American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-7, Issue-8, pp-62-74
www.ajer.org
Research Paper Open Access

Improved Protection FOR Rivers State University 2x15mva, 33/11KV Injection Substation

Idoniboyeobu, D. C.[1], Braide, S. L.[2]and Ekeriance, D. E.[3]
[1,2&3]*Department of Electrical Engineering, Rivers State University, Port Harcourt,* Nigeria
Corresponding Author: Ekeriance,, D. E.

ABSTRACT: *This research work was improved protection for RSU 2 X 15MVA, 33/11kv Injection Substation. Primary data were collected from Port Harcourt Electricity Distribution Company and others were calculated which aided in the hand calculation and decision making on the verification of lightning arresters and protective margin, voltage gradients and transformers differential protection (Case 1). The table value for verification of lightning arresters and protective margin indicated that discharge current was 0.7996KA meaning that the available 5KA lightning arresters in use are adequate and protective margin of 145% is adequate as it is >20%. The table value of voltage gradients indicated that E step (tolerable) for faults of duration < 3seconds and sustained faults are 305.8V and 9.135V respectively while E touch (tolerable) for faults of duration < 3seconds and sustained faults are 308.1V and 9.03375V respectively showed that they are good as none is greater than the reference figures. The table value for transformers differential protection (Case 1) showed that a matching CT of ratio 3.280A/4.374A which is a mismatch. Case 2 of the transformer differential protection is improved protection as it showed a matching CT ratio of 4.921A/4.374A. Report from verification of relay operation, case 1 showed that T1ASR and T2ASR failed to trip their respective CBs under fault condition while case 2 relay operation report showed that T1ASR and T2ASR tripped normally. Case 2 relay operation is improved protection too.*

KEYWORDS: *Discharge current, Lightning arresters, Protective margin, Voltage gradients*

Date of Submission: 20-07-2018 Date of acceptance: 04-08-2018

I. INTRODUCTION

An injection substation can be viewed as a substation by which a step down of higher voltage to a lower one is perfected as transmitted in densely populated dwellings. To serve the densely populated areas, transformers whose capacity are in the MVA value are used. It constitutes a set of complex electrical devices such as circuit breakers, current transformers, voltage transformers. busbars and power transformers in a confined place. Many substations act as a connecting point of systems and/or areas that operate at different voltage levels. Such substations include power transformers to scale the voltage of one area to match the voltage of the adjacent area. In order to provide adequate reliability to the overall system, protective devices are installed to detect abnormalities and react accordingly in a coordinated way with other devices [1].

Transformers generally speaking appear to be the most important component in the transmission of electricity. This they become very imperative as they change voltage level as required. Each control panel is always connected to a defined fascia annunciation compartment which will alert the operator by means of alarm. The annunciation may be classified into trip annunciation and warning annunciation [2].

Adequate precautions need to be taken to allow equipment operate normally at peak efficiency, eliminate damage to life and property and provides reliable uninterrupted service of quality because of high cost in investing on power system. A relay can be viewed as an electrical device that responds to its input information in a determined way and by the virtue of its contact operation, initiates a sudden change in the corresponding control circuits [3].

Different power apparatus must always be connected and provided with protection in the control room. equipment devices (in the switchyard) to the individual protective relays in the control house. Every protection or control function needs a distinct wire and a distinct physical termination at the required relay [4].

II. RELATED WORKS

A Bucholz relay can be viewed as a safety device capable of sensing the accumulation of gas in large oil-filled transformers that can produce alarm on slow accumulation of gas or disengage the transformer if gas evolves speedily in the transformer oil [5]. A CT is installed at the earthing cable connecting between the frame and the earthing point. The CT energizes an instantaneous earth fault relay to trip the switchgear, typically all the CB's connected to the busbar [6].

The most important thing in differential protection is the application of universal matching C.Ts such that the right ratio and connections are selected in a manner that individual auxiliary C.Ts for every distinct application of transformers differential protection of various voltage values and vector groups is eliminated [7]. As a unit protection with its zone constrained by location of current transformers (CTs), the differential protection principle is considered superior with respect to selectivity, sensitivity, and speed of operation when compared with directional comparison, phase comparison, or stepped distance schemes [8].

To avoid the risk of fast-rising high-current surges within the substation, two protection system characteristics are required: Prevention of direct strikes to any operational component within the substation. Prevention of fast-rising high-current surges from entering the substation through the incoming or outgoing lines [9]. A typical size of mesh is of 4m x 5m of earthing conductor. These meshes are connected to several earth electrodes of size 1.9cm x 3m driven at intervals [10]. External overvoltages can cause several damages to a substation, leading to insulation breakdowns, a series of malfunctions, power outages and safety issues to the staff. Furthermore, lightning surges may also cause dangerous electromagnetic interference problems to low voltage systems and especially to electronic devices [11].

A lightning may strike the power system (e.g. overhead lines, towers or sub-stations) directly and the current path may be over the insulators down to pole to the ground or it may strike indirectly, resulting from electrostatically induced charges on the conductors due to the presence of charged clouds [2]. In a substation, surge arrester is located at the starting of the substation from incoming transmission lines and it becomes the threshold equipment of the substation. Surge arresters are also installed near the transformer terminals phase to ground [12]. If the tip of mast becomes largely less, then the mast attracts lightning flashes quicker than the shielding wire. Masts are therefore considered more than shielding wires for lightning protection for substations [13]. The lightning protection system must be so applied that the magnitude of lightning produced - overvoltages and currents experienced by facilities be reduced to definite lower levels [14].

III. MATERIALS AND METHODS

3.1 Materials

The data required were collected from Port Harcourt Electricity Distribution Company (PHEDC) to analyse and investigate protection status of RSU 2 X 15MVA, 33/11kv Injection Substation. The procedure for actualizing this goes as follows.

3.2 Method of Analysis

An Injection Substation can be viewed as a substation where a higher voltage is stepped down to a lower value via a transformer often in the MVA range such that the output can serve a wide area. The transformer in this regard being of paramount importance requires adequate protection to avoid prolonged outage in the event of failure. Transformers and feeder buses must have adequate protection. All data concerning CTs, station earthing, relays and other relevant data collected were used for analysis.

With the use of the available data, hand calculation method was employed to verify the protection level of lightning arrester, voltage gradients and transformer differential protection while protective relays sensitivity was verified with the use of ETAP.

