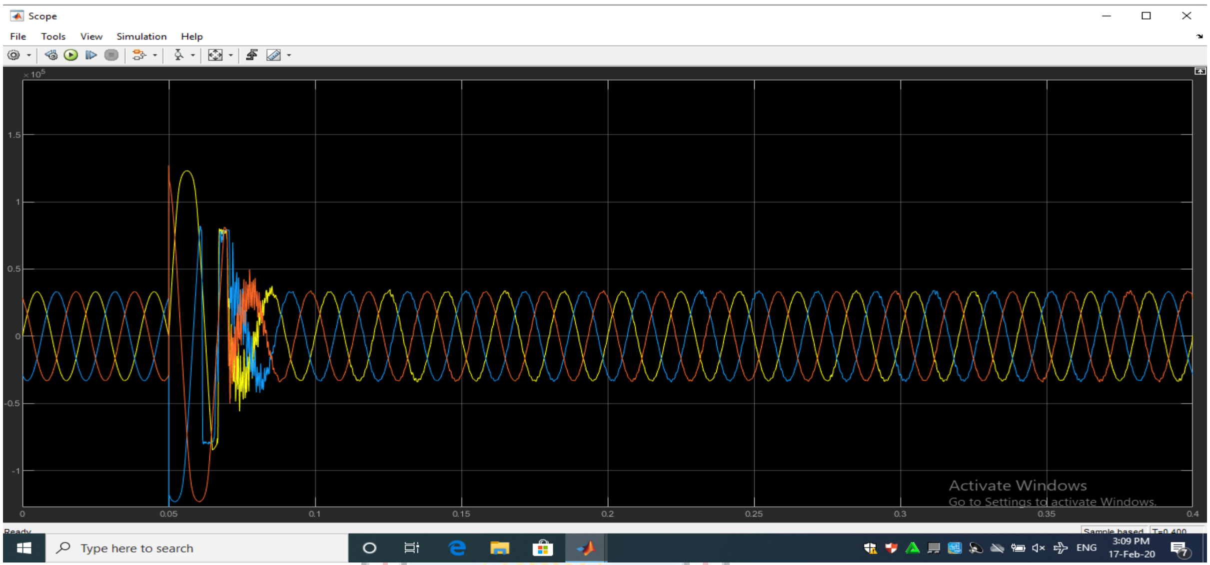


Figure 4.6 Simulation Results on Lightning Condition of Proposed Zero Lead Length Configurations

From Figure 4.6, the magnitude of the surge discharge after the arrester operated is about 85 kV compare to the arresters discharge of 90 kV. This means that without the arrester lead length, there is less discharges across the transformer insulation compare to arrester with lead length as shown in Figure 4.5 and Figure 4.6, respectively.

4.4 Summary of Findings

The findings made during this research are as follows:

a. The simulation result shows that there was an increase in total discharge voltage from 90 kV to 120 kV when the lead length was present;

b. With no lead length present in the network, the system recorded a peak voltage of 85 kV;

c. Even though the total voltage discharged by the lead length settles after 8 μs, there is a high rise in voltage when a fault is injected unto the network; and

d. The arrester discharge voltage changes from 50 kV to 90 kV and becomes steady at this value for the entire simulation time. The reference current also remains constant at 10 kA.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions are drawn based on the findings:

a. The positioning of a lightning arrester is a contributing factor to transformer burnouts during lightning strikes;
b. A lead length contributes an extra discharge voltage to the arrester discharge voltage across the transformer insulation during lightning or surge overvoltage;
c. The longer the lead length, the higher the discharge voltage it contributes and therefore, the lesser the protective level;
d. The total discharge voltage across a transformer with arrester lead length present, has a high possibility of causing damage to transformers; and
e. The margin of protection of transformers is reduced when the arresters are placed at a distance away from the transformer.

5.2 Recommendations

The following recommendations are made in respect to the thesis:

a. To reduce transformer burnout during lightning, the lightning arresters should be placed on the tanks of respective transformers;
b. With the arrester on the transformer tank, the medium voltage supply line must first be connected on the arresters before the transformer bushing to achieve the zero lead length configurations; and
c. The work focused on removing the lead length, which contributes to discharge voltage. Further work should focus on the characteristics of lightning surges and its effects on existing arresters.
d. Incorporating the earth resistance studies into the lightning caused distribution transformer burnouts can also be carried out as further work.

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APPENDICES

APPENDIX A

FIELD DATA

Table A1 Damaged Transformers in Central Region and their Replacement cost in 2017

No.	Rating (KVA)	Type	Voltage Level (kV)	District	Date of Damage	Cause of Damage	Replacement Cost (GH₵)
January							
1	50	PMT	33/0.433	Agona Swedru	03/01/2017	Faulty phase	13,947.76
2	100	PMT	33/0.433	AssinFosu	19/01/2017	Cracked HV Bushing	25,185.63
3	50	PMT	33/0.433	Ajumako	16/01/2017	Unknown	13,947.76
February							
4	50	PMT	33/0.433	Saltpond	27/02/2017	Lightning	13,847.76
5	200	PMT	33/0.433	Kasoa	12/02/2017	Lightning	32,891.84
6	100	PMT	11/0.433	Saltpond	27/02/2017	Lightning	25,185.63
7	200	PMT	33/0.433	AssinFosu	05/02/2017	Lightning	32,891.84
8	225	GMT	11/0.433	Swedru	08/02/2017	Cracked Bushing	32,891.84
March							
9	200	PMT	33/0.433	Kasoa North	14/03/2017	Inherent Fault	32,891.84
10	100	PMT	33/0.433	Twifo Praso	15/03/2017	Lightning	25,185.63
11	50	PMT	33/0.433	Praso	08/03/2017	Lightning	13,947.76
12	50	PMT	33/0.433	Twifo Praso	04/03/2017	Lightning	13,947.78
13	50	PMT	33/0.433	Swedru	08/03/2017	Deterioration LV Cable	13,947.76
April							
14	50	PMT	33/0.433	Kasoa North	18/04/2017	Lightning	13,947.76
15	50	PMT	11/0.433	Winneba	21/04/2017	Short Circuit on LV Side	13,947.76
16	200	PMT	33/0.433	Kasoa South	22/04/2017	Lightning	32,891.84
17	100	PMT	33/0.433	Twifo Praso	21/04/2017	Lightning	25,185.63
18	50	PMT	33/0.433	Breman Asikuma	27/04/2017	Lightning	13,947.76
19	50	PMT	33/0.433	Twifo Praso	10/04/2017	Short Circuit on LV side	13,947.76

20	50	PMT	33/0.433	Kasoa	10/04/2017	Lightning	13,947.76
21	50	PMT	33/0.433	Saltpond	11/04/2017	Lightning	13,947.76
May							
22	50	PMT	33/0.433	Assin Fosu	19/05/2017	Lightning	13,947.76
23	200	PMT	33/0.433	Assin Fosu	20/05/2017	Lightning	32,891.84
24	100	PMT	33/0.433	Twifo Praso	22/05/2017	Lightning	25,185.63
25	100	PMT	33/0.433	Swedru	23/05/2017	Lightning	25,185.63
26	50	PMT	33/0.433	Cape Coast	25/05/2017	Lightning	13,947.76
27	50	PMT	33/0.433	Assin Fosu	11/05/2017	Lightning	13,947.76
28	25	PMT	33/0.433	Assin Fosu	11/05/2017	Lightning	13,947.76
29	50	PMT	33/0.433	Kasoa South	11/05/2017	Lightning	13,947.76
June							
30	200	PMT	33/0.433	Kasoa	13/06/2017	Lightning	32,891.84
31	200	PMT	33/0.433	Kasoa	07/06/2017	Insulation Failure	32,891.84
July							
32	100	PMT	11/0.433	Kasoa	03/07/2017	Lightning	25,185.63
33	200	PMT	33/0.433	Swedru	03/07/2017	Lightning	32,891.84
34	200	PMT	33/0.433	Kasoa	06/07/2017	Lightning	32,891.84
35	50	PMT	33/0.433	Kasoa	15/07/2017	Short Circuit on LV Side	13,947.76
36	50	PMT	33/0.433	Twifo Praso	27/07/2017	Lightning	13,947.76
37	200	PMT	33/0.433	Kasoa	12/07/2017	Lightning	32,891.84
38	200	PMT	33/0.433	Saltpond	12/07/2017	Inherent Fault	32,891.84
August							
39	50	PMT	11/0.433	Cape Coast	05/08/2017	Lightning	13,947.76
40	50	PMT	33/0.433	Kasoa	06/08/2017	Lightning	13,947.76
41	100	PMT	33/0.433	Ajumako	30/08/2017	Inherent Fault	25,185.63
42	100	PMT	33/0.433	Kasoa	10/08/2017	Lightning	25,185.63
43	50	PMT	33/0.433	Winneba	11/08/2017	Lightning	13,947.76
September							
44	100	PMT	33/0.433	Cape Coast	27/09/2017	Lightning	25,185.63
45	50	PMT	33/0.433	Assin Fosu	27/09/2017	Lightning	13,947.76
46	50	PMT	33/0.433	Assin Fosu	27/09/2017	Lightning	13,947.76
47	50	PMT	33/0.433	Kasoa	28/09/2017	Inherent Fault	13,947.76
48	50	PMT	33/0.433	Ajumako	10/09/2017	Unknown	13,947.76
49	50	PMT	33/0.433	Twifo Praso	22/09/2017	Cracked Bushing	13,947.76

October							
50	100	PMT	33/0.433	Saltpond	06/10/2017	Lightning	25,185.63
51	50	PMT	33/0.433	Ajumako	22/10/2017	Uknown	13,947.76
52	50	PMT	33/0.433	Saltpond	20/10/2017	Lightning	13,947.76
53	200	PMT	33/0.433	Kasoa	28/10/2017	Lightning	32,891.84
54	315	GMT	11/0.433	Kasoa	14/10/2017	Unknown	36,555.65
55	200	PMT	33/0.433	Kasoa	29/10/2017	Lightning	32,891.84
November							
56	200	PMT	33/0.433	Assin Fosu	04/11/2017	Lightning	32,891.84
57	100	PMT	33/0.433	Assin Fosu	04/11/2017	Lightning	25,185.63
58	100	PMT	33/0.433	Assin Fosu	04/11/2017	Lightning	25,185.84
59	200	PMT	33/0.433	Kasoa	04/11/2017	Lightning	32,891.84
60	200	PMT	33/0.433	Kasoa	14/11/2017	Unknown	32,891.84
61	200	PMT	33/0.433	Cape Coast	20/11/2017	Lightning	33,535.79
62	50	PMT	33/0.433	Swedru	20/11/2017	Unknown	13,947.76
63	50	PMT	33/0.433	Saltpond	21/11/2017	Lightning	13,947.76
64	50	PMT	33/0.433	Cape Coast	19/11/2017	Lightning	13,947.76
65	50	PMT	33/0.433	Assin Fosu	29/11/2017	Lightning	13,947.76
66	200	PMT	33/0.433	Kasoa	24/11/2017	Inherent Fault	32,891.84
December							
67	100	PMT	11/0.433	Saltpond	30/12/2017	Insulation Failure	33,835.79

(Source: ECG Central Region Maintenance Department, 2017)

Table A2 Damaged Transformers in Central Region and their Replacement Cost in 2018

No.	**Rating (KVA)**	**Type**	**Voltage Level (kV)**	**District**	**Date of Damage**	**Cause of Damage**	**Replacement Cost (GH₵)**
January							
1	100	PMT	33/0.433	Tafo Praso	11/01/2018	Inherent fault	25,185.63
February							
2	100	PMT	33/0.433	Ajumako	09/02/2018	Short Circuit	25,185.63
3	50	PMT	33/0.433	Saltpond	14/02/2019	Short Circuit	13,947.76
4	200	PMT	33/0.433	Kasoa	14/02/2018	Insulation failure	32,891.84
5	100	PMT	33/0.433	Assin Foso	19/02/2018	Insulation failure	25,185.63
6	200	PMT	33/0.433	Kasoa	20/02/2018	Ingress of Moisture	32,891.84
7	50	PMT	33/0.433	Twifo Praso	27/02/2018	Lightning	13,947.76

March							
8	50	PMT	33/0.433	Bremang Assikuma	18/03/2018	Lightning	13,947.76
9	200	PMT	33/0.433	Agona Swedru	23/03/2018	Crack Bushing	25,185.63
10	100	PMT	33/0.433	Kasoa	26/03/2018	Short Circuit	25,185.63
11	200	PMT	33/0.433	Cape Coast	31/03/2018	Insulation failure	32,891.84
April							
12	100	PMT	33/0.433	Saltpond	08/04/2018	Lightning	25,185.63
13	200	PMT	33/0.433	Kasoa	11/04/2018	Lightning	32,891.84
14	100	PMT	33/0.433	Kasoa	23/04/2018	Short Circuit	25,185.63
15	50	PMT	33/0.433	Kasoa	29/04/2018	Unknown	13,947.76
May							
16	100	PMT	33/0.433	Winneba	01/05/2018	Ingress Moisture	25,185.63
17	50	PMT	33/0.433	Twifo Praso	10/5/2018	Lightning	13,947.76
18	200	PMT	33/0.433	Kasoa	10/05/2018	Lightning	32,891.84
19	200	PMT	33/0.433	Kasoa	10/05/2018	Lightning	32,891.84
20	200	PMT	33/0.433	Kasos	13/05/2018	Lightning	32,891.84
21	100	PMT	33/0.433	Kasoa	13/05/2018	Lightning	25,185.63
22	200	PMT	33/0.433	Kasoa	13/05/2018	Lightning	32,891.84
23	100	PMT	33/0.433	Assin Foso	16/05/2018	Lightning	25,185.63
June							
24	100	PMT	33/0.433	Assin Foso	11/06/2018	Ingress Moisture	25,185.63
25	50	PMT	33/0.433	Saltpond			13,947.76
July							
26	50	PMT	33/0.433	Winneba	06/07/2018	Contaminated Oil	13,947.76
27	50	PMT	33/0.433	Twifo Praso	09/07/2018	Lightning	13,947.76
28	100	PMT	33/0.433	Kasoa	17/07/2018	Damage by truck	25,185.63
29	100	PMT	33/0.433	Kasoa	20/07/2018	Insulation failure	25,185.63
September							
30	50	PMT	33/0.433	Assin Foso	14/09/2018	Unkonwn	13,947.76
31	50	PMT	33/0.433	Assin Foso	15/09/2018	Contaminated Oil	13,947.76

October							
32	15	PMT	33/0.433	Saltpond	05/10/2018	Lightning	
33	200	PMT	33/0.433	Kasoa	09/10/2018	Lightning	32,891.84
34	50	PMT	11/0.433	Winneba	09/10/208	Lightning	13,947.76
35	200	PMT	33/0.433	Kasoa	13/10/2018	Lightning	32,891.84
36	50	PMT	33/0.433	Bremang Asikuma	22/10/2018	Lightning	13,947.76
37	50	PMT	33/0.433	Ajumako	22/10/2019	Lightning	13,947.76
38	100	PMT	11/0.433	Agona Swedru	25/10/2018	Lightning	25,185.63
November							
39	200	PMT	33/0.433	Cape Coast	05/11/2018	Inherent fault	32,891.84
40	50	PMT	33/0.433	Assin Foso	06/11/2018	Lightning	13,947.76
41	100	PMT	33/0.433	Kasoa	08/11/2018	Inherent fault	25,185.63
42	100	PMT	33/0.433	Twifo Praso	08/11/2018	Inherent fault	25,185.63
43	100	PMT	33/0.433	Kasoa	13/11/2018	Unknown	25,185.63
44	100	PMT	33/0.433	Kasoa	13/11/2018	Fire outbreak	25,185.63
45	50	PMT	33/0.433	Assin Foso	14/11/2018	Unknown	13,947.76
46	100	PMT	33/0.433	Kasoa	19/11/2018	Lightning	25,185.63
47	100	PMT	33/0.433	Kasoa	19/11/2018	Lightning	25,185.63
December							
48	500	GMT	11/0.433	Winneba	01/12/2018	Inherent fault	
49	15	PMT	33/0.433	Assin Foso	01/12/2018	Unknown	13,947.76
50	200	PMT	11/0.433	Cape Coast	15/12/2018	Insulation failure	32,891.84
51	100	PMT	33/0.433	Kasoa	17/12/2018	Inherent fault	25,185.63
52	50	PMT	33/0.433	Twifo Praso	20/12/2018	Lightning	13,947.76
53	200	GMT	11/0.433	Cape Coast	23/12/2018	Inherent fault	32,891.84
54	100	PMT	11/0.433	Agona Swedru	24/12/2018	Lightning	25,185.63

(Source: ECG Central Region Maintenance Department, 2018)