Table 3.1 Available Data Considered for the Work

S/NO	PARAMETER	VALUE
1	NOMINAL RATED VOLTAGE	33KV
2	HIGHEST SYSTEM VOLTAGE	36KV
3	BASE MVA	100
4	FLASHOVER VOLTAGE FOR 33KV, 3UNITS	APPROX. 215KV
5	BIL FOR 33KV (BRITISH STANDARD BIL)	200KV
6	PROTECTIVE MARGIN	≥ 20%
7	T1A IMPEDANCE	11.1%
8	T2A IMPEDANCE	10.7%
9	E STEP(TOLERABLE) FOR FAULTS LESS THAN 3SEC	310V
10	E STEP (TOLERABLE) FOR SUSTAINED FAULTS	10V
11	E TOUCH (TOLERABLE) FOR FAULTS LESS THAN 3SEC	310V
12	E TOUCH (TOLERABLE) FOR SUSTAINED FAULTS	10V
13	15MVA TRANSFORMER PRIMARY CTR	300/5

14	15MVA TRANSFORMER SECONDARY CTR	1200/5
15	LIGHTNING ARRESTERBRATING	5KA
16	SOIL RESISTIVITY NEAR SURFACE OF THE GROUND	2.5Ω/M

Source: PHEDC

3.3 Relay Protective Technology and other protective devices at RSU 2 X 15MVA, 33/11kv Injection Substation.

The protective devices in place at RSU 2 X 15MVA, 33/11kv Injection Substation are: IDMT 3sec. electromechanical relay (CDG type) for OC and EF protection, sky wire run across the power transformers, lightning arresters on both lines, 8 pieces of non-functional batteries, direct on- line rectifier unit for DC supply etc.

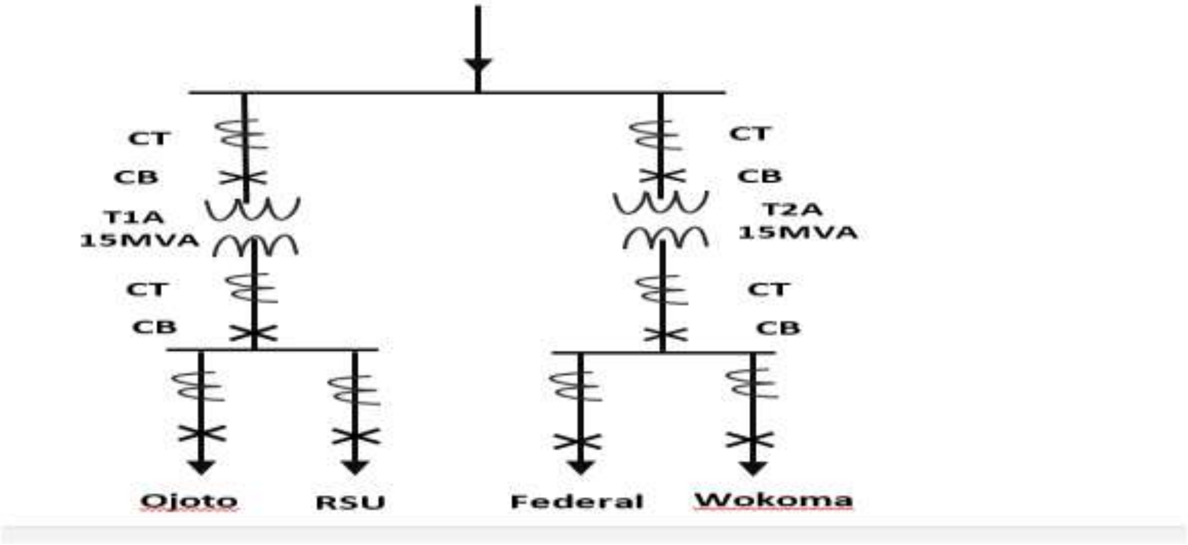

Figure 3.1 One – Line Diagram of RSU 2 X 15MVA, 33/11kv Injection Substation

3.3.1 Station Tripping Unit (DC unit)

Since there are only 8 pieces of protection batteries that are virtually bad and disconnected from the circuit, the rectifier unit is connected directly to the supply source (MCB). To this end, the rectifier will be temporarily disconnected from the supply source when all outgoing feeders are on off position to ascertain the retainability and reliability of the DC unit. This is to note the behavior of the DC unit in the event of the MCB cutting supply due to trip while there is supply at the station and outgoing 11kv feeder is on.

3.3.2 Switch Yard Sky Wire

Visual checks will be conducted on the switch yard sky wire to ascertain if it does exist and if it does, then the continuity as this will determine to a large extent its reliability even when connected to a healthy earthing system (effectively earthed system). Also check the physical layout of the sky wire across the switch yard power equipment.

As far as lightning protection system is to intercept lightning and safely discharge its current to ground, the three elements of the system should serve as a continuous conductive path for lightning discharge current having all terminations between the elements typically being accompanied by bolting and welding. The lightning protection system must be so applied that the magnitude of lightning produced – overvoltages and currents experienced by facilities be reduced to definite lower levels [14].

3.4 Lightning Arresters

The following are deduced to ascertain the true status of the lightning arresters in use at RSU 2 X 15MVA, 33/11kv Injection Substation:

It is known that nominal voltage = 33kv

Highest system voltage = 36kv

System having effectively grounded earthing

At 80% rating; rating of lightning arrester = $Highest\ system\ voltage\ X\ 0.8$ (3.1)

With 85% rating; rating of lightning arrester = $Highest\ system\ voltage\ X\ 0.85$ (3.2)

We now select rating using equation (3.1) and equation (3.2) as both are recommended L. A voltage rating in B.S.S.

Residual voltage resulting from equation (3.2) will yield the following:
Residual voltage = $(Highest\ system\ voltage\ X\ 0.85)\ X\ 3.6$ (3.3)
Power frequency spark-over voltage = $(Highest\ system\ voltage\ X\ 0.85)\ X\ 1.6$ (3.4)
For a 33kv system 3 units all tensioned and viewing from a volt-time curve and its flash over.
Discharge current, $i_a = \frac{2el-ea}{Z}$ (3.5)
Where
$i_a = Discharge\ current$
$el = Voltage\ of\ a\ travelling\ wave$
$ea = Residual\ voltage\ of\ lightning\ arrester$
$Z\ becomes\ Surge\ impedance\ of\ the\ line(\ generally\ 400\ ohms)$
The value of el is usually found by the line insulator string flash over characteristics. From equation (3.5), we can select a discharge current.
Protection level of the L.A. is located within 30feet of the transformer can be expressed as:
PL = $1.15\ X\ (Residual\ voltage\ of\ Highest\ system\ voltage\ X\ 0.85) + 30$ (3.6)
Impulse spark over-voltage $= Highest\ system\ voltage\ X\ 0.85\ X\ 3.6$ (3.7)
A protective margin of 15% for switching over voltages and 25% for lightning over voltages is adopted.
Protection level for lightning and switching surges may be:
$Protection\ level = Impulse\ spark\ over - voltage\ X\ 1.25$ (3.8)
Thus, the highest system voltage L.A. derived from equation (3.4) will usually protect a transformer provided the B.I.L of the transformer is higher than protection level for lightning and switching surges as may be derived from equation (3.7). We select the nearest B.I.L for 33kv to correspond to the value in equation (3.8).
Protective margin $= \frac{B.I.L}{Protection\ \ level}$ (3.9)
Where
B.I.L is basic insulation level
The result of equation (3.9) serves for switching and lightning and for temporary over voltages.