Table A3 Global ECG Damage Transformer Report for 2019

No.	Region	kVA	Type	Location	District	Date Damaged	Voltage level (kV)	Replacement Cost (GH¢)
1	A/E	100	PMT	M08/253 MADINA ESTATE	LEGON	11/01/2019	11/0.433	22960.27
2	A/E	25	PMT	ND11/272 ASHALEY BOTWE	LEGON	15/01/2019	11/0.433	12024.48
3	A/E	25	PMT	T03/03E ADENTA POST OFFICE	DODOWA	23/01/2019	11/0.433	30361.96
4	A/E	200	PMT	TM07 TEIMAN	DODOWA	24/01/2019	11/0.433	37225.96
5	A/E	200	PMT	ST. KIZITO BASIC SCHOOL, NIMA	ROMAN RIDGE	27/01/2019	11/0.433	30066.18
6	ACCRA WEST	200	PMT	PEACE VILLAGE	ABLEKUMA	31/01/2019	11/0.433	32139.58
7	ACCRA WEST	200	PMT	NIC DOWN	ABLEKUMA	04/01/2019	11/0.433	32139.58
8	ACCRA WEST	500	GMT	SUKURA	DANSOMAN	08/01/2019	11/0.433	115640.29
9	ACCRA WEST	50	PMT	NSAWAM	NSAWAM	12/01/2019	33/0.433	36672.67
10	ACCRA WEST	200	PMT	POBIMAN	NSAWAM	16/01/2019	33/0.433	36672.67
11	ASHANTI	200	PMT	APPIADU ICAD	ASOKWA	20/01/2019	11/0.433	30999.85
12	ASHANTI	50	PMT	ASONOMANSO BOREHOLE	KWABRE	24/01/2019	33/0.433	28536.76
13	ASHANTI	100	PMT	KUMI	OFFINSO	28/01/2019	33/0.433	26139.32
14	ASHANTI	50	PMT	DOMPOASE PALACE	OBUASI	19/01/2019	11/0.433	12949.6
15	ASHANTI	50	PMT	BAKOYEDEN TOMCOF	OBUASI	19/01/2019	11/0.433	22947.2
16	ASHANTI	50	PMT	KRONUM TAXI STATION	SUAME	19/01/2019	11/0.433	12949.6
17	ASHANTI	25	PMT	KWAPRA HIGHGATE SCHOOL	SUAME	19/01/2019	11/0.433	14202.34
18	ASHANTI	25	PMT	BREMANG FORJOUR WALL II (HVDS)	SUAME	19/01/2019	11/0.433	14023.38
19	EASTERN	50	PMT	DOMINASE	Begoro	20/01/2019	33/0.433	13947.76
20	WESTERN	200	PMT	APOWA CLINIC	AGONA	21/01/2019	11/0.433	30986.7
21	WESTERN	50	PMT	FREBOHU	AGONA	22/01/2019	33/0.250	16296.57

22	WESTERN	100	PMT	HUNI VALLEY	TARKWA	23/01/2019	33/0.433	69387.18
23	WESTERN	200	PMT	ETESO	JUABOSO	24/01/2019	33/0.433	36908.4
24	A/E	50	PMT	M13/78 MEMPEASEM	LEGON	02/02/2019	11/0.433	21576.67
25	A/E	25	PMT	M08/202 MADINA SOCIAL WELFARE	LEGON	02/02/2019	11/0.433	12320.26
26	A/E	100	PMT	TW21A DANFA AFTER POLICE STATION	DODOWA	02/02/2019	11/0.433	34610.41
27	ACCRA WEST	315	GMT	DOBLO	NSAWAM	02/02/2019	11/0.433	38099.37
28	ACCRA WEST	50	GMT	HEBRON	NSAWAM	02/02/2019	11/0.433	32306.36
29	ASHANTI	100	PMT	APRIE LIVING SEED	DANYAME	02/02/2019	11/0.433	30999.85
30	ASHANTI	50	PMT	ANOMANGYE MARKET	SUAME(HVDS)	02/02/2019	33/0.433	28536.76
31	ASHANTI	50	PMT	BRONKONG ALMIGHTY INTER. SCH	SUAME(HVDS)	02/02/2019	33/0.433	26139.32
32	ASHANTI	50	PMT	WA STATION	SUAME(HVDS)	02/02/2019	11/0.433	12949.6
33	ASHANTI	50	PMT	MPATASIA TOILET	SUAME	02/02/2019	11/0.433	22947.2
34	ASHANTI	100	PMT	ADAGYA	BEKWAI	02/02/2019	11/0.433	12949.6
35	ASHANTI	50	PMT	KROFA	KONONGO	02/02/2019	11/0.433	14202.34
36	ASHANTI	50	PMT	KYEMPO	KONONGO	02/02/2019	11/0.433	
37	ASHANTI	100	PMT	GYAMAN 1	DUNKWA	02/02/2019	11/0.433	14023.38
38	CENTRAL	100	PMT	NORTH CAMPUS ROMA	WINNEBA	02/02/2019	11/0.433	23924.8
39	VOLTA	50	PMT	LEKLEBI AGBESIA	HOHOE	02/02/2019	33/0.433	17050.72
40	VOLTA	50	PMT	LIATI WOTE	HOHOE	02/02/2019	33/0.433	16063.53
41	VOLTA	200	PMT	PICNIC	HOHOE	02/02/2019	11/0.433	31555.18
42	VOLTA	100	PMT	BARRACKS NEWTOWN	HO	02/02/2019	33/0.433	28106.28
43	VOLTA	50	PMT	DZOGBEKORPE	DENU	02/02/2019	33/0.433	15364.39
44	WESTERN	100	PMT	ANTIBIA	JUABOSO	02/02/2019	33/0.433	27697.44

45	WESTERN	50	PMT	ABONPUNISO	TARKWA	02/02/2019	11/0.433	16447.79
46	WESTERN	100	PMT	KIKAM POST OFFICE	AXIM	02/02/2019	33/0.433	35943.61
47	WESTERN	200	PMT	ANKYERNYI NKWANTA	AGONA	02/02/2019	33/0.433	33845.52
48	A/E	100	PMT	ND04/06 NANAKROM	LEGON	03/03/2019	11/0.433	30361.96
49	A/E	50	PMT	TW20C OSCAR DOWN	DODOWA	03/03/2019	33/0.433	13947.76
50	A/E	25	PMT	T03/03B ADENTA ESTATES NHIS	DODOWA	03/03/2019	11/0.433	12024.48
51	A/E	100	PMT	M13/64 NEAR AYELE BUILDING	LEGON	03/03/2019	11/0.433	21576.67
52	A/E	25	PMT	T05/288 ASHALEY BOTWE NEAR 3RD GATE	DODOWA	03/03/2019	11/0.433	21576.67
53	A/E	100	PMT	T11/47/09 ABOKOBI WOMEN TRAINING CENTER	DODOWA	03/03/2019	11/0.433	30435.64
54	A/E	50	PMT	WU53A AMRAHIA	DODOWA	03/03/2019	11/0.433	
55	A/E	100	PMT	ND10/31 AHLIDZA LAKESIDE ESTATE	LEGON	03/03/2019	11/0.433	30361.96
56	A/E	25	PMT	T03/07C ADENTA	DODOWA	03/03/2019	33/0.433	12024.48
57	A/E	50	PMT	ND11/356 OGBOJO FASEMKYE	LEGON	03/03/2019	11/0.433	21576.67
58	A/E	100	PMT	M08/201 MADINA NDC OFFICE	LEGON	03/03/2019	11/0.433	30361.96
59	ACCRA WEST	200	PMT	AGAPE	ABLEKUMA	03/03/2019	11/0.433	30986.7
60	ACCRA WEST	200	PMT	TREBA	NSAWAM	03/03/2019	33/0.433	33812.37
61	ACCRA WEST	315	GMT	BELGE CAPITAL KWASHIEMAN	ACHIMOTA	03/03/2019	11/0.433	47604.3
62	ACCRA WEST	100	PMT	KOKROBITE	BORTIANOR	03/03/2019	11/0.433	30986.7
63	ACCRA WEST	200	PMT	BRAIN BIRDS ACADEMY ISREAL	ACHIMOTA	03/03/2019	11/0.433	30986.7
64	ASHANTI SBU	50	PMT	MAAKRO SILVER JUNCTION	ABUAKWA	03/03/2019	11/0.433	12949.81
65	ASHANTI SBU	100	PMT	ANKAASE(ANWOMASO)	ASOKWA	03/03/2019	11/0.433	21592.02
66	ASHANTI SBU	500	GMT	NSENIE	AYIGYA	03/03/2019	11/0.433	37520.72

67	ASHANTI SBU	50	PMT	ANOMANGYE SPECIALIST HOSPITAL(HVDS)	SUAME	03/03/2019	11/0.433	12949.6
68	ASHANTI SBU	100	PMT	ABOABOKESSE	DANYAME	03/03/2019	11/0.433	21592.02
69	ASHANTI SBU	100	PMT	SUAME CENTRAL MOSQUE	SUAME	03/03/2019	11/0.433	22665.8
70	ASHANTI SBU	100	PMT	NHYIASO	OBUASI	03/03/2019	11/0.433	21592.02
71	ASHANTI SBU	100	PMT	SASA NR. FINAL HERBAL CLINIC	OFFINSO	03/03/2019	11/0.433	21592.02
72	ASHANTI SBU	25	PMT	HVDS(NO. 35)	OFFINSO	03/03/2019	11/0.433	13892.67
73	CENTRAL	50	PMT	EKUMFI ABUAKWA	SALTPOND	03/03/2019	11/0.433	17427.27
74	CENTRAL	100	PMT	EKUMFI AKRA	WINNEBA	03/03/2019	33/0.433	28665.14
75	CENTRAL	100	PMT	AMPENYI TOWN NO. 2	CAPE COAST	03/03/2019	33/0.433	28665.14
76	CENTRAL	200	PMT	KUWAIT NO.2	KASOA NORTH	03/03/2019	33/0.433	36371.35
77	CENTRAL	50	PMT	ANOMA OBI	KASOA NORTH	03/03/2019	33/0.433	28665.14
78	CENTRAL	50	PMT	ASSIN MESOMAGOR	SALTPOND	03/03/2019	33/0.433	17427.27
79	EASTERN	200	PMT	OFOASE ZONGO	AKIM ODA	03/03/2019	33/0.433	38769.77
80	EASTERN	100	PMT	OBOMENG OBRONIKROM	MPRAESO	03/03/2019	11/0.433	27812.52
81	TEMA	50	PMT	ABOTIA KPOTA	KROBO	03/03/2019	33/0.433	17470.00
82	TEMA	200	PMT	ZENU	AFIENYA	03/03/2019	11/0.433	36409.38
83	TEMA	100	PMT	BUADE	NUNGUA	03/03/2019	11/0.433	22497.20
84	TEMA	100	PMT	ADA FOA	ADA	03/03/2019	33/0.433	26106.16
85	TEMA	100	PMT	BUADE	NUNGUA	03/03/2019	11/0.433	22497.20
86	TEMA	20	PMT	AVEYIME	ADA	03/03/2019	33/0.433	17470.24
87	VOLTA	50	PMT	DODO AMANFROM MARKET	NKWANTA	03/03/2019	33/0.433	18652.23
88	VOLTA	100	PMT	FODOME HELO	HOHOE	03/03/2019	33/0.433	29890.10
89	VOLTA	50	PMT	AVENORFEME MARKET	AKATSI	03/03/2019	33/0.433	18625.23
90	VOLTA	100	PMT	DZENUNYEKPODZI	DENU	03/03/2019	33/0.433	31214.01
91	VOLTA	100	PMT	KWAME AKURA	DAMBAI	03/03/2019	33/0.433	31214.01

92	VOLTA	200	PMT	GAKLI/AVENU	DENU	03/03/2019	33/0.433	38920.22
93	VOLTA	50	PMT	BEN TOTAL	HO	03/03/2019	11/0.433	13677.2
94	VOLTA	100	PMT	NYAGBO SROE	KPEVE	03/03/2019	33/0.433	26106.16
95	WESTERN	50	PMT	HWEMEHAA	JUABOSO	03/03/2019	33/0.433	15942.07
96	WESTERN	100	PMT	ESSASE	JUABOSO	03/03/2019	33/0.433	27697.44
97	WESTERN	50	PMT	SUBRI NKWANTA	BIBIANI	03/03/2019	33/0.433	14868.29
98	WESTERN	100	PMT	TIKOBO NO.2	HALF ASSINI	03/03/2019	33/0.433	26106.16
99	WESTERN	100	PMT	WHINDO PALACE	TAKORADI	03/03/2019	11/0.433	22497.7
100	WESTERN	200	PMT	NSUEKYIR	BOGOSO	03/03/2019	33/0.433	33812.37
101	A/E	50	PMT	AN02/17 ABREFI PLAZA	LEGON	04/04/2019	11/0.433	30,361.96
102	A/E	500	GMT	L05 LA DEGAUL'S PARK	MAKOLA	05/04/2019	11/0.433	127,565.66
103	A/E	50	PMT	AN02/05 WESTLAND	LEGON	06/04/2019	11/0.433	31,282.48
104	A/E	200	PMT	ASHONGMAN HILLTOP BEHIND BANK OF GHANA	KWABENYA	07/04/2019	11/0.433	30,066.18
105	A/E	200	PMT	M05/06 OKGONGLO	LEGON	08/04/2019	11/0.433	30,066.18
106	A/E	200	PMT	Q04/22/02 TEBIBIANO NR. ST JOHN SCHOOL	TESHIE	09/04/2019	11/0.433	30,986.70
107	A/E	200	PMT	J04/33 BEHIND SHELL FUEL STATION	KWABENYA	10/04/2019	11/0.433	30,996.89
108	A/E	315	GMT	T08/18 PANTANG	KWABENYA	11/04/2019	11/0.433	36,565.84
109	A/E	200	PMT	AE02/30 DOME PILLAR 2, KWAHU STORES	KWABENYA	12/04/2019	11/0.433	30,996.89
110	A/E	200	PMT	T02/06 OYARIFA GRAVEL PIT	DODOWA	13/04/2019	11/0.433	30,996.89
111	A/E	200	PMT	T09/01K PANTANG SUNCITY	KWABENYA	14/04/2019	11/0.433	30,996.89
112	A/E	25	PMT	MAYEHOT COLDSTORE	LEGON	15/04/2019	11/0.433	12,756.67
113	A/E	25	PMT	MADINA MAYEHOT SPOT NR.	LEGON	16/04/2019	11/0.433	12,756.67

114	A/E	25	PMT	ND11/365 OGBOJO	LEGON	17/04/2019	11/0.433	12,756.67
115	A/E	50	PMT	NR. MADINA SAMANPOM	LEGON	18/04/2019	11/0.433	23,229.39
116	ACCRA WEST	200	PMT	TETEGU	BORTIANOR	19/04/2019	11/0.433	30,986.705
117	ACCRA WEST	200	PMT	TETEGU	BORTIANOR	20/04/2019	11/0.433	30,986.705
118	ACCRA WEST	100	PMT	OBUOM	NSAWAM	21/04/2019	33/0433	28,194.65
119	ACCRA WEST	100	PMT	TANTRA HILL BEHIND ROCTERS	ACHIMOTA	22/04/2019	11/0.433	23,213.90
120	ACCRA WEST	200	PMT	OSHUMAN	ABLEKUMA	23/04/2019	11/0.433	37,527.16
121	ACCRA WEST	100	PMT	GBAWE	BORTIANOR	24/04/2019	11/0.433	36,115.42
122	ACCRA WEST	500	GMT	APPIAH DANQUAH	DANSOMAN	25/04/2019	11/0.433	57,657.55
123	ACCRA WEST	315	GMT	MANGO DOWN	DANSOMAN	26/04/2019	11/0.433	38,223.76
124	ACCRA WEST	N/A	RMU	CABLE AND WIRELESS	KANESHIE	27/04/2019	11/0.433	27,490.2
125	ASHANTI SBU	100	PMT	HVDS NO. 9 BUOHO [HVDS]	OFFINSO	28/04/2019	11/0.433	24,967.55
126	ASHANTI SBU	25	PMT	BUOHO T 42	OFFINSO	29/04/2019	11/0.433	14,023.38
127	ASHANTI SBU	25	PMT	ASHIOBI KOMFO MANU [HVDS]	SUAME	30/04/2019	11/0.433	14,023.38
128	ASHANTI SBU	50	PMT	MAGAZINE QUEENS PUP[HVDS]	SUAME	01/04/2019	11/0.433	23586.33
129	ASHANTI SBU	100	PMT	MAGAZINE ETAKULLAH [HVDS]	SUAME	01/04/2019	11/0.433	23,512.55
130	ASHANTI SBU	50	PMT	MAAKRO AKWASI AWUAH CHURCH [HVDS]	SUAME	01/04/2019	11/0.433	12,949.6
131	ASHANTI SBU	100	PMT	SUAME NR. GARAGES [HVDS]	SUAME	01/04/2019	11/0.433	23,512.55
132	ASHANTI SBU	50	PMT	MAGAZINE WOMEN WORLD BANK [HVDS]	SUAME	01/04/2019	11/0.433	15512.18
133	ASHANTI SBU	25	PMT	AFRANCHO BLUE EYE LTD [HVDS]	SUAME	01/04/2019	11/0.433	19484.67
134	ASHANTI SBU	100	PMT	AKRAFO KOKOBEN	SUAME	01/04/2019	33/0.433	26127.69
135	ASHANTI SBU	100	PMT	SUAME IMAM III	SUAME	01/04/2019	11/0.433	23586.33

136	ASHANTI SBU	200	PMT	OTAQUAH	DANYAME	01/04/2019	11/0.433	32064.86
137	ASHANTI SBU	100	PMT	SOKOBAN TIMPOMU NO.I	DANYAME	01/04/2019	11/0.433	22512.55
138	ASHANTI SBU	100	PMT	SANTASI NR. ADOM CLINIC	DANYAME	01/04/2019	11/0.433	22512.55
139	ASHANTI SBU	50	PMT	ADUGYAMA ZONGO	ABUAKWA	01/04/2019	33/0.433	26134.31
140	ASHANTI SBU	100	PMT	MANSO AKWASISO	ABUAKWA	01/04/2019	33/0.433	26127.69
141	ASHANTI SBU	100	PMT	NKORANG	ABUAKWA	01/04/2019	33/0.433	26664.58
142	ASHANTI SBU	100	PMT	DOMEABRA MTN	ASOKWA	01/04/2019	11/0.433	24318.52
143	ASHANTI SBU	50	PMT	DODGE CITY NO.2	DUNKWA	01/04/2019	110.433	13681.97
144	EASTERN	200	PMT	OFOASE ZONGO	Akim Oda	01/04/2019	33/0.433	38769.77
145	EASTERN	100	PMT	OBOMENG OBRONIKROM	Mpraeso	01/04/2019	11/0.433	27812.52
146	TEMA	200	PMT	ADJEI KOJO	NORTH	01/04/2019	11/0.433	39737.76
147	TEMA	100	PMT	AGOVERME	KROBO	01/04/2019	11/0.433	30674.73
148	WESTERN	50	PMT	HWEMEHAA	JUABOSO	01/04/2019	33/0.433	15942.07
149	WESTERN	100	PMT	ESSSASE	JUABOSO	01/04/2019	33/0.433	27697.44
150	WESTERN	50	PMT	SUBRINKWATA	BIBIANI	01/04/2019	33/0.433	14868.29
151	WESTERN	100	PMT	TIKOBO NO.2	HALF ASSINI	01/04/2019	33/0.433	26106.16
152	WESTERN	100	PMT	WHINDO PALACE	TAKORADI	01/04/2019	11/0.433	22497.2
153	WESTERN	200	PMT	NSUEKYIR	BOGOSO	01/04/2019	33/0.433	33812.37
154	A/E	200	PMT	DODOWA SOTA	DODOWA	05/05/2019	33/0.433	33108.47
155	A/E	315	GMT	AHWERASE W115	MAMPONG	05/05/2019	11/0.433	45500.62
156	A/E	100	PMT	KWABENYA ABUOM JUNCTION AE09/25	KWABENYA	05/05/2019	11/0.433	32014.68
157	A/E	200	PMT	LAKESIDESIDE AROUND POLICE STN	LEGON	05/05/2019	11/0.433	32014.68
158	A/E	100	PMT	T11/31/02 ABOKOBI WASHING BAY	KWABENYA	05/05/2019	11/0.433	32014.68