3.5 Determination of Grid Resistance

If the equivalent length of earth mat area is L and the equivalent width of earth mat area becomes W, the number of conductors along length is NL while the number of conductors along width is NW.
If fault current is known, then:
Minimum number of electrodes $= \frac{Fault\ \ current}{500}$ (3.10)
If we Keep an additional margin of 50%, number of electrodes is mathematically presented as:
$Nr = 1.5\ X\ \frac{Fault\ \ current}{500}$ (3.11)
If the length of individual electrode is LR, total length becomes:
$LT = LC + LR = (L\ X\ NL + W\ X\ NW) + (Nr + Lr)$ (3.12)
Furthermore, the total area of earth mat can be deduced as follows:
$A = L\ X\ W$ (3.13)
The procedure below can be used to determine tolerable touch and step voltages respectively:
E step (tolerable) $= (R_K\ +\ 2R_F)I_K$ volts (3.14)
Where
R_F *becomes* grounding resistance of one foot in ohms.
For practical reasons it is assumed to be $3P_S$ where
$P_{S\,=}$ resistivity of the soil near the ground surface in ohm-meter.
$R_{K\,=}$ resistance of the body in ohms, which is always 1000 ohms.
$I_{K\,=}$ R.M.S current that flow via the body in amps = $\frac{0.165}{\sqrt{t}}$ (3.15)
Where
t = duration of shock usually in seconds and is below 3seconds = 0.009A for sustained faults. Therefore, for faults with duration less below 3seconds;
E step (tolerable) = $(1000\ + 6P_s)\frac{0.165}{\sqrt{t}}$ (3.16)
The above relation can further be reduced to:
E step (tolerable) = $\frac{(165\ + P_s)}{\sqrt{t}}\ volts$ (3.17)
Therefore, sustained fault becomes:
E step (tolerable) = $(1000\ +\ 6P_s)\ 0.009$ (3.18)
This relation can further be seen as:
E step (tolerable) = $(9\ +\ 0.054P_s)\ volts$ (3.19)

On the other hand, E touch can be expressed in the following way:

E touch (tolerable) $= (R_K + \frac{R_F}{2})I_K$ (3.20)

For faults of duration less than 3seconds:

E touch (tolerable) $= (1000 + \frac{3P_S}{2})\frac{0.165}{\sqrt{t}}$ (3.21)

The above can also be reduced to;

E touch (tolerable) $= \frac{(165 + 1.5P_S)}{\sqrt{t}}\ volts$ (3.22)

Therefore, sustained faults $= (1000 + 1.5P_S)0.009$ (3.23)

And E touch can further be reduced to:

E touch (tolerable) $= (9 + 0.0135P_S)$ volts (3.24)

3.6 Differential protection for a 15MVA, 33/11kv Dy1 transformer

Primary full load current $= \frac{p}{\sqrt{3}xV}$ (3.25)

Where

V = 11kv

The above relation will guide us in selecting the proper CTR which also will aid in finding the secondary full load current as:

Secondary full load current $= Primary\ full\ load\ current\ X\ CTR$ (3.26)

Also, secondary full load current can be resolved by using equation (3.25) with V = 33kv. After which, a CT is selected and the full load current in CT secondary is found by making use of equation (3.26). The secondary CT secondary line current has to be matched with primary CT secondary line current.

3.7 Verification of the Various 11kv Feeder Breaker Relays

Transformer impedance at RSU 2 X 15MVA Injection Substation base MVA can be defined by the following:

$Z_{P.U} = \frac{\% Z_1\ X\ Base\ MVA}{Transformer\ \ MVA}$ (3.27)

For a 3-phase fault on 11kv side, the following can be deduced:

Fault MVA $= \frac{Base\ MVA}{fault\ impedance}$ (3.28)

Fault current $= \frac{Fault\ MVA}{\sqrt{3}XV}$ (3.29)

Where

V = 11kv

For one phase to ground, earth fault impedance $= \frac{Transformer\ \ impedance}{3}$ (3.30)

Also, earth fault MVA $= \frac{Base\ MVA}{Earth\ fault\ impedance}$ (3.31)

The above can further be used to generate the following:

Earth fault current $\frac{Earth\ fault\ MVA}{\sqrt{3}XV}$(3.32)

3.7.1 Verification of Relay Sensitivity for 11kv Feeder Breaker Overcurrent Relay (OCR)

From the available feeder CTR and calculated fault current, secondary value of fault current can be calculated thus:

Secondary value of fault current $= Fault\ current\ X\ CTR$ (3.33)

If full load current is identified, the following can be deduced:

Secondary full load current $= Full\ load\ current\ X\ CTR$ (3.34)

The above relation determines the plug set (P.S), and this further determines the Multiplier Plug Setting (MPS) as shown:

MPS $= \frac{Secondary\ \ value\ \ of\ fault\ \ current}{P.S}$ (3.35)

If Time Multiplier Setting is known, we can calculate the actual operating time of relay as:

$t = TMS\ X\ \frac{0.14}{MPS^{0.02} - 1}$ (3.36)

3.7.2 Verification of Relay Sensitivity for 11kv Feeder Breaker Earth Fault Relay (EFR)

From the available feeder CTR and calculated earth fault current, secondary value of earth fault current can be calculated thus:

Secondary value of earth fault current $= Earth\ fault\ current\ X\ CTR$ (3.37)

Finally, eqn.3.6 can be used to calculate the time of operation if P.S and MPS are established.

3.8 Verification of Station Parameters using Hand Calculation

With all the data required, hand calculation is used to check the selection of lightning arrester, voltage gradients and differential protection for the 2 X 15MVA, 33/11kv Dy1 transformers at RSU Injection Substation.

3.8.1 Verification of Lightning Arresters for RSU 2 X 15MVA, 33/11kv Injection Substation

Nominal voltage = 33kv
Highest system voltage = 36kv
System is effectively grounded
With 80% rating; rating of L.A = 36 X 0.8
= 28.8kv
With 85% rating; rating of L.A = 36X0.85
= 30.6kv
By British standard, any of the above values is recommended.
Residual voltage of a 30.6kv L.A = 30.6 X 3.6
= 110.16kv Peak
Power frequency spark over voltage = 30.6 X 1.6
= 48.96
= 49kv (R.M.S)
For a 33kv system and 3units at tension e_l is approximately 215kv.
Using eqn.3.5, $Discharge\ current = \frac{2(215)-110.16}{400}$
0.7996KA
Hence we can select 5KA lightning arrester.
Since the L.A is located within 30ft of the transformer, protection level becomes
1.15 X 110.16 + 30 = 156.689kv
Impulse sparkover voltage = 30.6 X 3.6
= 110.16kv Peak
A protective margin of 15% for switching over-voltages and 25% for lighting over-voltages is adopted.
Protection level for lightning and switching surges will be 110.16 X 1.25
= 137.7kv Peak
Thus the 30.6kv L.A will protect a transformer provided the BIL of the transformer is greater than 137.7kv. The nearest BIL for 33kv to correspond to 137.7kv is 200kv (British Standard BIL)
Protective margin = $\frac{200}{137.7}$
= 1.45
That is 145% for switching and lightning and for temporary over voltages.