159	A/E	315	PMT	ATOMIC ENERGY	KWABENYA	05/05/2019	11/0.433	37131.27
160	A/E	200	PMT	ND08/72 NMAIDZOR	LEGON	05/05/2019	11/0.433	32014.68
161	A/E	315	PMT	L05/03/10 TSEADDO	TESHIE	05/05/2019	11/0.433	37131.27
162	A/E	100	PMT	T11/47/11 SESEME	KWABENYA	05/05/2019	11/0.433	32014.68
163	A/E	25	PMT	ND11/74 ABEN WOHA LAST STOP	LEGON	05/05/2019	11/0.433	13028.37
164	A/E	200	PMT	W02/04 AMANOKROM ESTATE	MAMPONG	05/05/2019	11/0.433	32014.68
165	A/E	100	PMT	AN10/02 ANUMLE	LEGON	05/05/2019	11/0.433	22580.56
166	A/E	100	PMT	ND04/50 EAST LEGON HILLS	LEGON	05/05/2019	11/0.433	32014.68
167	A/E	25	PMT	M08/348 MAMA LIT	LEGON	05/05/2019	11/0.433	13028.37
168	A/E	200	PMT	WU04 GEGEDOKUM	DODOWA	05/05/2019	11/0.433	33108.47
169	A/E	100	PMT	W02/65 AWUKUGUA	MAMPONG	05/05/2019	11/0.433	22580.56
170	A/E	100	PMT	T02/71 TEIMAN BURGER TOWN	DODOWA	05/05/2019	11/0.433	22580.56
171	A/E	100	PMT	T09/01N NR AGBOGBA EP CHURCH	KWABENYA	05/05/2019	11/0.433	32014.68
172	ASHANTI SBU	200	PMT	NYANKYERENEASE QUEENS	ABUAKWA	05/05/2019	11/0.433	34769.47
173	ASHANTI SBU	50	PMT	NKROANG	ABUAKWA	05/05/2019	33/0.433	14888.54
174	ASHANTI SBU	500	PMT	AKOREM ST. PATRICK	AYIGYA	05/05/2019	11/0.433	114209.5
175	ASHANTI SBU	200	PMT	BROFOYEDRU	AYIGYA	05/05/2019	11/0.433	34769.47
176	ASHANTI SBU	100	PMT	GARDEN CITY UNI. COLLEGE	AYIGYA	05/05/2019	11/0.433	34769.47
177	ASHANTI SBU	100	PMT	YAASE ADWAFO	BEKWAI	05/05/2019	33/0.433	26127.69
178	ASHANTI SBU	100	PMT	KUNTENANCE LORRY STATION	BEKWAI	05/05/2019	33/0.433	26127.69
179	ASHANTI SBU	500	PMT	ADUM STORAGE	DANYAME	05/05/2019	11/0.433	58490.02
180	ASHANTI SBU	50	PMT	KOKOBEN GAS	DANYAME	05/05/2019	11/0.433	22512.55
181	ASHANTI SBU	50	PMT	BREMAN [ABUAKWA]	DUNKWA	05/05/2019	11/0.433	12949.6

182	ASHANTI SBU	100	PMT	KYEKYEBIASE	KONONGO	05/05/2019	11/0.433	22512.55
183	ASHANTI SBU	100	PMT	FAWOADE CHRIST COLLEGE	KWABRE	05/05/2019	11/0.433	22512.55
184	ASHANTI SBU	50	PMT	GOMOA	NEW EDUBIASE	05/05/2019	33/0.433	15963.6
185	ASHANTI SBU	100	PMT	KYEKYEWERE	OBUASI	05/05/2019	11/0.433	22512.55
186	ASHANTI SBU	100	PMT	AKOM	OFFINSO	05/05/2019	11/0.433	22665.8
187	ASHANTI SBU	50	PMT	BONSUA	OFFINSO	05/05/2019	11/0.433	12949.6
188	ASHANTI SBU	50	PMT	ABOAHIA SDA CHURCH II [HVDS]	SUAME	05/05/2019	33/0.433	14023.38
189	ASHANTI SBU	50Y	PMT	MAAKRO OPP. ENERGY BANK[HVDS]	SUAME	05/05/2019	11/0.433	13102.85
190	ASHANTI SBU	50	PMT	BREMANG OLD TOWN TOILET T13[HVDS]	SUAME	05/05/2019	11/0.433	12949.6
191	ASHANTI SBU	50	PMT	BREMANG AGYIN HOTEL[HVDS]	SUAME	05/05/2019	11/0.433	14023.38
192	ASHANTI SBU	100	PMT	ACHIASE DEEP WATER	SUAME	05/05/2019	33/0.433	28856.56
193	ASHANTI SBU	50	PMT	ADANKWAME R/C SCHOOL	SUAME	05/05/2019	33/0.433	15962.32
194	ASHANTISBU	100	PMT	HEMANG NVTI II KWADWO	SUAME	05/05/2019	33/0.433	26127.69
195	ASHANTI SBU	200	PMT	ADANKWAME	SUAME	05/05/2019	33/0.433	36371.35
196	CENTRAL	100	PMT	ABURA NEW SITE	CAPE COAST	05/05/2019	11/0.433	25056.18
197	CENTRAL	25	PMT	ESUOANKUMASO	ASSIN FOSU	05/05/2019	33/0.433	13947.76
198	CENTRAL	25	PMT	JUASO OTABILNKWANTA	ASSIN FOSU	05/05/2019	33/0.433	16506.74
199	CENTRAL	50	PMT	BUDUKWA	AJUMAKO	05/05/2019	33/0.433	15503.99
200	CENTRAL	50	PMT	GOMOA ABOTIA	WINNEBA	05/05/2019	11/0.433	15503.99
201	CENTRAL	100	PMT	ICGC WATER WORKS	WINNEBA	05/05/2019	11/0.433	25056.18
202	CENTRAL	200	PMT	OFAAKOR EBENEZER	KASOA NORTH	05/05/2019	33/0.433	36371.35

203	CENTRAL	50	PMT	KROKOHWE	KASOA NORTH	05/05/2019	33/0.433	17427.27
204	CENTRAL	100	PMT	LAMPTEY MILLS	KASOA NORTH	05/05/2019	33/0.433	28665.14
205	CENTRAL	100	PMT	OFFASO NO.1	KASOA SOUTH	05/05/2019	33/0.433	25056.18
206	EASTERN	100	PMT	SUBI NO. 1	KADE	05/05/2019	33/0.434	30966.67
207	EASTERN	100	PMT	OTUMI ZONGO	KADE	05/05/2019	33/0.435	30966.67
208	EASTERN	50	PMT	AKWADUUSO	KADE	05/05/2019	33/0.436	40486.33
209	EASTERN	200	PMT	TEASE	DONKORKROM	05/05/2019	33/0.437	40486.33
210	TEMA	50	PMT	AKORLEY	KROBO	01/05/2019	11/0.433	17470.24
211	TEMA	200	PMT	ABANSE	KROBO	01/05/2019	11/0.433	36409.38
212	TEMA	200	PMT	KOJONYA MENEKPO	KROBO	01/05/2019	11/0.433	36409.38
213	TEMA	50	PMT	ASILEVIKOPE	KROBO	01/05/2019	11/0.433	17470.24
214	TEMA	100	PMT	ASUTUARE	KROBO	01/05/2019	11/0.433	26434.21
215	TEMA	100	PMT	TESCO	KROBO	01/05/2019	11/0.433	26434.21
216	TEMA	100	PMT	GRACELAND	KROBO	01/05/2019	11/0.433	36409.38
217	TEMA	100	PMT	FIRE SERVICE	AFIENYA	01/05/2019	11/0.433	26434.21
218	TEMA	200	PMT	S139P	AFIENYA	01/05/2019	11/0.433	36409.38
219	TEMA	100	PMT	S418F	AFIENYA	01/05/2019	11/0.433	26434.21
220	WESTERN	50	PMT	ADJAKAA MANSO	SEFWI WIAWSO	01/05/2019	33/0.433	18079.24
221	WESTERN	100	PMT	DADIESO OLD TOWN	BOGOSO	01/05/2019	33/0.433	29317.11
222	WESTERN	50	PMT		ASANKRAGWA	01/05/2019	33/0.433	18079.11
223	WESTERN	200	PMT	TAMSO SENYAKROM	TARKWA	01/05/2019	33/0.433	55516.07
224	A/E	500	GMT	AE08/13 ASHONGMAN	KWABENYA	06/06/2019	11/0.433	57,547.07
225	A/E	200	PMT	NL01/AB1 NEW LEGON	DODOWA	06/06/2019	11/0.433	30,986.70
226	A/E	25	PMT	APPROTECH	LEGON	06/06/2019	11/0.433	12,756.67
227	A/E	25	PMT	M08/440, LEGON	LEGON	06/06/2019	11/0.433	12,756.67

228	A/E	200	PMT	WU09 AMRAHIA DAIRY FARMS AREA	DODOWA	06/06/2019	33/0.433	33,812.37
229	A/E	100	PMT	WARREN FILLING STATION	KWABENYA	06/06/2019	11/0.433	22,497.20
230	A/E	25	PMT	ND11/366 BOTWE	LEGON	06/06/2019	11/0.433	12,756.67
231	A/E	25	PMT	NSAMANPOM PENTECOST CHURCH	LEGON	06/06/2019	11/0.433	12,756.67
232	A/E	50	PMT	T05/229 BOTWE NEWTOWN	LEGON	06/06/2019	11/0.433	23,229.39
233	A/E	100	PMT	AE08/15 ASHONGMAN BOHYE LAST STOP	KWABENYA	06/06/2019	11/0.433	22,497.20
234	ACCRA WEST	50	PMT	ANYAA	ACHIMOTA	06/06/2019	11/0.433	25,185.63
235	ACCRA WEST	100	PMT	DOBRO AYIBI	NSAWAM	06/06/2019	11/0.433	30,482.00
236	ACCRA WEST	200	PMT	SAMPA VALLEY	NSAWAM	06/06/2019	11/0.433	31,903.30
238	ACCRA WEST	50	PMT	ADJEIMAN	NSAWAM	06/06/2019	11/0.433	25,185.63
239	ACCRA WEST	315	GMT	MALLAM KOKROKO	ACHIMOTA	06/06/2019	11/0.433	120,594.70
240	ACCRA WEST	100	PMT	AKRAMAN	NSAWAM	06/06/2019	11/0.433	25,185.63
241	ACCRA WEST	200	PMT	AKRAMAN	NSAWAM	06/06/2019	11/0.433	31,903.30
242	ASHANTI SBU	200	PMT	KENYASI TEWOBABI	AYIGYA	06/06/2019	11/0.433	34624.26
243	ASHANTI SBU	50	PMT	ABOO	OBUASI	06/06/2019	11/0.433	14023.38
244	ASHANTI SBU	100	PMT	AKROFUOM PALACE	OBUASI	06/06/2019	11/0.433	34769.47
245	CENTRAL	50	PMT	EKUMFI AMISANO	SALTPOND	06/06/2019	33/0.433	17424.27
246	CENTRAL	200	PMT	BEACH DRIVE	KASOA SOUTH	06/06/2019	33/0.433	36043.05
247	CENTRAL	200	PMT	NYANNYANO PENTICOAST	KASOA SOUTH	06/06/2019	33/0.433	33812.37
248	CENTRAL	200	PMT	CHRIST FOR ALL MISSION NO.1	KASOA SOUTH	06/06/2019	33/0.433	36371.35
249	EASTERN	100	PMT	NANKESE	KOFORIDUA	06/06/2019	11/0.433	25470.11
250	EASTERN	100	PMT	BONYA DORSI	KOFORIDUA	06/06/2019	11/0.435	24597.71

251	EASTERN	100	PMT	BUNSO – ASIKUMA	AKIM ODA	06/06/2019	33/0.436	29565.3
252	TEMA	100	PMT	LASHIBI	NUNGUA	06/06/2019	11/0.433	26434.21
253	TEMA	100	PMT	KASSEH	ADA	06/06/2019	33/0.433	26106.16
254	TEMA	50	PMT	PETER K	ADA	06/06/2019	33/0.433	17470.24
255	TEMA	100	PMT	ADIDOKP	KROBO	06/06/2019	33/0.433	26106.16
256	TEMA	50	PMT	ADJEI-KO	NORTH	06/06/2019	11/0.433	36409.38
257	TEMA	50	PMT	KPOTA-A	KROBO	06/06/2019	33/0.433	17470.24
258	TEMA	200	PMT	OGOME	KROBO	06/06/2019	11/0.433	36409.38
259	TEMA		GMT		PRAMPRAM	06/06/2019	11/0.433	68047.02
260	VOLTA	100	PMT	DAGBAMATE NO.2	AKATSI	06/06/2019	33/0.433	28173.13
261	VOLTA	50	PMT	AKORME GBOGAME	KPEVE	06/06/2019	33/0.433	15226.22
262	VOLTA	50	PMT	NYAGBO ODUMASI	KPEVE	06/06/2019	33/0.433	14868.29
263	VOLTA	100	PMT	TSIBU BETHEL	KPEVE	06/06/2019	11/0.433	22855.121
264	VOLTA	100	PMT	DEKPOR HORME	DENU	06/06/2019	33/0.433	31668.06
265	VOLTA	50	PMT	SAVIEFE GBORGAME	KPEVE	06/06/2019	33/0.433	14868.29
266	VOLTA	100	PMT	GOVIEFE TODZI	KPEVE	06/06/2019	33/0.433	26464.09
267	VOLTA	100	PMT	LAGBOKOPE	AKATSI	06/06/2019	33/0.433	30844.37
268	VOLTA	50	PMT	DZOKU	HOHOE	06/06/2019	33/0.433	15888.02
269	VOLTA	50	PMT	BAKPE NO.2	KPEVE	06/06/2019	33/0.433	15522.77
270	VOLTA	100	PMT	ANYAKO POLICE STATION	AKATSI	06/06/2019	33/0.433	26760.64
271	WESTERN	100	PMT	WASSA DUNKWA	ASANKRAGWA	06/06/2019	33/0.433	35403.65
272	WESTERN	50	PMT	ADIDASE	ASANKRAGWA	06/06/2019	33/0.433	23717.43
273	WESTERN	100	PMT	AYIEM	AGONA	06/06/2019	11/0.433	22497.2
274	WESTERN	100	PMT	JUABOSO NKWANTA	JUABOSO	06/06/2019	33/0.433	41311.51
275	A/E	315	GMT	W02/24 LARTEH KUBEASE	MAMPONG	06/06/2019	11/0.433	41,662.87
276	A/E	200	PMT	J04/35 AYEGBE TOWN	KWABENYA	06/06/2019	11/0.433	30,986.70

277	A/E	25	PMT	ND11/195 BOTWE HIGHWAYS	LEGON	06/06/2019	11/0.433	12,756.67
278	A/E	25	PMT	ND11/109 LITTLE ROSES	LEGON	06/06/2019	11/0.433	12,756.67
279	A/E	800	GMT	L07 (L05/10) LA ABORMLI	MAKOLA	06/06/2019	11/0.433	66,313.16
280	A/E	200	PMT	AK04/20 SHIASHIE BUSH CANTEEN JUNCTION	LEGON	06/06/2019	11/0.433	34,003.80
281	A/E	100	PMT	Q04/24/03 TESHIE CAMP 2	TESHIE	06/06/2019	11/0.433	21,872.45
282	A/E	315	GMT	Q06/11 (Q733) MR BAFFOUR RESIDENCE, A LIFE JUNCTION	TESHIE	06/06/2019	11/0.433	37,131.27
283	A/E	50	PMT	M13/73 ATTRACO	LEGON	06/06/2019	11/0.433	21,576.67
284	A/E	25	PMT	T40 NR. COLONEL SAMUEL'S RESIDENCE	LEGON	06/06/2019	11/0.433	12,756.67
285	A/E	50	PMT	T05/238 DEYOUNGSTERS SCHOOL, ADENTA	LEGON	06/06/2019	11/0.434	13,677.20
286	ACCRA WEST	200	PMT	AFUAMAN	ABLEKUMA	06/06/2019	11/0.433	32,133.83
287	A/E	315	GMT	W02/24 LARTEH KUBEASE	MAMPONG	07/07/2019	11/0.433	41,662.87
288	A/E	200	PMT	J04/35 AYEGBE TOWN, KWABENYA ACP	KWABENYA	07/07/2019	11/0.433	30,986.70
289	A/E	25	PMT	ND11/195 BOTWE HIGHWAYS	LEGON	07/07/2019	11/0.433	12,756.67
290	A/E	25	PMT	ND11/109 LITTLE ROSES	LEGON	07/07/2019	11/0.433	12,756.67
291	A/E	800	GMT	L07 (L05/10) LA ABORMLI	MAKOLA	07/07/2019	11/0.433	66,313.16
292	A/E	200	PMT	AK04/20 SHIASHIE BUSH CANTEEN JUNCTION	LEGON	07/07/2019	11/0.433	34,003.80
293	A/E	100	PMT	Q04/24/03 TESHIE CAMP 2	TESHIE	07/07/2019	11/0.433	21,872.45
294	A/E	315	GMT	Q06/11 (Q733) MR BAFFOUR RESIDENCE, A LIFE JUNCTION	TESHIE	07/07/2019	11/0.433	37,131.27
295	A/E	50	PMT	M13/73 ATTRACO	LEGON	07/07/2019	11/0.433	21,576.67

296	A/E	25	PMT	T40 NR. COLONEL SAMUEL'S RESIDENCE	LEGON	07/07/2019	11/0.433	12,756.67
297	A/E	50	PMT	T05/238 AROUND ASCHOOL, ADENTA	LEGON	07/07/2019	11/0.434	13,677.20
298	ACCRA WEST	200	PMT	AFUAMAN	ABLEKUMA	07/07/2019	11/0.433	32,133.83
299	VOLTA	100	PMT	DODI PAPASE HOSPITAL	JASIKAN	07/07/2019	33/0.433	26829.74
300	VOLTA	200	PMT	SOKODE BAGBLE NO.2	HO	07/07/2019	33/0.433	34228.15
301	VOLTA	50	PMT	HOVE LOMNAVA	HOHOE	07/07/2019	33/0.433	15522.77
302	WESTERN	200	PMT	PBC	JUABOSO	07/07/2019	33/0.433	35403.65
303	WESTERN	25	PMT	ANSU SHED	JUABOSO	07/07/2019	33/0.433	25,229.49
304	WESTERN	100	PMT	OSEI KOJOKROM	JUABOSO	07/07/2019	33/0.433	27697.44
305	WESTERN	15	PMT	EZAKPOLE	AXIM	07/07/2019	33/0.25	23259.68
306	WESTERN	200	PMT	BARRIER	AGONA	07/07/2019	33/0.433	33812.37
307	A/E	50	PMT	ND11/426 OHENEBA KISSI OGBOJO	LEGON	08/08/2019	11/0.433	13,677.20
308	A/E	200	PMT	WU54 KATAMANSO	DODOWA	08/08/2019	33/0.433	33,812.37
309	A/E	50	PMT	ND11/189 ASHALEY BOTWE	LEGON	08/08/2019	11/0.433	12,756.67
310	ASHANTI SBU	50	PMT	ATETEM	NEW EDUBIASE	08/08/2019	33/0.433	17581.99
311	ASHANTI SBU	50	PMT	NINTENG NO.2	MAMPONG	08/08/2019	33/0.433	14813.20
312	ASHANTI SBU	50	PMT	BOMFA ZONGO	KONONGO	08/08/2019	11/0.433	14813.20
313	CENTRAL	50	PMT	APAM NSU EKYIRE NO. 3	WINNEBA	08/08/2019	11/0.433	14583.46
314	CENTRAL	15	PMT	ADJETEY CAMP	PRASO	08/08/2019	33/0.433	13947.76
315	CENTRAL	50	PMT	KWAME ANUM	KASOA NORTH	08/08/2019	33/0.433	16506.74
316	CENTRAL	100	PMT	ANOMABO WAKAM	SALTPOND	08/08/2019	33/0.433	14583.46

317	VOLTA	50	PMT	PETERKOPE	HOHOE	08/08/2019	33/0.433	17197.12
318	VOLTA	50	PMT	ABOTOASE ROUNDABOUT	JASIKAN	08/08/2019	33/0.433	15577.45
319	VOLTA	50	PMT	TAPA AMANFROM RESETTLEMENT	JASIKAN	08/08/2019	33/0.433	15568.41
320	VOLTA	200	PMT	JASIKAN EP CHURCH	JASIKAN	08/08/2019	33/0.433	37281.92
321	A/E	25	PMT	M13/70 LEGON	LEGON	19/09/2019	11/0.433	12,756.67
322	A/E	200	PMT	ND11/402 OGBOJO NR. GOIL FILLING STATION	LEGON	19/09/2019	11/0.433	68,254.25
323	A/E	50	PMT	T03/13X ADENTA HELGA INT. SCHOOL	DODOWA	19/09/2019	11/0.433	23,750.86
324	ACCRA WEST	200	PMT	OPPOSITE SATELITE JUNCTION	NSAWAM	19/09/2019	33/0.433	34900.96
325	ACCRA WEST	200	PMT	ADOAGYIRI	NSAWAM	19/09/2019	11/0.433	32075.29
326	ACCRA WEST	200	PMT	GBAWE	BORTIANOR	19/09/2019	11/0.433	32075.29
327	ACCRA WEST	200	PMT	KPOBIKOPE	NSAWAM	19/09/2019	11/0.433	32075.29
328	ACCRA WEST	100	PMT	NEAR KOANS ESTATE SATELLITE	NSAWAM	19/09/2019	11/0.433	32075.29
329	ASHANTI SB	100	PMT	ASENUA COLUMBOS	KWABRE	19/09/2019	11/0.433	32433.76
330	ASHANTI SBU	200	PMT	ASAMANG CEMETERY	SUAME	19/09/2019	33/0.433	66757.89
331	ASHANTI SBU	50	PMT	BOAMANG	BEKWAI	19/09/2019	33/0.433	12347.14
332	ASHANTI SBU	50	PMT	ANOMANGYE J.W	SUAME	19/09/2019	11/0.433	23217.64
333	ASHANTI SBU	200	PMT	NEW EDUBIASE SHS	NEW ADUBIASE	19/09/2019	33/0.433	YET TO RECEIVE
335	ASHANTI SBU	50	PMT	ADUGYAMA ZONGO	ABUAKWA	19/09/2019	33/0.433	YET TO RECEIVE

336	ASHANTI SBU	315	PMT	ASH TOWN COURT	MANHYIA	19/09/2019	11/0.433	YET TO RECEIVE
337	ASHANTI SBU	200	PMT	ANTOA OLD TWON	AYIGYA	19/09/2019	11/0.433	YET TO RECEIVE
338	ASHANTI SBU	100	PMT	DENYASE	BEKWAI	19/09/2019	33/0.433	YET TO RECEIVE
339	ASHANTI SBU	200	PMT	SAY ADSAM EDUCATIONAL	DANYAME	19/09/2019	11/0.433	YET TO RECEIVE
340	VOLTA	50	PMT	ADAKLU TORDA	HO	19/09/2019	11/0.433	13684.15
341	VOLTA	50	PMT	LIKE MATE SHS	HOHOE	19/09/2019	33/0.433	17402.39
342	VOLTA	100	PMT	LIATI AGBONYRA	HOHOE	19/09/2019	33/0.433	15782.72
343	VOLTA	50	PMT	LOLOBI KUMASI MARKET	HOHOE	19/09/2019	33/0.433	34412.77
344	WESTERN	100	PMT	AFERE MAIN	JUABOSO	19/09/2019	33/0.433	27160.55
345	WESTERN	50	PMT	NYAMEBEKYERE	AGONA	19/09/2019	33/0.433	25326.65
346	WESTERN	100	PMT	ESIKAFOABANTEM	TARKWA	19/09/2019	33/0.433	34233.12
347	WESTERN	50	PMT	ENYINAM NO. 2	BOGOSO	19/09/2019	33/0.433	16302.3
348	WESTERN	50	PMT	AMEYAWKROM	SEFWI WIAWSO	19/09/2019	33/0.433	66971.63
349	WESTERN	50	PMT	DATANO CLINIC	SEFWI WIAWSO	19/09/2019	33/0.433	14868.29
350	WESTERN	50	PMT	DATANO ROMAN CATHOLIC	SEFWI WIAWSO	19/09/2019	33/0.433	20146.21
351	A/E	50	PMT	T03/08WX NR. HELGA INT. SCHOOL	DODOWA	10/10/2019	11/0.433	23,750.86
352	A/E	200	PMT	Y03/48/01 TESHIE	TESHIE	10/10/2019	11/0.433	32,969.37
353	A/E	200	PMT	TM12 OYARIFA	DODOWA	10/10/2019	11/0.433	33,172.21
354	A/E	50	PMT	T05/373 ADENTA HOUSING DOWN	DODOWA	10/10/2019	11/0.433	23,229.39
355	A/E	50	PMT	M08/176 MADINA NR. J'FAMCO	LEGON	10/10/2019	11/0.433	27,354.41
356	A/E	50	PMT	T05/97 MADINA MAYEHOT NR. MAMA'S KITCHEN	LEGON	10/10/2019	11/0.433	

357	A/E	100	PMT	AGOMEDA	DODOWA	10/10/2019	33/0.433	29,792.80
358	A/E	100	PMT	KPONE BAWALESHIE CLINIC	DODOWA	10/10/2019	33/0.433	26,928.78
359	A/E	200	PMT	NANAKROM ABASS	LEGON	10/10/2019	11/0.433	32,821.48
360	A/E	200	PMT	DOME PILLAR 2 PENTECOST CHURCH	KWABENYA	10/10/2019	11/0.433	32,821.48
361	ACCRA WEST	200	PMT	OPPOSITE SATELITE JUNCTION	NSAWAM	10/10/2019	33/0.433	34900.96
362	ACCRAWEST	200	PMT	ADOAGYIRI	NSAWAM	10/10/2019	11/0.433	32075.29
363	ACCRA WEST	200	PMT	GBAWE	BORTIANOR	10/10/2019	11/0.433	32075.29
364	ACCRA WEST	200	PMT	KPOBIKOPE	NSAWAM	10/10/2019	11/0.433	32075.29
365	ACCRA WEST	100	PMT	NEAR KOANS ESTATE SATELLITE	NSAWAM	10/10/2019	11/0.433	32075.29
366	ASHANTI SBU	100	PMT	MANSO HIAKOSE	ABUAKWA	10/10/2019	33/0.433	27559.39
367	ASHANTI SBU	100	PMT	ADUGYAMA	ABUAKWA	10/10/2019	33/0.433	14888.54
368	ASHANTI SBU	100	PMT	AYEDUASE AJENGO	ASOKWA	10/10/2019	11/0.433	14888.54
369	ASHANTI SBU	100	PMT	MOUNT HIGH NO.2	MAMPONG	10/10/2019	33/0.433	26127.69
370	ASHANTI SBU	50	PMT	JACOBU FILLING STA.	OBUASI	10/10/2019	11/0.433	43768
371	ASHANTI SBU	100	PMT	BUOHO NO. 13[HVDS]	OFFINSO	10/10/2019	11/0.433	23944.45
374	CENTRAL	100	PMT	GOMOA AKROPONG NO.2	SWEDRU	10/10/2019	33/0.433	25215.42

375	CENTRAL	100	PMT	GARAGES	SALTPOND	10/10/2019	11/0.433	22497.2
376	CENTRAL	200	PMT	CAMP RED KITCHEN NO.3	KASOA NORTH	10/10/2019	33/0.433	36371.35
377	CENTRAL	200	PMT	INSAANIYA GIRLS NO.2	KASOA NOTH	10/10/2019	33/0.433	36371.35
378	CENTRAL	200	PMT	LAMPTEY REPUBLIC NO.1	KASOA NOTH	10/10/2019	33/0.433	28665.14
379	CENTRAL	100	PMT	AKAIKROM	CAPE COAST	10/10/2019	11/0.433	21576.67
380	CENTRAL	200	PMT	HOLY CHILD	CAPE COAST	10/10/2019	11/0.433	30986.7
381	CENTRAL	100	PMT	WORLD VISSION	TWIFO PRASO	10/10/2019	33/0.433	28665.14
382	EASTERN	50	PMT	OBOURHO	ASAMANKESE	10/10/2019	33/0.433	13947.76
383	EASTERN	200	GMT	AMUI	TAFO	10/10/2019	11/0.435	33835.79
384	EASTERN	100	PMT	ASUBONI RAILS	NKAWKAW	10/10/2019	33/0.436	25185.63
385	TEMA	100	PMT	MATAHEKO	AFIENYA	10/10/2019	11/0.433	10794.39
386	VOLTA	50	PMT	AVEE TOKOR	HO	10/10/2019	33/0.433	21431.99
387	VOLTA	50	PMT	KPETOE KPORTA	HO	10/10/2019	33/0.433	16900.57
388	VOLTA	50	PMT	WUDZEKOPE NO.2	SOGAKOPE	10/10/2019	33/0.433	15623.1
389	VOLTA	50	PMT	AMUTINU	DENU	10/10/2019	33/0.433	15623.1
390	VOLTA	100	PMT	AGORVIE	DENU	10/10/2019	33/0.433	30005
391	VOLTA	100	PMT	TUIME JUNCTION	AKATSI	10/10/2019	33/0.433	26926.89
392	A/E	50	PMT	ND11/01 NMAI DZORN NANAKROM	LEGON	11/11/2019	11/0.433	23,229.39
393	A/E	200	PMT	ND08/01 NMAI DZOR	LEGON	11/11/2019	11/0.433	31,716.90
394	A/E	100	PMT	M13/96/01 OGBOJO	LEGON	11/11/2019	11/0.433	23,229.39
395	A/E	200	PMT	JAPAN MOTORS	LEGON	11/11/2019	11/0.433	30,986.70
396	A/E	200	PMT	PANTANG AGBOGBA ROAD	KWABENYA	11/11/2019	11/0.433	68,924.58
397	ASHANTI SBU	200	PMT	DUNKWA ESTATE JUNT	DUNKWA	11/11/2019	11/0.433	26127.69
398	ASHANTI SBU	50	PMT	SAWABA NO. 4	EFFIDUASE	11/11/2019	11/0.433	
400	ASHANTI SBU	200	PMT	ADB	NEW EDUBIAS	11/11/2019	33/0.433	35458.88

401	ASHANTI SBU	50	PMT	AYAMFURI MKT	DUNKWA	11/11/2019	11/0.433	31734.25
402	CENTRAL	200	PMT	ABBINA	CAPE COAST	11/11/2019	11/0.433	33545.68
403	CENTRAL	50	PMT	OBAAKROWA	KASOA NORTH	11/11/2019	33/0.433	17098.97
404	CENTRAL	50	PMT	ANWEEMU	CAPE COAST	11/11/2019	33/0.433	18135.93
405	CENTRAL	50	PMT	ANWEEMU JUNCTION	CAPE COAST	11/11/2019	33/0.433	18135.93
406	CENTRAL	100	PMT	FOSO ANSA	ASIKUMA	11/11/2019	33/0.433	27805.7
407	EASTERN	50	PMT	AMANFROM	ASAMANKESE	11/11/2019	33/0.433	13947.76
408	EASTERN	50	PMT	DOMI	ASAMANKESE	11/11/2019	33/0.433	13947.76
409	EASTERN	50	PMT	META	ASESEWA	11/11/2019	33/0.433	13947.76
410	EASTERN	100	PMT	ZION SCHOOL	ASAMANKESE	11/11/2019	11/0.433	21576.67
411	EASTERN	100	PMT	EKOSO	ASAMANKESE	11/11/2019	11/0.433	21576.67
412	VOLTA	50	PMT	TAPAMAN SHS	JASIKAN	11/11/2019	33/0.433	17267.33
413	VOLTA	50	PMT	TAFI MADOR	KPEVE	11/11/2019	33/0.433	5.12
414	VOLTA	50	PMT	LOGBA AKUSAME NO.2	HOHOE	11/11/2019	33/0.433	19029.84
415	VOLTA	50	PMT	LIKPE ALAVANYO	HOHOE	11/11/2019	33/0.433	16542.65
416	VOLTA	50	PMT	BATOR ATIGONU	SOGAKOPE	11/11/2019	33/0.433	23914.961912
417	A/E	200	PMT	M13/23 MADINA LYBIA QTRS	KWABENYA	08/12/2019	11/0.433	34,115.15
418	A/E	100	PMT	AE09/16/ KW16 ABUOM JUNCTION	KWABENYA	02/12/2019	11/0.433	22,497.20
419	A/E	50	PMT	M13/49 MEMPEASEM	LEGON	03/12/2019	11/0.433	22,497.20
420	A/E	50	PMT	WU01E RAMAH TOWN	DODOWA	04/12/2019	33/0.433	33,043.50
421	A/E	50	PMT	M08/41/02 TAIFA BURKINA	KWABENYA	05/12/2019	11/0.433	22,497.20
422	A/E	50	PMT	M08/447 MADINA	LEGON	06/12/2019	11/0.433	25,890.02
423	A/E	50	PMT	M08/309 OGBOJO	LEGON	07/12/2019	11/0.433	25,890.02
424	A/E	200	PMT	NL07 DODOWA	DODOWA	08/12/2019	11/0.433	30,986.70
425	A/E	50	PMT	TW04E BEHIND SPECIAL ICE	DODOWA	09/12/2019	11/0.433	30,986.70