3.8.2 Verification of Voltage Gradients for RSU 2 X 15MVA, 33/11kv Injection Substation

For faults of duration less than 3seconds, equation (3.17) was used where
t = 0.3sec
$P_S = 2.5\Omega/m$
E step (tolerable) = $\frac{(165+2.5)}{\sqrt{0.3}}$
= 305.8V
For sustained faults, equation (3.19) was used with t and Ps as in above.
E step (tolerable) = 9 + 0.054 X 2.5
= 9.135V
For faults of less than 3seconds, equation (3.22) was used with t and Ps as in above.
E touch (tolerable) = $\frac{(165+1.5\ x\ 2.5)}{\sqrt{0.3}}$
= 308.1V
For sustained faults, equation (3.24) was used with t and Ps as in above.
E touch (tolerable) = 9 + 0.135 X 2.5
= 9.03375V

3.8.3 Differential Protection for the 2 X 15MVA, 33/11kv Dy1 Transformers at RSU Injection Substation (Case 1)

The following are considered:
From equation (3.25),
Primary full load current = $\frac{15\ X\ 10^6}{\sqrt{3}X\ 33\ X10^3}$

= 262.43A

CTR = 300/5 is available

Secondary full load current = $262.43\ X\ \frac{5}{300}$

= 4.374A

Secondary full load current = $\frac{15\ X\ 10^6}{\sqrt{3}X\ 11\ X10^3}$

= 787.30A

CTR = 1200/5 is available

Full load current in CT secondary = $787.30\ X\ \frac{5}{1200}$

= 3.280A

3.8.4 Differential Protection for the 2 X 15MVA, 33/11kv Dy1 Transformers at RSU Injection Substation (Case 2)

The following are considered:

From equation (3.25),

Primary full load current = $\frac{15\ X\ 10^6}{\sqrt{3}X\ 33\ X10^3}$

= 262.43A

CTR = 300/5 is available

Secondary full load current = $262.43\ X\ \frac{5}{300}$

= 4.374A

Secondary full load current = $\frac{15\ X\ 10^6}{\sqrt{3}X\ 11\ X10^3}$

= 787.30A

CTR = 800/5 is selected

Full load current in CT secondary = $787.30\ X\ \frac{5}{800}$

= 4.921A

3.9 Verification of Relays Sensitivity (Case 1)

ETAP 12.6.0 software was used to ascertain the sensitivity of the relays at RSU 2 X 15MVA, 33/11kv Injection Substation. The available data required served as input data for the simulation as in Figures 3.3(a-h).

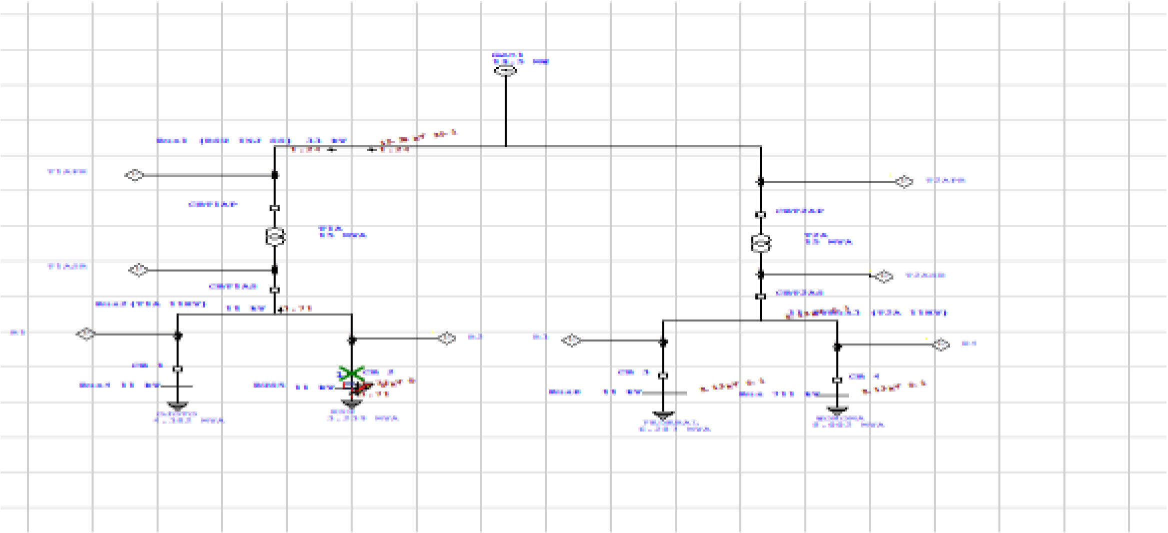

Figure 3.3a RSU 11kv Feeder (Case 1)

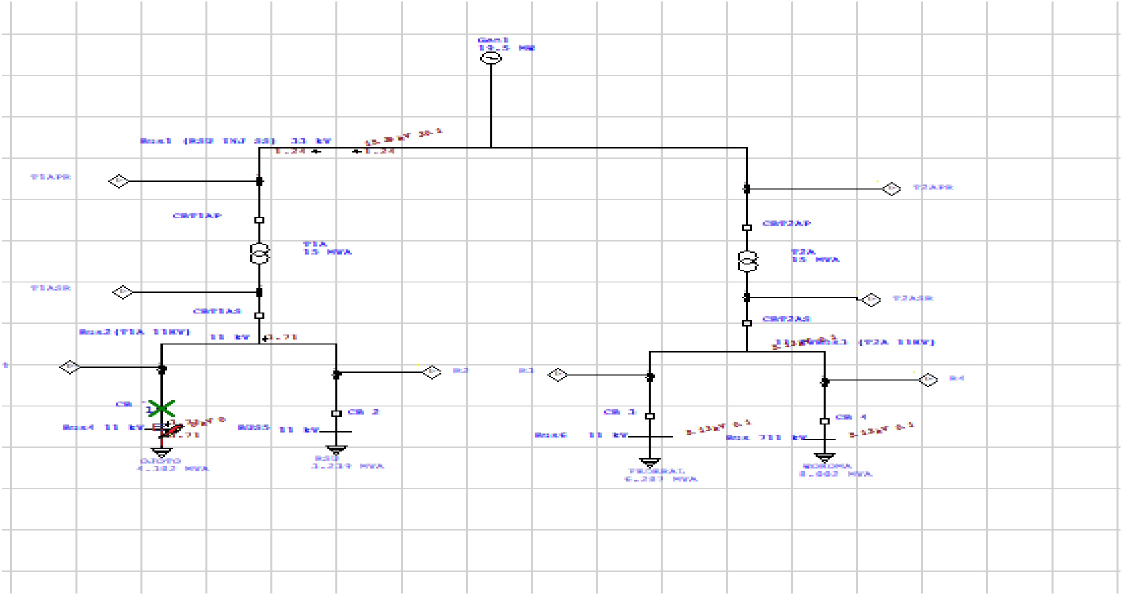

Figure 3.11b Ojoto 11kv Feeder (Case 1)