426	A/E	50	PMT	M08/347 MADINA BEHIND ALFA HOSP.	LEGON	10/12/2019	11/0.433	12,945.01
427	A/E	200	PMT	TW19 DANFA	DODOWA	11/12/2019	33/0.433	33,812.37
428	ASHANTI SBU	50	PMT	TARKWA MAAKRO OMINTIMINIM	SUAME	17/12/2019	11/0.433	23862.18
429	ASHANTI SBU	50	PMT	(HVDS NO.1) BUOHO	OFFINSO	18/12/2019	11/0.433	23229.39
430	ASHANTI SBU	100	PMT	FAWOADE NO.2	KWABRE	19/12/2019	33/0.433	23,229.39
431	ASHANTI SBU	25	PMT	BRONKRONG MAAME DORA I	SUAME	20/12/2019	11/0.433	15113.5
432	ASHANTI SBU	200	PMT	KYEREASE KWAKU BONSAM	SUAME	21/12/2019	11/0.433	36371.35
433	CENTRAL	50	PMT	KYIASE	CAPE COAST	23/12/2019	33/0.433	19039.52
434	CENTRAL	200	PMT	LIBERIA CAMP	KASOA NORTH	24/12/2019	33/0.433	36371.35
435	CENTRAL	100	PMT	GHANA NATIONAL	CAPE COAST	25/12/2019	11/0.433	25053.18
436	CENTRAL	200	PMT	NYANYANO JHS NO.2	KASOA SOUTH	26/12/2019	33/0.433	33812.37
437	CENTRAL	50	PMT	JEDU	SALTPOND	27/12/2019	33/0.433	26105.16
438	CENTRAL	100	PMT	ABEKA	SALTPOND	28/12/2019	33/0.433	26105.16
439	CENTRAL	200	PMT	OFAAKO GADA FARM	KASOA NORTH	29/12/2019	33/0.433	33812.37
440	CENTRAL	200	PMT	BISHOP MAKALA	KASOA NORTH	30/12/2019	33/0.433	33812.37
441	EASTERN	50	PMT	TWEPEASE	ASESEWA	31/12/2019	33/0.433	16707.76
442	EASTERN	50	PMT	KOFORIDUA	ASAMANKESE	27/12/2019	33/0.433	13947.76
443	EASTERN	25	PMT	OSUBETOR	KOFORIDUA	30/12/2019	33/0.433	16707.76
444	EASTERN	100	PMT	ANYINAM NHIS	TAFO	31/12/2019	33/0.433	27945.63
445	TEMA	200	PMT	AHODWO	KROBO	27/12/2019	11/0.433	39729.54
446	VOLTA	50	PMT	NYAGBO ANYIGBE	KPEVE	31/12/2019	33/0.433	20248.11
447	VOLTA	100	PMT	AMEDZOFE TRANSMITTER	KPEVE	27/12/2019	33/0.433	26203.56
448	VOLTA	100	PMT	FODOME HELU	HOHOE	30/12/2019	33/0.433	26106.16
449	VOLTA	100	PMT	KUDZEKOPE	SOGAKOPE	31/12/2019	33/0.433	26935.17

450	VOLTA	50	PMT	KORPEDEKE	SOGAKOPE	27/12/2019	11/0.433	13719.79
451	VOLTA	100	PMT	KREPO	SOGAKOPE	30/12/2019	11/0.433	23310.55
452	VOLTA	100	PMT	AKPAFU ODORMI	HOHOE	31/12/2019	33/0.433	23310.55
453	WESTERN	200	PMT	BREMAN MAIN	ASANKRAGWA	27/12/2019	33/0.433	51291.79
454	WESTERN	100	PMT	YAKASE NAKABA	ENCHI	30/12/2019	33/0.433	28816.06
455	WESTERN	100	PMT	ESHIEM	SEKONDI	31/12/2019	33/0.433	26106.16
456	WESTERN	50	PMT	ASONTI	AXIM	27/12/2019	33/0.433	24144.34
457	WESTERN	100	PMT	DANKWAKROM	SEFWI WIAWSO	30/12/2019	33/0.433	26106.16
458	WESTERN	50	PMT	NGALEKPOLE NEW SITE	AXIM	31/12/2019	33/0.433	23566.23
459	WESTERN	200	PMT	AYISAKROM LIGHT IND. AREA	AXIM	27/12/2019	33/0.433	35403.65

Table A4 Global ECG Damage Transformer Report for 2018

NO.	Region	kVA	Type	Location	District	Date Damaged	Voltage Level (kV)	Replacement Cost (GH¢)
1	ACCRA EAST	25	PMT	PEPPER STREET	LEGON	Jan-18	11/0.433	12,040.04
2	ACCRA EAST	50	PMT	ADJIRINGANOR RADIO XYZ	LEGON	Jan-18	11/0.433	21,592.23
3	ACCRA EAST	100	PMT	MADINA J'FAMCO ADENTA	LEGON	Jan-18	11/0.433	32,355.12
4	ACCRA EAST	50	PMT	DODOWA NEAR GHANATA SECONDARY SCHOOL	DODOWA	Jan-18	33/0.433	35,290.67
5	ACCRA EAST	100	PMT		KWABENYA	Jan-18	11/0.433	30,079.32
6	ACCRA EAST	100	PMT	NANAKROM	LEGON	Jan-18	11/0.433	22,821.13
7	ACCRA EAST	100	PMT			Jan-18	11/0.433	30,169.74
8	ACCRA EAST	315	GMT	FELI SPOT	ROMAN RIDGE	Jan-18	11/0.433	37,470.07
9	ACCRA EAST	100	PMT	ASHAIMAN JUNCTION	DODOWA	Jan-18	33/0.433	35,443.28
10	ASHANTI	50	PMT	BREMANG UGC T39	SUAME	Jan-18	11/0.433	14,381.05
11	ASHANTI	50	PMT	BEKWAI NEW RIDGE	BEKWAI	Jan-18	33/0.433	23,615.70
12	ASHANTI	50	PMT	BOUHO B5 PLUS COMP	OFFINSO	Jan-18	33/0.433	13,583.35
13	ASHANTI	100	PMT	ACHIASE CEMETERY	SUAME	Jan-18	33/0.433	26,843.52
14	ASHANTI	100	PMT	ANTOA SHS	AYIGYA	Jan-18	33/0.433	22,512.76
15	ASHANTI	25	PMT	AFRANCHO MARKET	SUAME(HVDS)	Jan-18	33/0.433	14,726.56
16	ASHANTI	500	GMT	OWASS	DANYAME	Jan-18	33/0.433	57,986.32
17	ASHANTI	50	PMT	TARKWA MAAKRO T13	SUAME(HVDS)	Jan-18	33/0.433	14,373.54
18	ASHANTI	100	PMT	MPOBI	KWABRE	Jan-18	11/0.433	27,559.14
19	CENTRAL	200	PMT	KRISPO CITY D SQUARE	KASOA NORTH	Jan-18	33/0.433	32,891.84
20	CENTRAL	200	PMT	ZONGO	KASOA SOUTH	Jan-18	33/0.433	32,891.84

21	CENTRAL	100	PMT	NKWANTANAN	KASOA	Jan-18	33/0.433	25,185.63
22	CENTRAL	15	PMT	APPIAKO KEEA	CAPE COAST	Jan-18	33/0.433	13,947.76
23	CENTRAL	50	PMT	OGUWASE	BREMAN ASSIKUMA	Jan-18	33/0.433	13,947.76
24	CENTRAL	200	PMT	BUDUBURAM	ASSIN FOSU	Jan-18	33/0.433	32,891.84
25	CENTRAL	100	PMT	BIRIWA SCHOOL INJECTION	SALTPOND	Jan-18	33/0.433	25,185.63
26	CENTRAL	25	PMT	AYIGBEFOM	ASSIN FOSU	Jan-18	33/0.433	13,947.76
27	CENTRAL	50	PMT	KEMEWOR	KASOA	Jan-18	33/0.433	13,947.76
28	EASTERN	50	PMT	GYEWANI NYAMEBEKYERE	AKIM ODO	Jan-18	11/0.433	17,239.87
29	EASTERN	50	PMT	ABENA NTOBEA	KOFORIDUA	Jan-18	33/0.433	17,239.87
30	EASTERN	50	PMT	SOUTH TOWN	AKIM ODA	Jan-18	11/0.433	15,316.59
31	TEMA	100	PMT	AGAVE GADZEKPOTA	ADA	Jan-18	33/0.433	31,496.23
32	VOLTA	200	PMT	ZOTORGLO	KETA	Jan-18	33/0.433	**34,170.18**
33	VOLTA	100	PMT	ZIAVI ADUKOPE	HO	Jan-18	11/0.433	**22,497.20**
34	VOLTA	50	PMT	APESOKUBI TOWNSHIP	JASIKAN	Jan-18	33/0.433	**15,226.10**
35	WESTERN	50	PMT	NYINAHIM SHS AREA	BIBIANI	Jan-18	33/0.433	16,804.23
36	WESTERN	50	PMT	DOKORESO	ASANKRAGWA	Jan-18	33/0.433	18,420.26
37	WESTERN	200	PMT	AGOGOSO	BIBIANI	Jan-18	33/0.433	37,267.51
38	WESTERN	100	PMT	DOMPIM MTN	TARKWA	Jan-18	33/0.433	41,477.58
39	WESTERN	100	PMT	MANPONSO	TARKWA	Jan-18	33/0.433	29,850.41
40	ACCRA EAST	200	GMT	ASIEDU NKETIA	DODOWA	Feb-18	11/0.433	37,268.21
41	ACCRA EAST	50	PMT		KWABENYA	Feb-18	11/0.433	22,390.76
42	ACCRA EAST	200	PMT		LEGON	Feb-18	11/0.433	63,204.59
43	ACCRA EAST	100	PMT	ANIMAL RESEARCH FRAFRAHA	DODOWA	Feb-18	11/0.433	30,079.32
44	ACCRA EAST	50	PMT	ABOKOBI	DODOWA	Feb-18	11/0.433	22,390.76

45	ACCRA EAST	200	PMT	TESHIE TEBIBIIANO	TESHIE	Feb-18	11/0.433	30,066.18
46	ACCRA EAST	200	PMT	HE REIGNS PREPARATORY SCHOOL	TESHIE	Feb-18	11/0.433	30,079.32
47	ACCRA EAST	25	PMT	MADINA WELFARE SCHOOL	LEGON	Feb-18	11/0.433	13,009.19
48	ACCRA EAST	50	PMT	ADENTA MALL RESERVOIR	LEGON	Feb-18	11/0.433	22,482.72
49	ACCRA EAST	50	PMT	MADINA PENTECOST CHURCH	LEGON	Feb-18	11/0.433	21,595.16
50	ACCRA WEST	200	PMT	ADU GYAMFI SOWUTUOM	ACHIMOTA	Feb-18	11/0.433	162,022.20
51	ACCRA WEST	200	PMT	HODEM POKUASE	NSAWAM	Feb-18	33/0.433	25,771.09
52	ASHANTI	25	PMT	ARANCHO MARKET(HVDS)	SUAME(HVDS)	Feb-18	11/0.433	14,726.56
53	ASHANTI	50	PMT	ADABIE	ASOKWA	Feb-18	11/0.433	13,585.28
54	ASHANTI	200	PMT	JAMASI ZONGO	MAMPONG	Feb-18	11/0.433	34,555.04
55	ASHANTI	500	GMT	KROFROM TRAFFIC LIGHT	MANHYIA	Feb-18	11/0.433	93,765.93
56	ASHANTI	50	PMT	SEPAASE-AHODWO(REFUR)	ABUAKWA	Feb-18	11/0.433	22,512.26
57	ASHANTI	300	GMT	WEWESO	AYIGYA	Feb-18	11/0.433	33,864.12
58	ASHANTI	100	PMT	DENKYEMUOSO WARE HOUSE II	ABUAKWA	Feb-18	11/0.433	23,944.00
59	ASHANTI	100	PMT	TONKOASE	NEW EDUBIASE	Feb-18	11/0.433	26,127.90
60	ASHANTI	100	PMT	SUAME NVTI(REF)	SUAME	Feb-18	11/0.433	33,139.21
61	ASHANTI	100	PMT	MAAKRO HERITAGE BANK(REF)	SUAME	Feb-18	11/0.433	24,652.11
62	ASHANTI	50	PMT	TOPRE DOMINASE	ABUAKWA	Feb-18	11/0.433	14,023.24
63	EASTERN	100	PMT	AKOTE	SUHUM	Feb-18	11/0.433	24,336.67
64	EASTERN	100	PMT	AGOGO CLINIC	ASESEWA	Feb-18	33/0.433	27,945.63
65	EASTERN	50	PMT	NOBI ROAD	TARFO	Feb-18	33/0.433	16,707.76
66	TEMA	N/A	N/A	MAIN H(161)	NORTH	Feb-18	11/0.433	76,434.75

67	TEMA	50	PMT	TSIDZENU OFF VOLO ROAD	KROBO	Feb-18	33/0.433	13,947.76
68	TEMA	315	PMT	ATIMPOKU	KROBO	Feb-18	33/0.433	38,526.41
69	TEMA	500	GMT	COASTAL ESTATE	NUNGUA	Feb-18	11/0.433	112,490.14
70	TEMA	200	PMT	APPOLONIA	AFIENYA	Feb-18	33/0.433	30,066.18
71	TEMA	200	PMT	SUNCITY	NORTH	Feb-18	11/0.433	30,986.70
72	TEMA	200	GMT	TORGORME	KROBO	Feb-18	11/0.433	32,898.84
73	VOLTA	50	PMT	PETERKROM	HOHOE	Feb-18	33/0.433	14,868.29
74	VOLTA	100	PMT	AKATSI DISTRICT HOSPITAL	AKATSI	Feb-18	33/0.433	27,884.80
75	VOLTA	50	PMT	KLOTEKPO	SOGAKOPE	Feb-18	33/0.433	16,139.36
76	VOLTA	100	PMT	DZOGBEFEME	KPEVE	Feb-18	33/0.433	34,052.48
77	VOLTA	100	PMT	LEKLEBI DUGA	HOHOE	Feb-18	33/0.433	26,106.16
78	WESTERN	50	PMT	AITINASI	AXIM	Feb-18	33/0.433	26,106.16
79	WESTERN	100	PMT	SAMEYE	HALF ASSIN	Feb-18	33/0.433	28,829.19
80	WESTERN	50	PMT	KAMABOI	ASANKRAGWA	Feb-18	33/0.433	27,391.83
81	WESTERN	50	PMT	GWIRA ASONTI	AXIM	Feb-18	33/0.433	17,960.90
82	ACCRA EAST	25	PMT	ADENTA AVIATION	LEGON	Mar-18	11/0.433	13,137.96
83	ACCRA EAST	50	PMT	NANOMAN	DODOWA	Mar-18	33/0.433	32,891.84
84	ACCRA EAST	25	PMT	ASHALEY BOTWE	LEGON	Mar-18	11/0.433	12,031.21
85	ACCRA EAST	25	PMT	ADENTA	DODOWA	Mar-18	11/0.433	12,031.21
86	ACCRA EAST	25	PMT	MADINA	LEGON	Mar-18	11/0.433	15,437.42
87	ACCRA EAST	100	PMT	ADENTA	LEGON	Mar-18	11/0.433	30,066.18
88	ACCRA EAST	25	PMT	OBOJO FASEMKYE	LEGON	Mar-18	11/0.433	12,031.21
89	ACCRA EAST	50	PMT	MADINA JEBOTHERS	LEGON	Mar-18	11/0.433	21,592.23
90	ACCRA WEST	200	PMT	OSHUMAN	ABLEKUMA	Mar-18	33/0.433	32,891.84
91	ACCRA WEST	100	PMT	ECG OFFICE	NSAWAM	Mar-18	11/0.433	60,961.43
92	ACCRA WEST	200	PMT	AMASAMAN SONITRA	NSAWAM	Mar-18	33/0.433	32,891.84

93	ACCRA WEST	200	PMT	DOBLO GONNO	NSAWAM	Mar-18	33/0.433	32,891.84
94	ASHANTI	500	GMT	ADUKROM MOKE	AYIGYA	Mar-18	11/0.433	60,975.29
95	ASHANTI	100	PMT	ASOTWE NO. 2	EFFIDUASE	Mar-18	11/0.433	23,586.19
96	ASHANTI	25	PMT	ABUSUAKRUWA ASS.OF GOD(HVDS)	SUAME(HVDS)	Mar-18	11/0.433	14,381.05
97	ASHANTI	50	PMT	ANOMANGYE MARKET	SUAME(HVDS)	Mar-18	11/0.433	13,486.52
98	ASHANTI	50	PMT	TAKYIMAN AGYARKOO	ABUAKWA	Mar-18	11/0.433	920,53
99	ASHANTI	100	PMT	ABUAKWA BLOOD OF JESUS	ABUAKWA	Mar-18	11/0.433	23,049.47
100	ASHANTI	315	GMT	DENASE No. 4	OFFINSO	Mar-18	11/0.433	34,912.85
101	ASHANTI	100	PMT	ATWEDIE	KONONGO	Mar-18	11/0.433	23,228.38
102	ASHANTI	100	PMT	AGONA TOWN	MAMPONG	Mar-18	33.0.433	27,223.59
103	ASHANTI	50	PMT	BREMANG CHURCH IN KUMASI(HVDS)	SUAME	Mar-18	11/0.433	14,381.05
104	ASHANTI	200	PMT	ESRESO OPHELIA JUNCTION	BEKWAI	Mar-18	11/0.433	35,270.66
105	ASHANTI	50	PMT	AKYAAKROM PRI. STATION	EFFIDUASE	Mar-18	11/0.433	15,282.82
106	CENTRAL	50	PMT	DCE'S RESIDENCE	TWIFO PRASO	Mar-18	33/0.433	13,947.76
107	EASTERN	100	PMT	GUGGISBERG	KADE	Mar-18	33/0.433	23,876.67
108	EASTERN	50	PMT	ASUOKOR	ASESEWA	Mar-18	33/0.433	16,315.21
109	EASTERN	50	PMT	ANYINASIN	TAFO	Mar-18	11/0.433	14,324.48
110	TEMA	50	PMT	KWAME NYANTEH	KROBO	Mar-18	11/0.433	14,960.79
111	TEMA	250	GMT	K20 KROBO GIRLS SHS	KROBO	Mar-18	11/0.433	43,784.91
112	VOLTA	50	PMT	NKONYA TAYI CENTRAL	KPANDO	18/3/2018	33/0.433	15,226.10
113	VOLTA	200	PMT	SOGAKOPE S.H.S	SOGAKOPE	25/03/2018	33/0.433	36,163.68
114	WESTERN	100	PMT	PALM LANDS	SEKONDI	Mar-18	11/0.433	22,512.76
115	WESTERN	50	PMT	EBEM	HALF ASSINI	Mar-18	33/0.433	14,868.29
116	WESTERN	100	PMT	AGYEZA	HALF ASSINI	Mar-18	33/0.433	26,127.90