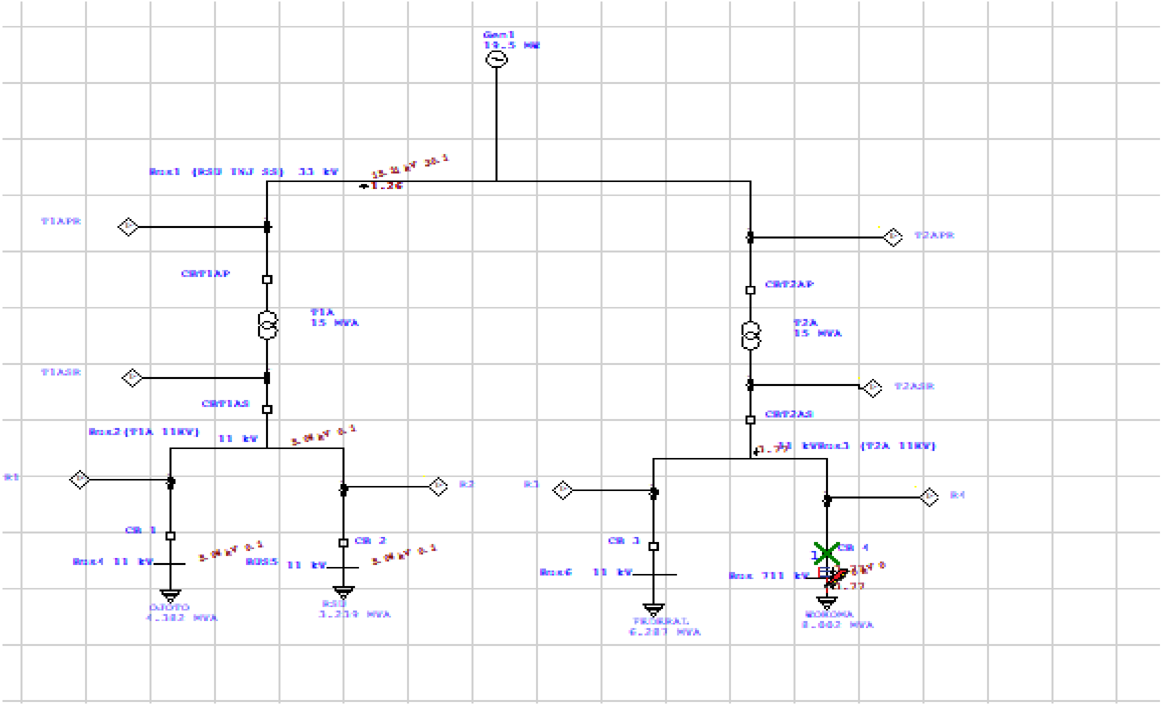

Figure 3.3c Wokoma 11kv Feeder (Case 1)

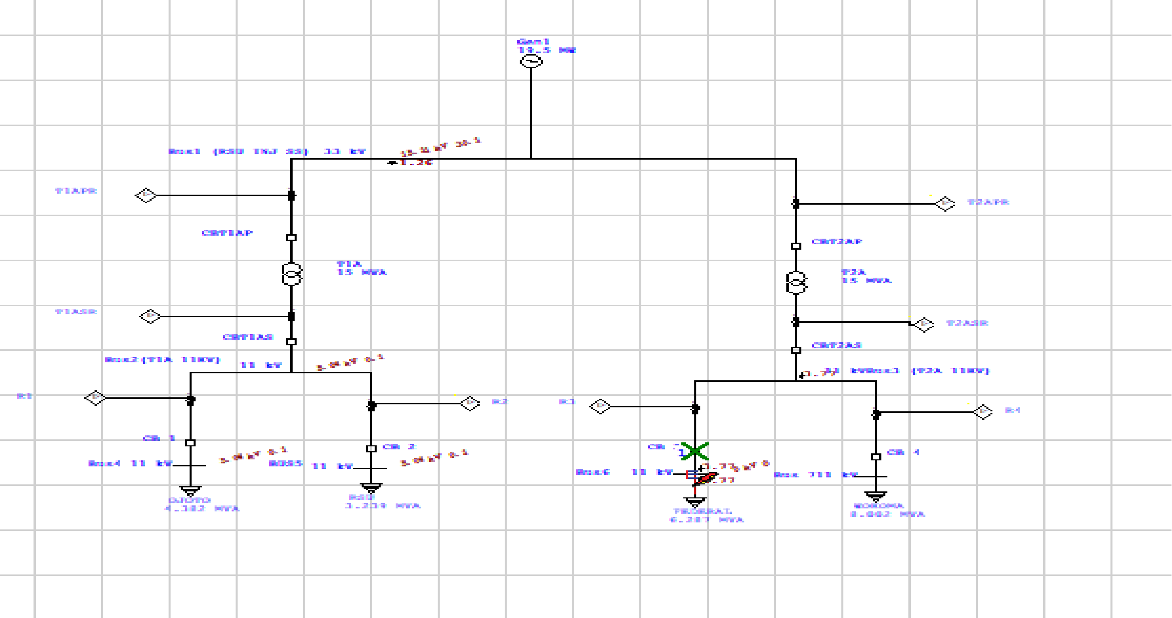

Figure 3.3d Federal 11kv Feeder (Case 1)

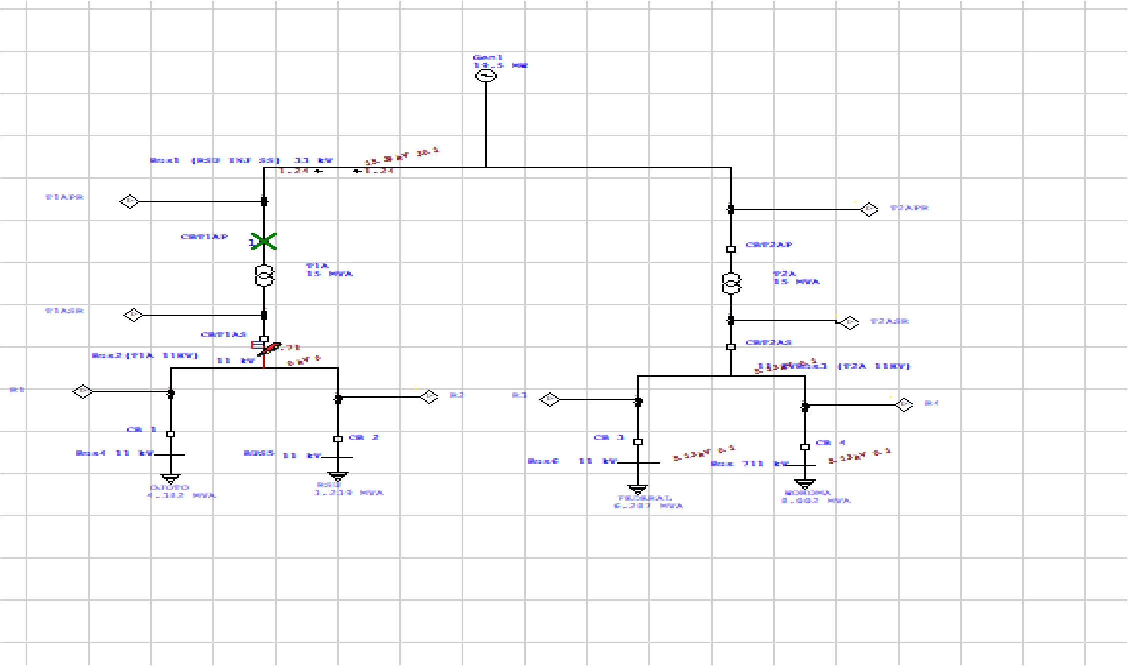

Figure 3.3e T1A 11kv Incomer (Case 1)

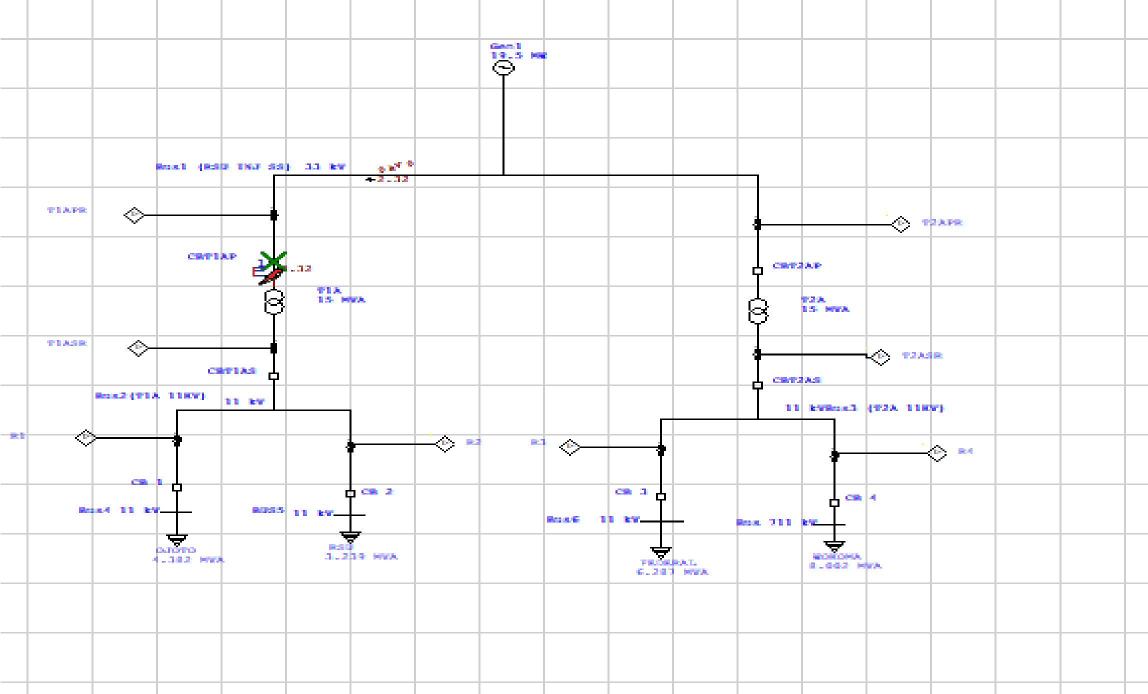

Figure 3.3f T1A 33kv Breaker (Case 1)

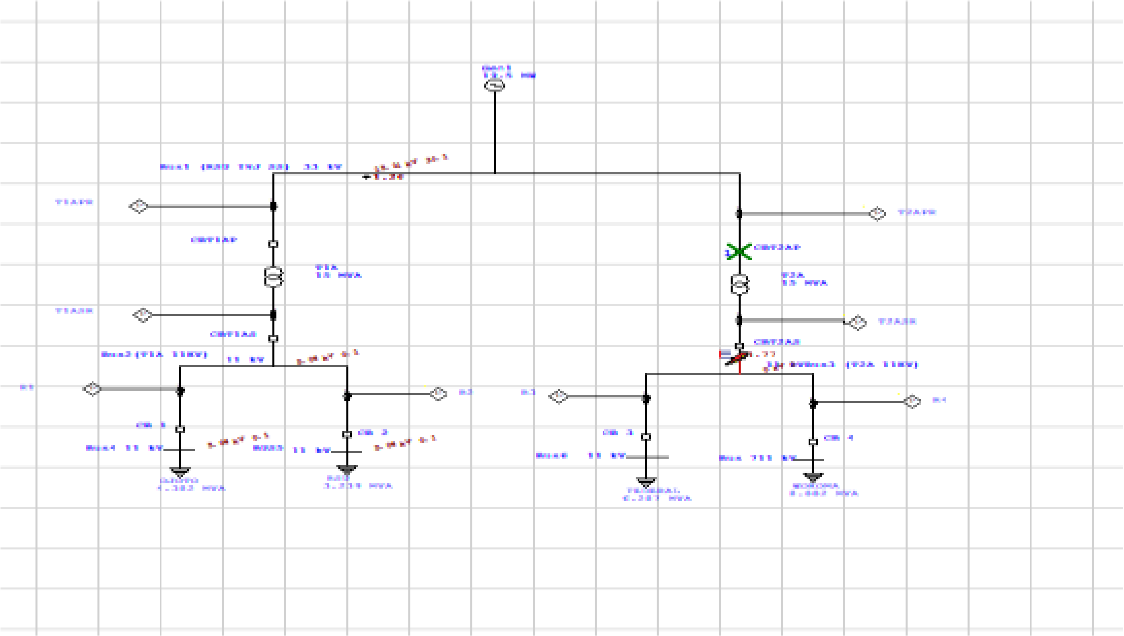

Figure 3.3g T2A 11kv Incomer (Case 1)