117	WESTERN	50	PMT	SEKCO JUNCTION	SEKONDI	Mar-18	11/0.433	22,566.65
118	WESTERN	50	PMT	AKYEKYERE	ASANKRAGWA	Mar-18	33/0.433	17,653.40
119	WESTERN	100	PMT	METHODIST CHURCH AREA	ASANKRAGWA	Mar-18	33/0.433	26,106.16
120	WESTERN	100		METHODIST CHURCH AREA	ASANKRAGWA	Mar-18	33/0.433	26,106.16
121	WESTERN	100	PMT	EFFASU	ASSINI	Mar-19	33/0.433	26,106.16
122	WESTERN	50	PMT	NSABREKWA	ASANKRAGWA	Mar-18	33/0.433	14,868.29
123	WESTERN	100	PMT	ADESU	BOGOSO	Mar-18	33/0.433	41,665.97
124	WESTERN	100	PMT	EZINLIBO	HALF ASSINI	Mar-18	33/0.433	28,331.20
125	ACCRA EAST	500	GMT	GHANA STANDARD BORD IN	LEGON DISTRICT	Apr-18	11/0.433	58,097.52
126	ACCRA EAST	200	PMT	GRAND STAR HOTEL	KWABENYA	Apr-18	11/0.433	30,079.32
127	ACCRA EAST	100	PMT	FRAFRAHA PRISON	DODOWA	Apr-18	11/0.433	30,079.32
128	ACCRA EAST	25	PMT	OGBOJO SHELL	LEGON DISTRICT	Apr-18	11/0.433	22,605.90
129	ACCRA EAST	200	PMT	TEIMAN TAXI RANK	DODOWA	Apr-18	11/0.433	30,079.32
130	ACCRA EAST	500	GMT	GHANA STANDARD BORD IN	LEGON DISTRICT	Apr-18	11/0.433	58,097.52
131	ACCRA EAST	100	PMT	OPPOSITE GA EAST MUNICIPAL ASSEMBLY	KWABENYA	Apr-18	11/0.433	21,592.23
132	ACCRA WEST	315	GMT	SAKAMAN	DANSOMAN	Apr-18	11/0.433	32,891.84
133	ACCRA WEST	200	PMT	AHODJO	NSAWAM	Apr-18	11/0.433	65,783.68
134	ACCRA WEST	315	PMT	GONSEE	ABLEKUMA	Apr-18	11/0.433	60,539.01
135	ACCRA WEST	200	PMT	GIDIKOPE	NSAWAM	Apr-18	33/0.433	32,891.84
136	ASHANTI	100	PMT	AKYEREMADI	BEKWAI	Apr-18	11/0.433	26,127.90
137	ASHANTI	500	GMT	MOSHIE ZONGO No. 2	KWABRE	Apr-18	11/0.433	45,721.42

138	ASHANTI	200	PMT	ABOAHIA ANGEL EDU COMPLEX	SUAME	Apr-18	11/0.433	35,127.28
139	ASHANTI	200	PMT	ATWIMA AGOGOO TOWN	ABUAKWA	Apr-18	11/0.433	33,843.10
140	ASHANTI	100	PMT	KRONUM METHODIST	SUAME(HVDS)	Apr-18	11/0.433	13,665.43
141	ASHANTI	100	PMT	AKRAFO KOKOBEN	SUAME	Apr-18	11/0.433	13,665.43
142	ASHANTI	25	PMT	BREMANG AGOGOSO	SUAME(HVDS)	Apr-18	11/0.433	14,733.28
143	ASHANTI	50	PMT	AWANYA	EFFIDUASE	Apr-18	11/0.433	13,585.28
144	ASHANTI	200	PMT	ESRESO BRIGHT OPHILIA JUNCTION	BEKWAI	Apr-18	11/0.433	34,912.85
145	ASHANTI	50	PMT	BOMANG	BEKWAI	Apr-18	11/0.433	16,320.00
146	ASHANTI	25	PMT	KRONUM NEW KYEKYERE III	SUAME(HVDS)	Apr-18	11/0.433	14,733.28
147	ASHANTI	25	PMT	BREMANG NEW YORK T 31	SUAME(HVDS)	Apr-18	11/0.433	14,731.35
148	ASHANTI	50	PMT	KROPO RESSICRUCIAN CHURCH	SUAME(HVDS)	Apr-18	11/0.433	14,371.35
149	ASHANTI	50	PMT	ABUSUAKRUWA NEW LIFE IN CHRIST SCH.	SUAME(HVDS)	Apr-18	11/0.433	14,371.35
150	ASHANTI	25	PMT	MAAKRO NEAR THE TRAFFIC LIGHT	SUAME(HVDS)	Apr-18	11/0.433	14.731.35
151	ASHANTI	25	PMT	KWAPRA HIGHGATE HAJIA II	SUAME(HVDS)	Apr-18	11/0.433	14,731.35
152	ASHANTI	25	PMT	ANOMANGYE DAAVI	SUAME(HVDS)	Apr-18	11/0.433	14,731.35
153	ASHANTI	25	PMT	BOHYEN ASUOGYA T06	SUAME(HVDS)	Apr-18	11/0.433	14,731.35
154	ASHANTI	100	PMT	MAGAZINE FRAGINA OIL II	SUAME(HVDS)	Apr-18	11/0.433	24,294.30
155	ASHANTI	100	PMT	AFFASIEBON	ABUAKWA	Apr-18	11/0.433	23,146.30
156	ASHANTI	50	PMT	NNEREBEHI	ABUAKWA	Apr-18	11/0.433	14,025.17
157	ASHANTI	50	PMT	MANKRASO	ABUAKWA	Apr-18	11/0.433	18,311.10

158	CENTRAL	200	PMT	YAMRONSA SCHOOL	CAPE COAST	Apr-18	33/0.433	35,450.25
159	CENTRAL	50	PMT	OBAAKUWAA	KASOA NORTH	Apr-18	33/0.433	13,947.76
160	CENTRAL	100		BAIFIKROM	SALTPOND	Apr-18	11/0.433	22,497.20
161	CENTRAL	200	PMT	WALANTU PENTECOST	KASOA SOUTH	Apr-18	33/0.433	33,812.37
162	EASTERN	50	PMT	ABETIFI, ABEME ROAD	MPRAESO	Apr-18	11/0.433	12,024.48
163	EASTERN	100	PMT	DONKORKROM FORESTRY	DONKOKROM	Apr-18	33/0.433	27,945.63
164	EASTERN	200	PMT	ASENE N0.2	AKIM ODA	Apr-18	33/0.433	35,651.84
165	TEMA	200	PMT	GBETSILE	AFIENYA	Apr-18	11/0.433	30,066.18
166	TEMA	100	PMT	EMEF ESTATE	NUNGUA	Apr-18	11/0.433	26,184.62
167	VOLTA	50	PMT	ABENYINASE	HO	Apr-18	33/0.433	15,671.95
168	VOLTA	200	PMT	SOGAKOPE SENIOR HIGH SCHOOL	SOGAKOPE	Apr-18	33/0.433	30,223.85
169	VOLTA	50	PMT	KLOTEKPO	SOGAKOPE	Apr-18	33/0.433	16,139.36
170	WESTERN	100	PMT	LOWCOST	BOGOSO	Apr-18	33/0.433	35,432.04
171	WESTERN	50	PMT	BOSOMDO-ANLO BEACH	SECONDI	Apr-18	33/0.433	14,868.29
172	WESTERN	200	PMT	AHWIASO	BIBIANI	Apr-18	33/0.433	33,812.37
173	WESTERN	100	PMT	ASAFO	SEFWI WIAWSO	Apr-18	33/0.433	36,610.62
174	WESTERN	50	PMT	PEKYEI-TECHIMAN	SEFWI WIAWSO	Apr-18	11/0.433	12,945.01
175	WESTERN	50	PMT	PATABOSO JUNCTION	BIBIANI	Apr-18	33/0.433	26,106.16
176	WESTERN	50	PMT	KOFI –ESSOKROM	SEKONDI	Apr-18	11/0.433	23,786.76
177	WESTERN	200	PMT	DOME ASAMANG	SEFWI WIASO	Apr-18	33/0.433	37,359.51
178	WESTERN	100	PMT	BAKU	AXIM	Apr-18	33/0.433	30,875.40
179	WESTERN	100	PMT	KUKUVILLE	AXIM	Apr-18	33/0.433	29,894.40

180	WESTERN	200	PMT	AWIAKELE	AXIM	Apr-18	33/0.433	33,812.37
181	WESTERN	100	PMT	DATANO	SEFWI WIASO	Apr-18	336/0.433	28,214.59
182	WESTERN	200	PMT	CHARLEYKROM	TARKWA	Apr-18	33/0.433	36,114.46
183	WESTERN	50	PMT	SORANO	SEFWI WIAWSO	Apr-18	33/0.433	30,099.96
184	WESTERN	50	PMT	AFERE	JUABOSO-BIA	Apr-18	33/0.433	28,408.25
185	ACCRA EAST	50	PMT	ASHALEY BOTWE LITTLE ROSES	LEGON	May-18	11/0.433	21,576.67
186	ACCRA EAST	25	PMT	AGOWU DOWN	LEGON	May-18	11/0.433	12,732.59
187	ACCRA EAST	25	PMT	FASEMKYE OGBOJO	LEGON	May-18	11/0.433	12,732.59
188	ACCRA EAST	200	PMT	NR AMERICA HOUSE	LEGON	May-18	11/0.433	30,066.18
189	ACCRA EAST	50	PMT	ADENTA ESTATES	DODOWA	May-18	11/0.433	21,576.67
190	ACCRA EAST	50	PMT	NR TESHIE RASTA	TESHIE	May-18	11/0.433	30,288.01
191	ACCRA EAST	100	PMT	TESHIE RASTA	TESHIE	May-18	11/0.433	35,029.14
192	ACCRA EAST	200	PMT	ASHALEY BOTWE JUNCTION	LEGON	May-18	11/0.433	30,079.32
193	ACCRA EAST	50	PMT	NR. KISSEMAN PURE FIRE CHURCH	KWABENYA	May-18	11/0.433	30,079.32
194	ACCRA EAST	100	PMT	PANTANG JUNCTION	KWABENYA	May-18	11/0.433	30,079.32
195	ACCRA EAST	25	PMT	ADENTA COMMANDO	DODOWA	May-18	11/0.433	13,004.80
196	ACCRA WEST	500	GMT	ANYAA PALAS TOWN	ABLEKUMA	May-18	11/0.433	57,380.49
197	ACCRA WEST	200	PMT	PEACE VILLAGE	ABLEKUMA	May-18	33/0.433	39,861.86
198	ACCRA WEST	500	GMT	OGBOGLOSHIE YAM MARKET	KORLEBU DISTRICT	May-18	11/0.433	121,855.79
199	ASHANTI SBU	50	PMT	AFRANCHO KROBO	SUAME	May-18	11/0.433	14,731.35
200	ASHANTI SBU	50	PMT	AGEAREAGO	KONONGO	May-18	11/0.433	13,486.25
201	ASHANTI SBU	50	PMT	MORSO TOWN	KONONGO	May-18	11/0.433	13,486.25

202	ASHANTI SBU	100	PMT	KOKOBEN TOWN	ASOKWA	May-18	11/0.433	23,586.19
203	ASHANTI SBU	50	PMT	HEMANG ABAASI	SUAME	May-18	11/0.433	15,962.18
204	ASHANTI SBU	50	PMT	SUMMER PARK	ASOKWA	May-18	11/0.433	23,038.00
205	ASHANTI SBU	50	PMT	ABIRA	EFFIDUASE	May-18	11/0.433	13,488.45
206	ASHANTI SBU	50	PMT	BOMSO	OFFINSO	May-18	11/0.433	23,586.19
207	ASHANTI SBU	100	PMT	SUAME ZONGO II	SUAME	May-18	11/0.433	24,625.11
208	ASHANTI SBU	200	PMT	NWAMASE	AYIGYA	May-18	11/0.433	30,999.85
209	ASHANTI SBU	100	PMT	MENANG	NEW EDUBIASE	May-18	11/0.433	27,201.33
210	ASHANTI SBU	50	PMT	ABONKOSO	MAMPONG	May-18	11/0.433	27,201.33
211	ASHANTI SBU	500	GMT	KMA CHIEF EXEC.	DANYAME	May-18	11/0.433	59,406.83
212	ASHANTI SBU	500	GMT	KAKARI MENSAH	ASOKWA	May-18	11/0.433	58,966.94
213	ASHANTI SBU	50	PMT	PEPEDEN	BEKWAI	May-18	11/0.433	13,488.45
214	ASHANTI SBU	50	PMT	TAFO POLICE STN II	MANHYIA	May-18	11/0.433	13,585.28
215	ASHANTI SBU	100	PMT	ASOTWE No.III	EFFIDUASE	May-18	11/0.433	23,615.70
216	ASHANTI SBU	100	PMT	SARFO	KWABRE	May-18	11/0.433	26,127.90
217	ASHANTI SBU	200	PMT	OFFINSO AHENKRO	OFFINSO	May-18	11/0.433	34,924.79
218	CENTRAL	100	PMT	OBRACHIRE	KASOA NORTH	May-18	33/0.433	25,185.63
219	CENTRAL	200	PMT	SABON ZONGO	AGONA SWEDRU	May-18	11/0.433	30,066.18
220	CENTRAL	200	PMT	MILLENIUM CITY SECTOR 5	KASOA SOUTH	May-18	33/0.433	32,891.84
221	CENTRAL	50	PMT	ABECO	BREMAN ASSIKUMA	May-18	33/0.433	13,947.76
222	CENTRAL	200	PMT	NEW MARKET	KASOA NORTH	May-18	33/0.433	32,891.84
223	CENTRAL	50	PMT	KWAME ALERT SUBSTATION	TWIFO PRASO	May-18	33/0.433	13,947.76
224	CENTRAL	200	PMT	NEW MARKET HFC DOWN	KASOA NORTH	May-18	33/0.433	32,891.84

225	CENTRAL	200	PMT	OPEIKUMA D-SQUARE NO. 1	KASOA NORTH	May-18	33/0.433	32,891.84
226	EASTERN	50	PMT	ADDO NKWANTA	KOFORIDUA DISTRICT	May-18	33/0.433	17,065.57
227	TEMA	100	PMT	OCANSEYKOPE	ADA	May-18	33/0.433	29,593.11
228	TEMA	50	PMT	AZIZANYA KPORNYA NR. GOI	ADA	May-18	33/0.433	14,868.29
229	TEMA	100	PMT	EMEF ESTATE	NUNGUA	May-18	11/0.433	26,184.62
230	TEMA	100	PMT	ADOME (J10)	KROBO	May-18	33/0.433	25,185.63
231	VOLTA	50	PMT	NEW AYOMA ZONGO	HOHOE	May-18	33/0.433	15,925.25
232	WESTERN	100	PMT	BOAMAKROM ROAD	TARKWA	May-18	33/0.433	29,178.06
233	WESTERN	100	PMT	NGALEKYI	AXIM	May-18	33/0.433	30,293.62
234	WESTERN	100	PMT	AHWIASO HOSPITAL	BIBIANI	May-18	33/0.433	26,106.16
235	WESTERN	100	PMT	HWENAMPORI SCHOOL	BIBIANI	May-18	33/0.433	28,676.20
236	WESTERN	50	PMT	TENEWOHOYE	BIBIANI	May-18	33/0.433	17,438.34
237	WESTERN	100	PMT	AHWIASO POLICE STATION	BIBIANI	May-18	33/0.433	26,106.16
238	WESTERN	50	PMT	BONSASO	TARKWA	May-18	33/0.433	30,080.47
239	WESTERN	100	PMT	AHWIASO PENTECOST	BIBIANI	May-18	33/0.433	26,106.16
240	ACCRA EAST	50	PMT	BENKUM SEC SCH	MAMPONG	Jun-18	11/0.433	21,575.67
241	ACCRA EAST	100	PMT	BOHYE ASAASE	KWABENYA	Jun-18	11/0.433	30,066.18
242	ACCRA EAST	50	PMT	ASHALEY BOTWE 3RD GATE	LEGON	Jun-18	11/0.433	22,605.90
243	ACCRA EAST	100	PMT	SHIASHIE NR. SECAPS HOTEL	LEGON	Jun-18	11/0.433	30,361.96
244	ACCRA EAST	50	PMT	ASHALEY BOTWE PEACE BEE	LEGON	Jun-18	11/0.433	22,605.90
245	ACCRA EAST	25	PMT	ADENTA HELGA INTERNATIONAL SCH	DODOWA	Jun-18	11/0.433	21,576.67
246	ACCRA EAST	25	PMT	ADENTA CONTAINER	LEGON	Jun-18	11/0.433	13,053.71
247	ACCRA EAST	50	PMT	ABURI PWTC	MAMPONG	Jun-18	11/0.433	30,066.18
248	ACCRA EAST	200	PMT	ADENTA NEW SITE	KWABENYA	Jun-18	11/0.433	62,722.74

249	ACCRA EAST	100	PMT	AGYEMANKATA	KWABENYA	Jun-18	11/0.433	30,361.96
250	ACCRA EAST	50	PMT	T03/10M NR ADENTA QUEENS TAVERN	DODOWA	Jun-18	11/0.433	24,103.90
251	ACCRA EAST	100	PMT	AB08/10 RADIO XYZ	LEGON	Jun-18	11/0.433	30,361.96
252	ACCRA EAST	200	PMT	TM08 TEIMAN BURGER TOWN	DODOWA	Jun-18	11/0.433	30,361.96
253	ACCRA EAST	500	GMT	M11/13 MADINA LABONE	LEGON	Jun-18	11/0.433	127,870.03
254	ACCRA EAST	50	PMT	M08/120MADINA NR. METHODIST CHURCH	LEGON	Jun-18	11/0.433	22,580.56
255	ACCRA EAST	200	PMT	T08/64/02 HAATSO ECOMOG	KWABENYA	Jun-18	11/0.433	30,361.96
256	ACCRA EAST	25	PMT	M08/303 MADINA METHODIST	LEGON	Jun-18	11/0.433	21,576.67
257	ACCRA WEST	315		TESANO	KANESHIE	Jun-18	11/0.433	114,353.48
258	ASHANTI SBU	50	PMT	MAMPONTENG WATER	KWABRE	Jun-18	11/0.433	14,888.75
259	ASHANTI SBU	500	GMT	SUSANKYI No. 2	ASOKWA	Jun-18	11/0.433	38,154.47
260	ASHANTI SBU	100	PMT	KONKROMOASE	DANYAME	Jun-18	11/0.433	27,842.16
261	ASHANTI SBU	25	PMT	AFRANCHO BRONKON ROMAN	SUAME	Jun-18	11/0.433	14,023.20
262	ASHANTI SBU	100	PMT	ATWIMA KOFORIDUA HANSON I	ABUAKWA	Jun-18	11/0.433	23,146.30
263	ASHANTI SBU	200	PMT	REDEEMING GRACE SCH. KOKOBRA	AYIGYA	Jun-18	11/0.433	32,431.09
264	ASHANTI SBU	100	PMT	BUOKROM ESTATE WAYOSI	KWABRE	Jun-18	11/0.433	22,512.76
265	ASHANTI SBU	100	PMT	PENTRENSA	KONONGO	Jun-18	11/0.433	22,512.76
266	ASHANTI SBU	200	PMT	FEYIASE	BEKWAI	Jun-18	11/0.433	35,628.47
267	ASHANTI SBU	100	PMT	AKRAFO KOKOBEN II	SUAME	Jun-18	11/0.433	13,665.43
269	CENTRAL	200	PMT	GATEWAY	KASOA SOUTH	Jun-18	33/0.433	33,812.37

270	TEMA	500	GMT		AFIENYA	Jul-18	11/0.433	68,683.27
271	TEMA	50	PMT		KROBO	Jul-18	33/0.433	30,674.73
272	TEMA	100	PMT		AFIENYA	Jul-18	11/0.433	36,409.38
273	VOLTA	50	PMT	PALOMA	HOHOE	Jun-18	33/0.433	17,111.47
274	VOLTA	100	PMT	SAVIETULA BARRIER	KETA	Jun-18	33/0.433	28,349.34
275	VOLTA	50	PMT	LARVE	SOGAKOPE	Jun-18	33/0.433	16,845.78
276	VOLTA	50	PMT	TAPA AMANFROM RESETTLEMENT	JASIKAN	Jun-18	33/0.433	17,906.20
277	WESTERN	100	PMT	BONZAIN	JUABOSO	Jun-18	33/0.433	27,373.25
278	WESTERN	100	PMT	MANGYEA	HALF-ASSIN	Jun-18	33/0.433	28,408.25
279	WESTERN	200	PMT	BONYERE	HALF-ASSIN	Jun-18	33/0.433	36,114.46
280	ACCRA EAST	100	PMT	KWABENYA FRANCO ESTATE	KWABENYA	Jul-18	11/0.433	30,066.18
281	ACCRA EAST	100	PMT	GREDA ESTATE	TESHIE	Jul-18	11/0.433	32,491.50
282	ACCRA EAST	100	PMT	BEHIND DANFA HOSPITAL	DODOWA	Jul-18	33/0.433	32,891.84
283	ACCRA EAST	200	PMT	ADENTA NEWSITE	KWABENYA	Jul-18	11/0.433	30,361.96
284	ACCRA EAST	100	PMT	SAASABI	DODOWA	Jul-18	33/0.433	25,185.63
285	ACCRA EAST	50	PMT	NR ABUOM JUNCTION	KWABENYA	Jul-18	11/0.433	30,066.18
286	ACCRA WEST	200	PMT	AHUNJO	NSAWAM	Jul-18	33/0.433	39,210.12
287	ACCRA WEST	200	PMT	AGAPE	ABLEKUMA	Jul-18	11/0.433	37,381.81
288	ASHANTI SBU	200	PMT	BOSIE OSOFO KWADWO II	SUAME	Jul-18	11/0.433	34,906.26
289	ASHANTI SBU	25	PMT	BONKRON OLD POKUA II	SUAME	Jul-18	11/0.433	14,025.17
290	ASHANTI SBU	25	PMT	BONKRON OLD POKUA I	SUAME	Jul-18	11/0.433	14,025.17
291	ASHANTI SBU	25	PMT	BRONKRON MAAME DORA	SUAME	Jul-18	11/0.433	14,025.17
292	ASHANTI SBU	25	PMT	BREMANG NEW YORK T-30	SUAME	Jul-18	11/0.433	14,025.17
293	ASHANTI SBU	25	PMT	BUOHO T-40	SUAME	Jul-18	11/0.433	12,494.81
294	ASHANTI SBU	315	GMT	ADOATO II	SUAME	Jul-18	11/0.433	38,728.52

295	ASHANTI SBU	25	PMT	BREMANG NEW YORK T-32	SUAME	Jul-18	11/0.433	14,025.17
296	ASHANTI SBU	100	PMT	BEHENASE	BEKWAI	Jul-18	11/0.433	26,664.61
297	ASHANTI SBU	50	PMT	ADUGYAMA	ABUAKWA	Jul-18	11/0.433	17,494.28
298	ASHANTI SBU	100	PMT	D-LINE WATER	KWABRE	Jul-18	11/0.433	23,586.19
299	ASHANTI SBU	200	PMT	PANKRONO OSEI AKOTO	KWABRE	Jul-18	11/0.433	30,999.45
300	ASHANTI SBU	200	PMT	ABOASO ZONGO	KWABRE	Jul-18	11/0.433	35,628.47
301	ASHANTI SBU	500	GMT	CHILDRENS HOSPITAL	DANYAME	Jul-18	11/0.433	27,842.16
302	ASHANTI SBU	200	PMT	DIAMOND HOTEL	MANHYIA	Jul-18	11/0.433	24,652.11
303	ASHANTI SBU	50	PMT	OKAIKROM	EFFIADUASE	Jul-18	11/0.433	13,104.64
304	ASHANTI SBU	50	PMT	BOAMAN KAN DAPAAH	OFFINSO	Jul-18	11/0.433	26,761.44
306	CENTRAL	50	PMT	EBUKROM	CAPE COAST	Jul-18	11/0.433	14,808.35
307	CENTRAL	50	PMT	WARABEBA	WINNEBA	Jul-18	11/0.433	14,808.35
308	CENTRAL	100	PMT	MOSAMA	FOSU	Jul-18	33/0.433	27,969.51
309	CENTRAL	100	PMT	NYAMENADOM NO.3	KASOA SOUTH	Jul-18	33/0.433	27,048.98
310	EASTERN	100	PMT	KORLE NKWANTA	KOFORIDUA	Jul-18	11/0.433	24,694.48
311	EASTERN	100	PMT	NKWATIA ECG REVENUE	MPRAESO DISTRICT	Jul-18	11/0.433	25,410.10
312	TEMA	100	PMT	BAATSONA BEHIND TEXPO	NUNGUA	Jul-18	11/0.433	21,576.67
313	TEMA	50	PMT	NNUDO	KROBO	Jul-18	33/0.433	25,185.63
314	VOLTA	100	PMT	ATIYINTU NO. 1	HO	Jul-18	33/0.433	26,106.16
315	VOLTA	50	PMT	AVELE	HO	Jul-18	33/0.433	15,226.10
316	WESTERN	100	PMT	ACIASE COMMUNITY	JUABOSO	Jul-18	33/0.433	28,408.25
317	WESTERN	100	PMT	KOMFO YAA JUNCT	ASANKRAGWA	Jul-18	33/0.433	29,682.93
318	WESTERN	200	PMT	WASA AKROPNG SHS AREA	BOGOSO	Jul-18	33/0.433	36,114.46
319	ACCRA EAST	200	PMT	OGBOJO NR GOIL		Aug-18	11/0.33	30,066.18
320	ACCRA EAST	200	PMT	LAKE SIDE ESTATE NEWTOWN		Aug-18	11/0.433	30,321.57

321	ACCRA EAST	50	PMT	BOTWE BEHIND ALLIED OIL		Aug-18	11/0.433	21,576.67
322	ACCRA WEST	50	PMT	KOFISAH	NSAWAM	Aug-18	11/0.433	21,576.67
323	ACCRA WEST	100	PMT	DUNYO	NSAWAM	Aug-18	11/0.433	34,084.98
324	ACCRA WEST	200	PMT	AKOTOSHI	NSAWAM	Aug-18	33/0.433	65,783.68
325	ACCRA WEST	100	PMT	SATELITE	NSAWAM	Aug-18	11/0.433	30,066.18
326	ACCRA WEST	100	PMT	BEPOASE	NSAWAM	Aug-18	11/0.433	30,066.18
327	ACCRA WEST	200	PMT	AFUAMAN	ABLEKUMA	Aug-18	11/0.433	32,909.15
328	ACCRA WEST	200	PMT	BOJO BEACH	BORTIANOR	Aug-18	11/0.433	30,066.18
329	ACCRA WEST	100	PMT	TAKYIKROM	NSAWAM	Aug-18	33/0.433	31,676.83
332	ASHANTI SBU	200	PMT	TRABOUM SEC SCHOOL	ABUAKWA	Aug-18	08/04/2018	35,091.76
333	ASHANTI SBU	100	PMT	MIM SAWMILL	ABUAKWA	Aug-18	23/08/2018	23,049.47
334	ASHANTI SBU	500	GMT	Dr. TOGBE	DANYAME	Aug-18	27/08/208	37,523.86
337	ASHANTI SBU	200	PMT	DUMANAFO	KWABRE	Aug-18	26/08/2018	34,912.85
338	ASHANTI SBU	50	PMT	BOGYAWE	BEKWAI	Aug-18	25/08/2018	13,665.43
339	EASTERN	200	PMT	NKWANTANAN	KADE	Aug-18	33/0.433	38,769.65
340	TEMA	50	PMT	K69	KROBO	Aug-18	11/0.433	26,434.21
341	VOLTA	50	PMT	ODOMEABRA	JASIKAN	Aug-18	33/0.433	16,929.15
342	VOLTA	100	PMT	AZIAVE CEMETRY ROAD	KPANDO	Aug-18	11/0.433	23,563.12
343	VOLTA	100	PMT	TONGOR AXOR	KPEVE	Aug-18	11/0.433	25,688.64
344	VOLTA	50	PMT	SOKODE LOWCOST	HO	Aug-18	33/0.433	15,226.10
345	VOLTA	100	PMT	DABALA JUNCTION	SOGAKOPE	Aug-18	33/0.433	30,223.85
346	WESTERN	100	PMT	AIYINASE NIGHT MKT	AXIM	Aug-18	33/0.433	26,106.10
347	WESTERN	100	PMT	EGYAN	AXIM	Aug-18	33/0.433	22,497.20
348	WESTERN	100	PMT	KAKABO	TARKWA	Aug-18	33/0.433	31,070.03
349	WESTERN	100	PMT	DOMENASE-NKWANTA	ASANKRAGWA	Aug-18	33/0.433	26,103.16
351	ACCRA EAST	50	PMT	T03/13TADENTA ESTATE	DODOWA	Sep-18	11/0.433	21,592.23

352	ACCRA EAST	100	PMT	WU25 BAWALESHIE PILLAR 2	DODOWA	Sep-18	33/0.433	33,108.47
353	ACCRA EAST	50	PMT	AE 09/14 KWABENYA	KWABENYA	Sep-18	11/0.433	30,066.18
354	ACCRA EAST	50	PMT	T11/46 AKPORMAN	LEGON	Sep-18	11/0.433	30,361.91
355	ACCRA EAST	25	PMT	ND10/48 ASHALEY BOTWE HIGHWAYS JUCNTION	LEGON	Sep-18	11/0.433	12,024.48
356	ACCRA WEST	200	PMT	AGAPE	ABLEKUMA	28/08/2018	11/0.433	33,725.20
357	ACCRA WEST	100	PMT	KOTOKU	NSAWAM	24/08/2018	33/0.433	28,389.21
358	ASHANTI SBU	50	PMT	KOTSONS	KRONUM KWABRA NEW PALACE	Sep-18	11/0.433	14,932.52
359	ASHANTI SBU	315	GMT	KRONUM KWABRA NEW PALACE	SUAME	Sep-18	11/0.433	34,817.33
360	ASHANTI SBU	100	PMT	ASAMANG CEMETARY	SUAME	Sep-18	11/0.433	22,512.76
361	ASHANTI SBU	200	PMT	OPPOSITE MATHIAS JUNC.	SUAME	Sep-18	11/0.433	32,788.90
363	ASHANTI SBU	200	PMT	Dr. DENNIS	ASOKWA	Sep-18	11/0.433	31,879.62
364	ASHANTI SBU	50	PMT	ODUMASE APEBOASE	KONONGO	Sep-18	11/0.433	23,038.71
365	ASHANTI SBU	100	PMT	POMPOSO	OBUASI	Sep-18	11/0.433	23,668.27
366	ASHANTI SBU	25	PMT	BREMANG UGC MANNER SCH	KWABRE	Sep-18	11/0.433	15,916.52
367	ASHANTI SBU	200	PMT	BUOHO HVDS No.20	OFFINSO	Sep-18	11/0.433	31,991.21
368	CENTRAL	50	PMT	KOKOBEN SAKORA PARK	DANYAME	Sep-18	33/0.433	14,868.29
369	CENTRAL	50	PMT	FOSU DUNKWA	ASSIN FOSU	Sep-18	33/0.433	14,868.29
370	TEMA	100	PMT	TEXPO	NUNGUA	Sep-18	11/0.433	21,576.67
371	TEMA	200	PMT	ZENU	AFIENYA	Sep-18	110.433	35,313.30
372	TEMA	50	PMT	KWAME N	KROBO	Sep-18	11/0.433	22,497.20
373	TEMA	100	PMT	AGORTOR	PRAMPRAM	Sep-18	33/0.433	33,153.96

374	TEMA	500	GMT	LEBANON	AFIENYA	Sep-18	11/0.433	62,201.98
375	TEMA	315	GMT	NUNGUA	NUNGUA	Sep-18	11/0.433	37,476.18
376	TEMA	200	PMT	KPOTA	KROBO	Sep-18	33/0.433	33,156.96
377	VOLTA	100	PMT	DABALA JUNCTION	SOGAKOPE	Sep-18	33/0.433	30,223.85
378	VOLTA	100	PMT	TORKOR NARROW GATE CHURCH	KPANDO	Sep-18	11/0.433	23,563.12
379	VOLTA	100	PMT	ALANTAME	DENU	Sep-18	33/0.433	30,223.85
380	VOLTA	100	PMT	AFORKPUI	HO	Sep-18	33/0.433	26,463.97
381	WESTERN	100	PMT	BODI CHURCH	JUABOSO	Sep-18	33/0.433	27,179.59
382	WESTERN	15	PMT	BOWORA	SEFWI WIAWSO	Sep-18	33/0.25	25,539.24
383	WESTERN	15	PMT	APENTAMEDI	SEFWI WIAWSO	Sep-18	33/0.25	25,539.24
384	WESTERN	15	PMT	CANAN	SEFWI WIAWSO	Sep-18	33/0.25	25,539.24
385	A/E	25	PMT	T03/10P ADENTA QUEENS TAVERN	DODOWA	Oct-18	11/0.433	12,024.48
386	A/E	315	PMT	Q03/02 GREDA ESTATE	TESHIE	Oct-18	11/0.433	50,869.26
387	A/E	100	PMT	AE 09/14 KWABENYA	KWABENYA	Oct-18	11/0.433	30,066.18
388	A/E	100	PMT	WU03F ADOMENYA	DODOWA	Oct-18	11/0.433	33,197.81
389	A/E	100	PMT	AE10/06 HAATSO RABBIT	KWABENYA	Oct-18	11/0.433	30,372.14
390	A/E	50	PMT	AD02 POWERLAND	KWABENYA	Oct-18	11/0.433	30,372.14
391	A/E	500	GMT	AB08/27 ADJIRINGANOR	LEGON	Oct-18	11/0.433	113,954.87
392	A/E	200	PMT	KWABENYA OSCAR	KWABENYA	Oct-18	11/0.433	30,372.14
393	ACCRA WEST	100	PMT	AMASAMAN PLYWOOD	NSAWAM	Oct-18	11/0.433	30,066.18
394	ACCRA WEST	100	PMT	AGORTSIKOPE	NSAWAM	Oct-18	33/0.433	32,185.81