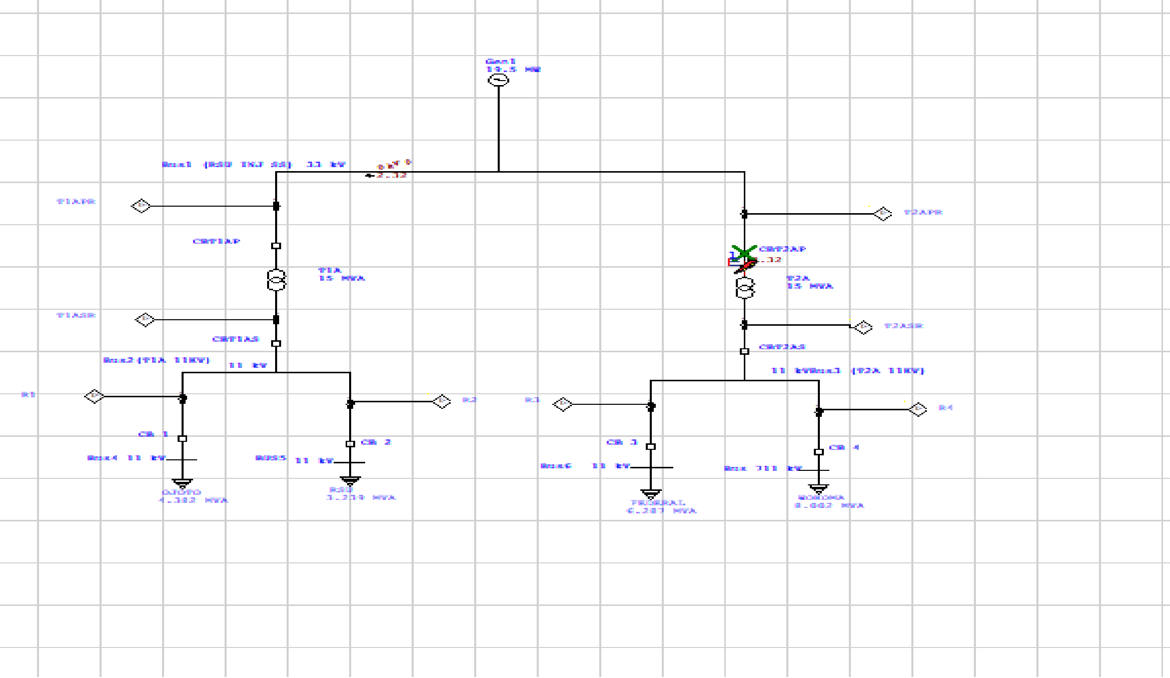

Figure 3.3h T2A 33kv Breaker (Case 1)

3.10 Verification of Relays Sensitivity (Case 2)

Having all the data in place, only CTR of 1200/5 was replaced with 800/5 for the 11kv incomers and the incomers are modelled as in Figures 3.4 (a-b).

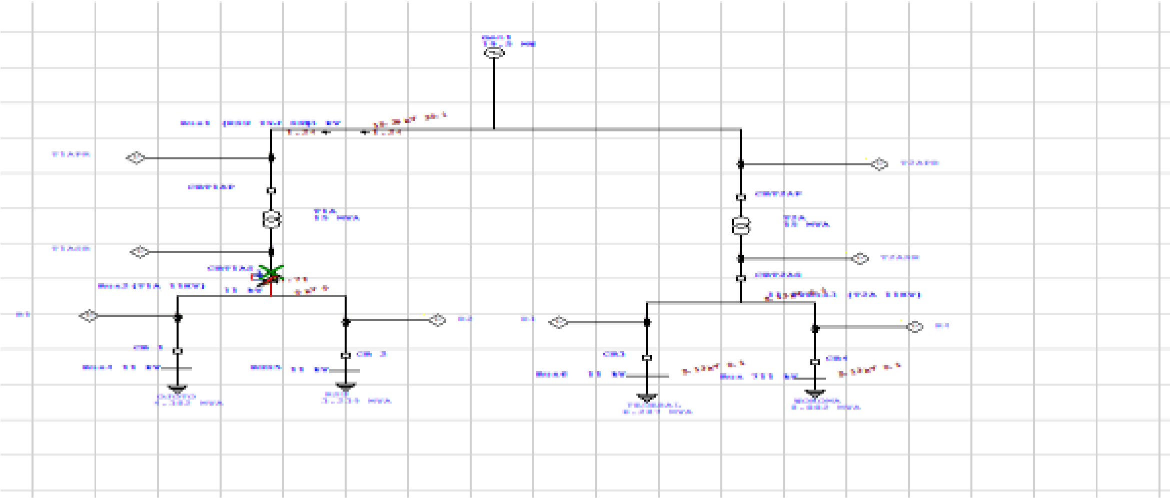

Figure 3.4a T1A 11kv Incomer (Case 2)

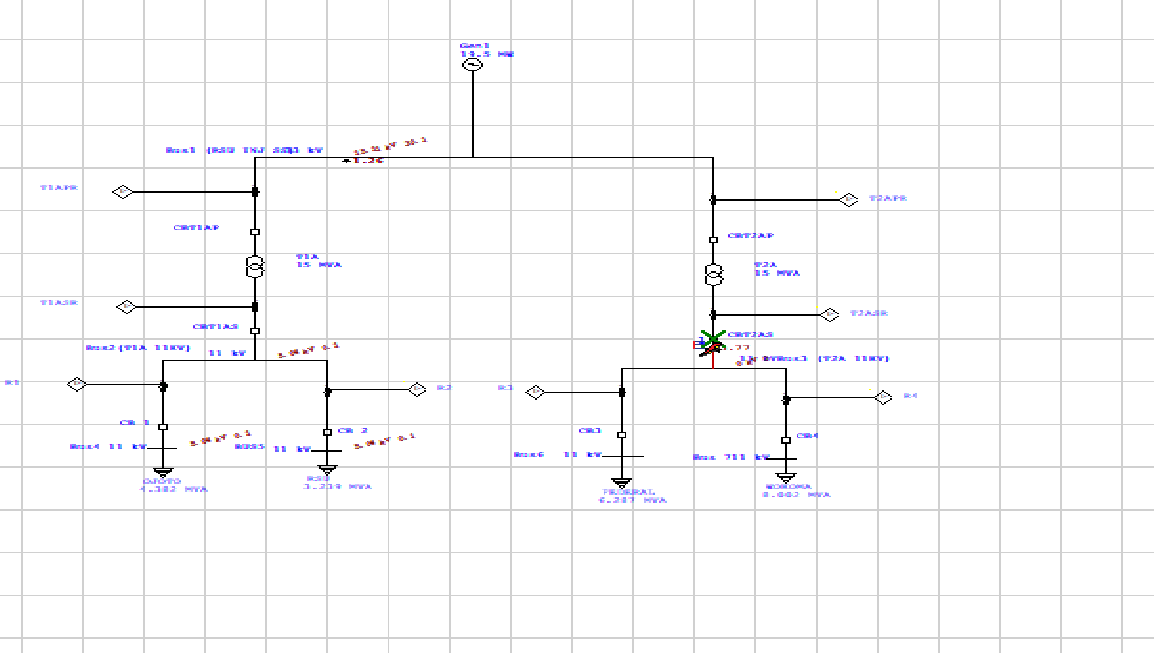

Figure 3.4b T2A 11kv Incomer (Case 2)