395	ACCRA WEST	100	PMT	ABLEKUMA	ABLEKUMA	Oct-18	11/0433	30,066.18
396	ACCRA WEST	200	PMT	BORTIANOR NEAR BOJO BEACH	BORTIANOR	Oct-18	11/0.433	30,066.18
397	ACCRA WEST	100	PMT	FIABOR NSAWAM	NSAWAM	Oct-18	11/0.433	32,201.04
398	ACCRA WEST	200	PMT	AFUAMAN ABLEKUMAN	ABLEKUMAN	Oct-18	11/0.433	32,909.15
399	ACCRA WEST	100	PMT	POKUASE – DUNYO	NSAWAM	Oct-18	11/0.433	34,084.96
400	ACCRA WEST	200	PMT	ADJEN KOTOKU	NSAWAM	Oct-18	33/0.433	32,891.84
401	CENTRAL	15	PMT	NYAMEBEKYERE SAAFA	SALTPOND	Oct-18	33/0.433	8,312.83
402	CENTRAL	200	PMT	OPEIKUMA D-SQUARE	KASOA NORTH	Oct-18	33/0.433	32,335.13
403	CENTRAL	50	PMT	WOARABEBA	WINNEBA	Oct-18	11/0.433	14,808.35
404	CENTRAL	200	PMT	OFAAKOR MTN	KASOA NORTH	Oct-18	33/0.433	32,335.13
405	CENTRAL	50	PMT	KUNTENASE SALVATION ARMY	BREMAN ASIKUMA	Oct-18	33/0.433	32,335.13
406	CENTRAL	50	PMT	OBRAWOGUM	AJUMAKO	Oct-18	33/0.433	16,158.64
407	CENTRAL	100	PMT	AGONA NANTIFA	AGONA SWEDRU	Oct-18	11/0.433	25,055.60
408	ASHANTI	315	GMT	ASAMANG CEMETERY	SUAME	Oct-18	33/0.433	34,817.33
409	ASHANTI	50	PMT	KWAPRA NEW PALACE	SUAME	Oct-18	11/0.433	14,932.52
410	ASHANTI	100	PMT	SOCIETE GENERAL BANK	SUAME	Oct-18	11/0.433	22,512.76
411	ASHANTI	50	PMT	MAGAZINE 2 POLES	SUAME	Oct-18	11/0.433	12,949.81
412	ASHANTI	100	PMT	MATHIAS JUNCTION	SUAME	Oct-18	11/0.433	22,512.76
413	ASHANTI	50	PMT	KWAPRA BBC II	SUAME(HVDS)	Oct-18	11/0.433	12,949.81
414	ASHANTI	200	PMT	APUTUOGYA LECTURER	BEKWAI	Oct-18	33/0.433	33,839.42
415	ASHANTI	50	PMT	AMAKOM	BEKWAI	Oct-18	33/0.433	26,843.52
416	ASHANTI	50	PMT	ADWAFO	BEKWAI	Oct-18	33/0.433	16,502.42
417	ASHANTI	100	PMT	ASAMAKAMA CHUR.OF CHRIST	OFFINSO	Oct-18	11/0.433	22,512.76

420	ASHANTI	50	PMT	DUROPIM	DANYAME	Oct-18	11/0.433	22,501.99
421	ASHANTI	100	PMT	KAASE WATER WORKS	DANYAME	Oct-18	11/0.433	22,512.76
422	ASHANTI	315	GMT	OHWIMASE SCH. PARK	ABUAKWA	Oct-18	11/0.433	37,699.91
423	ASHANTI	200	PMT	KROBO	MAMPONG	Oct-18	11/0.433	36,558.52
427	ASHANTI	100	PMT	AHENSAN ADANSI	OBUASI	Oct-18	33/0.433	22,512.76
428	ASHANTI	500	PMT	ALABAR TOILET	MANHYIA	Oct-18	11/0.433	126,924.36
432	Eastern	100	PMT	ABENASO	KADE	Oct-18	33/0.433	25,185.63
433	Eastern	100	PMT	OKRA ADJEI	MPRAESO	Oct-18	33/0.433	25,185.63
434	Eastern	50	PMT	ASUOKOR	ASESEWA	Oct-18	33/0.433	16,315.21
435	Eastern	100	PMT	KWEHU PRASO NO.4	NKAWKAW	Oct-18	11/0.433	21,576.67
436	Eastern	100	PMT	OKORASE JUNCTION 10	KOFORIDUA	Oct-18	11/0.433	21,576.67
437	TEMA	200	PMT	NUASO	KROBO	Oct-18	11/0.433	26,106.16
438	TEMA	100	PMT		AFIENYA	Oct-18	11/0.433	30,986.70
439	WESTERN	50	PMT	NKWANTA ESIA	AGONA	Oct-18	33/0.433	11,594.85
440	WESTERN	100	PMT	ALOMATUAPE NO. 1	HALF ASSINI	Oct-18	33/0.433	21,366.91
441	WESTERN	50	PMT	ELLUOKROM	JUABOSO	Oct-18	33/0.433	27,391.83
442	VOLTA	100	PMT	VE-DEME	HOHOE	Oct-18	33/0.433	30,223.85
443	VOLTA	50	PMT	OFOSU NO.1		Oct-18	33/0.433	16,845.78
444	VOLTA	50	PMT	AGENORXOE	KPANDO	Oct-18	33/0.433	18,985.98
445	VOLTA	100	PMT	ADINA GBAGBAKOPE	DENU	Oct-18	33/0.433	30,223.85
446	VOLTA	100	PMT	ASORGOR	DENU	Oct-18	33/0.433	28,083.64
447	VOLTA	50	PMT	AVEE GBORGAME	HOHOE	Oct-18	33/0.433	14,868.29
448	A/E	50	PMT	T03/10M NR ADENTA QUEENS TAVERN	DODOWA	Nov-18	11/0.433	24,103.90
449	A/E	100	PMT	AB08/10 RADIO XYZ	LEGON	Nov-18	11/0.433	30,361.96
450	A/E	200	PMT	TM08 TEIMAN BURGER TOWN	DODOWA	Nov-18	11/0.433	30,361.96

451	A/E	500	GMT	M11/13 MADINA LABONE	LEGON	Nov-18	11/0.433	127,870.03
452	A/E	50	PMT	M08/120MADINA NR. METHODIST CHURCH	LEGON	Nov-18	11/0.433	22,580.56
453	A/E	200	PMT	T08/64/02 HAATSO ECOMOG	KWABENYA	Nov-18	11/0.433	30,361.96
454	A/E	25	PMT	M08/303 MADINA METHODIST	LEGON	Nov-18	11/0.433	21,576.67
455	ACCRA WEST	315	GMT	A254	DANSOMAN	Nov-18	11/0.433	128,802.44
456	ACCRA WEST	100	PMT	JN01/143	NSAWAM	Nov-18	333/0.433	36,065.63
457	ASHANTI	50	PMT	BOAMANG MAASE OLD TOWN	OFFINSO	Nov-18	11/0.433	12,346.88
458	ASHANTI	100	PMT	NYAME NE BOAFO	SUAME	Nov-18	11/0.433	
459	ASHANTI	100	PMT	JACOBU DISTRICT ASSEMBLY	OBUASI	Nov-18	11/0.433	22,512.76
460	ASHANTI	100	PMT	KWAMANG	MAMPONG	Nov-18	11/0.433	22,512.76
461	ASHANTI	100	PMT	KYEKYBIASE	KONONGO	Nov-18	11/0.433	23,844.76
462	CENTRAL	50	PMT	OTABIL NKWANTA	ASSIN FOSU	Nov-18	33/0.433kV	17,426.70
463	CENTRAL	100	PMT	OPEIKUMA NO. 10	KASOA NORTH	Nov-18	33/0.433kV	28,664.54
464	CENTRAL	200	PMT	DOWN TOWN ASE NO. 1	KASOA NORTH	Nov-18	33/0.433kV	36,370.77
465	CENTRAL	100	PMT	APPIAH JUNCTION NO.2	KASOA SOUTH	Nov-18	33/0.433KV	28,664.54
466	CENTRAL	50	PMT	KYEIKROM	ASSIN FOSU	Nov-18	33/0.433kV	28,664.54
467	CENTRAL	100	PMT	OFFARKOR ASSEMBLY	KASOA NORTH	Nov-18	33/0.433kV	17,426.70
468	CENTRAL	100	GMT	ABAKAMU	CAPE COAST	Nov-18	11/0.433kV	25,055.60
469	Eastern	50	PMT	ABENAWIA	KOFORIDUA	Nov-18	33/0.433	16,315.21
470	Eastern	100	PMT	MANSO	AKIM ODA	Nov-18	33/0.433	25,185.63
471	Eastern	100	PMT	ACHIASE	AKIM ODA	Nov-18	11/0.433	21,576.67
472	Eastern	100	PMT	SANSAMI AMANFROM	SUHUM	Nov-18	11/0.433	21,576.67
473	TEMA	100	PMT		KROBO	Nov-18	11KV	26,106.16
474	TEMA	500	PMT		AFIENYA	Nov-18	11KV	68,683.27

475	TEMA	50	PMT		ADA	Nov-18	33KV	14,868.29
476	VOLTA	100	PMT	LOGBA TOTA	HOHOW	Nov-18	33/0.433	31,256.22
477	VOLTA	50	PMT	AGENORXOE	KPANDO	Nov-18	33/0.433	18,985.98
478	VOLTA	100	PMT	XAVI KATABOKOPE	AKATSI	Nov-18	33/0.433	26,463.97
479	VOLTA	200	PMT	OLD TOWN NO.1	DAMBAI	Nov-18	33/0.433	38,962.43
480	VOLTA	100	PMT	DAVE NEWTOWN	HO	Nov-18	33/0.433	26,463.97
481	VOLTA	50	PMT	KPEDZE ANOE	KPEVE	Nov-18	33/0.433	16,462.11
482	VOLTA	50	PMT	ADINA GBAGBAKOPE	DENU	Nov-18	33/0.433	18,602.32
483	WESTERN	100	PMT	MUOHO	SEFWI WIAWSO	Nov-18	33/0.433	31,911.86
484	WESTERN	100	PMT	BETENASE	SEFWI WIAWSO	Nov-18	33/0.433	31,911.86
485	WESTERN	200	PMT	JEMA	ENCHI	Nov-18	33/0.433	33,812.37
486	WESTERN	50	PMT	BENSO SHS	AGONA	Nov-18	11/0.433	12,945.01
487	WESTERN	200	PMT	KEJABIL	AGONA	Nov-18	11/0.433	30,986.70
488	WESTERN	100	PMT	ADUSUAZO	HALF ASSINI	Nov-18	33/0.433	29,316.77
489	A/E	25	PMT	T03/02E ADENTA	DODOWA	Dec-18	11/0.433	12,732.59
490	A/E	50	PMT	T03/02F ADENTA TUTU ROAD	DODOWA	Dec-18	11/0.433	22,284.78
491	A/E	200	PMT	T11/69 ADAMS STREET	DODOWA	Dec-18	11/0.433	30,066.18
492	A/E	25	PMT	M13/66 MEMPEASEM AYELE DOWN	LEGON	Dec-18	11/0.433	13,028.37
493	A/E	100	PMT	WU54C KATAMANSO	DODOWA	Dec-18	33/0.433	33,187.62
494	A/E	200	PMT	J04/32 ACP KWABENYA	KWABENYA	Dec-18	11/0.433	30,361.96
495	A/E	100	PMT	ND10/18 NEW LEGON	LEGON	Dec-18	11/0.433	21,872.45
496	ACCRA WEST	100	PMT	SOWUTOM	ACHIMOTA	Dec-18	11/0.433	32,207.28
497	ACCRA WEST	200	PMT	PEACE VILLAGE	ABLEKUMA	Dec-18	11/0.433	39,050.08

498	ACCRA WEST	100	PMT	COALTAR PRESBY	NSAWAM	Dec-18	11/0.433	32,207.28
499	ASHANTI	50	PMT	DENASE NO.3(CHOP BAR	OFFINSO	Dec-18	11/0.433	12,960.57
500	ASHANTI	100	PMT	JACOBU AKROFOM	OBUASI	Dec-18	11/0.433	35,610.67
501	ASHANTI	100	PMT	AMPABAME	DANYAME	Dec-18	11/0.433	23,586.19
502	ASHANTI	100	PMT	MAAKRO GIF MICRO FINANCE	SUAME	Dec-18	11/0.433	12,512.76
503	ASHANTI	100	PMT	ABRAFO KOKOBENG	ABUAKWA	Dec-18	11/0.433	30,999.85
504	ASHANTI	200	PMT	NEREBEHI	ABUAKWA	Dec-18	11/0.433	34,769.47
505	ASHANTI	100	PMT	DOTI NR LONGFORD HOTEL	AYIGYA	Dec-18	11/0.433	22,512.76
506	CENTRAL	500	GMT	UEW NORTH CAMPUS	WINNEBA	Dec-18	11/0.433	17,476.15
507	CENTRAL	15	PMT	MONIHA	ASSIN FOSU	Dec-18	33/0.433	60,470.76
508	CENTRAL	200	PMT	KEEA	CAPE COAST	Dec-18	11/0.433	17,476.15
509	CENTRAL	200	PMT	MFANTSIPIM SCHOOL	CAPE COAST	Dec-18	11/0.433	36,556.45
511	CENTRAL	100	PMT	SUROMANYA	AGONA SWEDRU	Dec-18	11/0.433	25,055.60
512	CENTRAL	200	PMT	SENYA METHODIST	ASSIN FOSU	Dec-18	33/0.433	33,812.37
513	TEMA	50	PMT		ADA	Dec-18	33/0.433	17,470.24
514	VOLTA	50	PMT	OFOSU NO.1	DAMBAI	Dec-18	33/0.433	16,845.78
515	VOLTA	50	PMT	LOLITO		Dec-18	33/0.433	16,845.78
516	WESTERN	50	PMT	AHMADIYYA HOSPITAL	SEKONDI	Dec-18	33/0.433	27,697.09
517	WESTERN	200	PMT	BEKWAI MARKET	SEFWI WIAWSO	Dec-18	33/0.433	33,812.37

APPENDIX B

MATLAB CODE

A. Arrester Lead Length on Lightning Discharge Simulation Code

```
clc;

%clear;

%format long

% Required Parameters

imp_peak_crest_time = 8;   %Impulse Peak Crest Time(us)

imp_peak_current = 10;     %Impulse Peak Current(KA)

lead_length = 20;          %Lead length of Arrestor (m)

lead_ind = 1.03;       %Arrestor lead inductance

arrestor_rat = 30;         %Arrestor rating


% Creating current impulse

t_crest_factor = 212*(imp_peak_crest_time^-1.01);   %Time to crest factor

magnitude_factor = 48*imp_peak_current;           %Magnitude factor

s1 = 0.1;                  %Scale factor 1

s2 = 3;                    %Scale factor 2

t = [0.001 0.125:0.125:6.9];

t1 = t.*t_crest_factor;

t1_1 = exp(-t1./100);
```

```
t2 = magnitude_factor.*t1_1;

t3 = magnitude_factor.*(s2.^(-t1./200));

imp_current = (t3-t2).*s1;


% Arrestor Voltage Calculations

k = arrestor_rat*2.5; n = 0.08;

T = 0:0.2:11;

total_ind = lead_length*lead_ind;

ar1 = k.*(imp_current.^n);

ar2 = 0.7.*ar1;

b = [imp_current 0]; p = [T 0];

imp_current_diff = diff(b);

T_diff = diff(p);

lead_voltage = total_ind.*(imp_current_diff./T_diff);

inv_lead_voltage = lead_voltage.*-1;

arr_plus_lead = ar1+lead_voltage;

arr_plus_lead2 = ar2+lead_voltage;

max_arr_plus_lead = max(arr_plus_lead);


%Plotting and Info

formatSpec = 'Maximum Combined Discharge Voltage is %4.2f KV';
```

```
fprintf(formatSpec, max_arr_plus_lead)

disp(' ')


figure('Name','Arrestor Voltage and Impulse Current')

plot(T(1:end-5),ar1(1:end-5),T(1:end-5),imp_current(1:end-5),'--','LineWidth',2)

set(gca, 'FontSize', 12)

title('Arrestor Voltage and Impulse Current')

xlabel('Time(\mus)')

ylabel('Arrestor Voltage (KV), Impulse Current (KA)')


figure('Name','Total Lead Voltage')

plot(T(1:end-5),lead_voltage(1:end-5),'LineWidth',2)

set(gca, 'FontSize', 12)

ax = gca;

ax.XAxisLocation = 'origin';

title('Total Lead Voltage')

xlabel('Time(\mus)')

ylabel('Lead Voltage (KV)')


figure('Name','Total Voltage Across Insulation')

plot(T(1:end-5),arr_plus_lead(1:end-5),'LineWidth',2)
```

```
set(gca, 'FontSize', 12)

title('Total Voltage Across Insulation')

xlabel('Time(\mus)')

ylabel('Total Voltage Across Insulation (KV)')
```

B. Lead Length Effects on Arrestor Voltage Comparison Code.

```
% to use this code, load accompanying .mat file

% to use old .mat file remove v11 and x11

load('yiran_new.mat','v0','v5','v10','v11','v15','v20','x0','x5','x10','x11','x15','x20','T')


figure('Name','Total Lead Voltage Comparison')

plot(T(1:end-5),v0(1:end-5),...

   T(1:end-5),v5(1:end-5),'--',...

   T(1:end-5),v10(1:end-5),'--r',...

   T(1:end-5),v11(1:end-5),'--g',...

   T(1:end-5),v15(1:end-5),':',...

   T(1:end-5),v20(1:end-5),'-.',...

   'LineWidth',2)

set(gca, 'FontSize', 12)

ax = gca;

ax.XAxisLocation = 'origin';
```

```
title('Total Lead Voltage Comparison')
xlabel('Time(\mus)')
ylabel('Lead Voltage (KV)')
legend({'L=0m','L=5m','L=10m','L=11m','L=15m','L=20m'},'Location','northeast')

figure('Name','Total Voltage Across Insulation Comparison')
plot(T(1:end-5),x0(1:end-5),...
    T(1:end-5),x5(1:end-5),'--',...
    T(1:end-5),x10(1:end-5),'--r',...
    T(1:end-5),x11(1:end-5),'--g',...
    T(1:end-5),x15(1:end-5),':',...
    T(1:end-5),x20(1:end-5),'-.',...
    'LineWidth',2)
set(gca, 'FontSize', 12)
title('Total Voltage Across Insulation Comparison')
xlabel('Time(\mus)')
ylabel('Lead Voltage (KV)')
legend({'L=0m','L=5m','L=10m','L=11m','L=15m','L=20m'},'Location','northeast')
```