IV. RESULTS AND DISCUSSION

4.1 Lightning Arrester Verification Result

The results so obtained pertaining the present lightning arresters are presented in Table 4.1. However, a 5KA current rating of lightning arrester is actually the one in place which is able to protect the system.

Table 4.1 Verification of Lightning Arrester and Protection Margin

Nominal Voltage(KV)	Discharge current(KA)	Lightning Arrester (KA)		Protection Margin (%)		Status
		Tolerable	Attained	Tolerable	Attained	
33	0.7996	5	5	≥ 20	145	> 20%

4.2 Voltage Gradients in the Vicinity of the Grounding System Verification Result

The results obtained pertaining the present voltage gradients are presented in Table 4.2. The calculated values are in line with the values provided by PHED.

Table 4.2 Verification of Voltage gradients in the Vicinity of the Grounding System

Voltage Gradients (V)	Tolerable (V)	Attained	Status
E step < 3sec	310	305.8	< 310
E step (Sustained fault)	10	9.135	< 10
E touch < 3sec	310	308.1	< 310
E touch (Sustained fault)	10	9.034	< 10

4.3 Transformers Differential Protection Result

The results obtained pertaining the present differential protection which is case 1 are presented in Table 4.3. A CT mismatch occurred. However, transformer secondary CTR was replaced and a matching CT was achieved.

Table 4.3 Transformer Differential Protection

Case	Primary CTRs	Secondary CTRs	Matching CT	Status
Case 1	300/5	1200/5	3.280A/4.374A	Mismatch
Case 2	300/5	800/5	4.921A/4.374A	Match

4.4 Relays Sensitivity Verification Result

The results obtained pertaining the present (Case 1) relays operation and improved relays operation (Case 2) are presented in Tables 4.4. The summary of fault report for Case 1 is presented in Appendix A while report for

Case 2 is presented in Appendix B. The replacement of the transformer secondary CTRs actually made the transformers secondary CTs to trip the associated CBs.

Table 4.4 Summary of Relay Operation Report for Cases 1 and 2

FEEDER	OPERATING TIME (ms)	
	CASE 1	CASE 2
RSU	7.3	7.3
OJOTO	7.3	7.3
WOKOMA	7.3	7.3
FEDERAL	7.3	7.3
T1ASR	0	8.3
T1APR	8.8	8.8
T2ASR	0	8.2
T2APR	8.7	8.7

V. CONCLUSION

5.1 Conclusion

To a large extent, this research has been able to show that it is vary essential to achieve improved protection for Rivers State University 2 x 15MVA, 33/11kv Injection Substation. The data collected were used to conduct well guided hand calculation to verify and further improve on as may be required the lightning arrester, step and touch voltages and transformer differential protection.

Also, ETAP 12.6 was used to ascertain and improve the relays operation of the Injection Substation.A CT mismatch occurred on the transformer differential protection. There was a wide gap between the secondary CT secondary line current of 3.280A and primary CT secondary line current of 4.374A.

The replacement of CTR on the transformer secondary automatically closed the wide gap. A matching CT was achieved with the value as 4.921A/4.374A. Also, all the relays operated when fault was introduced thereby leaving two (2) relays out. The transformer secondary relays failed to operate at the introduction of fault. However, the CT value of 1200/5 was replaced with 800/5 and the relays operated accordingly.

REFERENCE

[1]. Thompson,"The Future of Substations: Centralized Protection and Control".Thesis submitted to the Faculty of Virginia Polytechnic Institute and State University in Electrical Engineering, 2016.

[2]. S. Sudipta, C. Arindam. & S.Debanjan,"Design of 132/33KV Substation".Internation Journal of Computational Engineering Research, Vol, 03, Issue 7, 2013.

[3]. V. U. Duru,"Protection Techniques in Operations, Maintenance and Protection of Electric Power System, Injection Substations Management and Safety Precautions", Calabar, 2004.

[4]. K. Mital,"Integrated Substation Protection and Control". ECE Department, University of Western Ontario, 2013.

[5]. S. Som, "Protective Devices in a Substation". Electrical & Computer Engineering. Presidency University Dhaka, Bangladesh, 2011

[6]. C. W. Chiu &N. Alfreda,"Rough Balance Busbar Protection and Breaker Failure Protection for the HK Electrics Distribution Network". Journal of International Council on Electrical Engineering, 3 (1), 6-11, 2013.

[7]. NEPA Basic Protection Course P1 Training and Development Programme, Port Harcourt: National Electric Power Authority, 2005.

[8]. H. Miller &J. Burger, "Modern Line Current Differential Protection Solutions".Normann Fischer and BogdanKasztenny Schweitzer Engineering Laboratories, Inc., 2014.

[9]. A.A. Mohamed, "Surge Over-voltage Protection for Substations: International Conference on Energy and Environment". University of Cambrdge, UK, 2008.

[10]. N. K. Datta, "Power System and Protection". S. K. Kataria& Sons, Opposite Delhi Medical Association, Darygani, New Delhi, 2014.

[11]. T. Mahmud, "Lightning overvoltage and protection of power substations". WSEAS Transactions on Power Systems, Department of Electrical and Electronic Engineering, City, University London, Northampton Square, London EC 1V 0HB, UK, 2017.

[12]. K. S. Manoj,"Basics of Substation Design-Main Components of Substation". Blog, 2012.L. V. Dung & K. Petcharaks."Lightning Protection Systems Design for Substations by Using Masts and Matlab: World Academy of Science, Engineering and Technology". International Journal of Mathematical and Computational Science 4 (5), 66-70, 2010.

[13]. E. B. Peekate,"Protection Against Lightning Strikes Surges in the Rivers State University of Science and Technology, Nkpolu-Oroworukwo, Port Harcourt, Rivers State". 53-54, 2005.

Ekeriance,, D. E"Improved Protection FOR Rivers State University 2x15mva, 33/11KV Injection Substation." American Journal of Engineering Research (AJER), vol. 7, no. 08, 2018, pp. 62-74