© DEC 2021 | IRE Journals | Volume 5 Issue 6 | ISSN: 2456-8880

Analysis Of Improved Lightning Protection Scheme For 132/33kv Port Harcourt Mains Transmission Sub-Station

EMUDIANUGHE, ESEJUWVEWO JOHN[1], D. C. IDONIBOYEOBU[2], S. L. BRAIDE[3]
[1, 2, 3] *Electrical Engineering Department, Rivers State University*

Abstract- This research work is aimed to improve the existing condition of the earthing scheme under study, particularly the supply system 132/33kv transmission station (from Afam power station to Port Harcourt, Zone-2, Trans-Amadi Industrial layout), using touch & step voltage. Reliability techniques are used to check the effectiveness of the earthing condition under study. The results obtained under investigation shows activities and properties of the existing soil condition, the soil-derating factor of the soil are within 0.3 – 0.4 which suggests poor earthing condition this actually indicate poor interaction of soil earthing facility to the incidence of lightning occurrence in the event of probable faults incidence. The existing data was collected to validate operating earthing performance and check the effectiveness system reliability. The study case was modeled (power supply from Afam to zone-2) in electrical transient analyzer, Etap – 12.6 and application tool matlab for simulation of system parameters. The simulated plots show the exponential growing down behavior caused by a transient lightning strike incident on the station over the existing poor condition (derating factor 0.3-0.4) poor soil resistivity (m), low resistivity of thin layer materials, and low thickness of surface layer materials required necessary improvements (upgrade) of the soil variable for the purpose of ensuring reliable electricity power supply to end users. The study looked at the current start's configuration and design in order to upgrade all of the soil parameters and data that were below operating standards. The ground potential rise (GPR) and the thickness of thin layer crushed rock of (100mm, 4500m) materials were investigated for the proposition of an improved case in accordance with declared standard practice.

Indexed Terms- Earthen protection, 132/133Kv, lightning Protection

I. INTRODUCTION

A massive electric discharge and spark are both represented physically in lightning. The larger particles in a thunder cloud carry negative charges, while the smaller carriers carry positive charges; this is the norm. In this way, the ground is negatively charged, while the upper part is positively charged, making the whole cloud electrically neutral (Choi et al., 2005). Local field intensities approaching 30 kV/cm in atmospheric air or 100 kV/cm in water droplet presence cause the strike to be launched in the negative change center region. Stepped wave discharges descend downhill in 50- to 100-meter steps, pausing for a few microseconds after each one. This is stage 1. A low-brightness pilot streamer with a few amperes of current propagates into the virgin air from the hip of the discharge at a speed of about 1 105m/sec. A stepped wave, with an average velocity of about 100A, may follow the pilot streamer in some cases. A 3km-high stepped wave from the cloud is on a collision course with the earth's surface (IEEE Std 80, 2007). The objectives of this work will investigate the activities of lightning initiation in transmission substation (Z_2 Port Harcourt Main), in order to: Collect of existing soil data parameter for verification where applicable and to implement collected data into normalized equations of ground potential rise, touch and step potential in line with IEEE standard -80 and to determine minimum earthing grid conductors etc that are adequate for fault occurrence and to determine dangerous step and touch voltages evaluation that is declared according to the operating conditions.

- Past Review

Earth resistance can be as low as 3 ohms or as high as 25 ohms. In the event of an earth fault, the protection system can isolate the power supply due to low earth resistance, making Earth Potential Rise (EPR) less dangerous for humans (Lukong, et al., 2015). Earthing issues fall into three categories: soil resistance, soil stability, and environmental factors that influence how well electrical earthing installations work (Siow, et al., 2013). An earthing grid known as a ring electrode is sometimes used around structures like wing turbines as a peripheral earth conductor. To further reduce earth resistance, use vertical rods near the earthing grid's perimeter in addition to the horizontal grid.

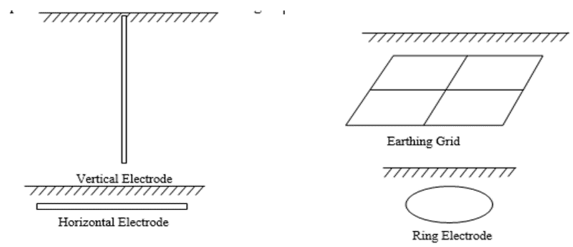

Figure 1: Different Types of Earthing Electrodes

- Size and Type of Electrode

Increasing the diameter of the ground electrode has very little effect in lowering the Resistance. Standard electrodes are often used to record the initial earth resistance.

- Depth to which the Electrode is buried

Driving ground electrodes deeper is a very effective way to lower ground resistance. Soil is not consistent in its resistivity and can be unpredictable. The resistance level can generally be reduced by an additional 40% by doubling the length of the ground electrode.

- Soil Resistivity Analysis

Actual resistivity measurements are required to fully quality the resistivity and its effects on the overall power system.

Using the Wenner method, the apparent soil resistivity value can be analytically found using the formula:

$$\rho_E = \frac{4\,.\pi\,.a\,.R_W}{1+\frac{2\,.a}{\sqrt{a^2+4.b^2}}-\frac{a}{\sqrt{a^2+b^2}}} \qquad (1)$$

The analytical equation can further be simplified to:

$$\rho_E = 2\,.\pi\,.a\,.R_W \qquad (2)$$

Where:

ρ_E : measured apparent soil resistivity (Ωm)

a : electrode spacing (m)

b : depth of the electrodes (m)

R_W : Wenner resistance measured as “V/I”. From Ohm’s law, Resistance = R_W

II. MATERIALS AND METHODS

- Methods Used

Numerous dangers are involved when analyzing electrical energy sources such as 132 kV transmission lines at Port Harcourt mains (Z2), as well as distribution stations and how they are used, including: lightning incidence on the 132 kV transmission line at Port Harcourt mains (Z2).

- Analysis 1:

The following information are required and desirable before starting the calculation:

i. A layout of the site
ii. Maximum earth fault current into the earthing grid
iii. Maximum fault clearing time
iv. Ambient (or soil) temperature at the site.
v. Soil resistivity measurements at the site (for touch and step only)
vi. Resistivity of any surface layers intended to be laid (for touch and step only)

- Earthing Grid Conductor Sizing Analysis

To ensure that the earthing grid can withstand the maximum earth fault current, it is necessary to determine the minimum size of the earthing grid's conductors. An adiabatic short circuit causes a rise in temperature in the earthing grid conductors similar to what happens in a normal power cable when it fails. It's important to note that the temperature limit for earthing grid conductors is different from that of a normal cable because it would not permanently damage the insulation. Standard (Std) 80 of the IEEE specifies the minimum conductor size that can withstand an adiabatic temperature rise due to earth faults as follows:

Equation (3) represent minimum cross-sectional area, A (mm^2) given as:

$$A = \sqrt{i^2 t \left(\frac{\frac{a_T \rho_T \times 10^4}{TCAP}}{In\left[1+\left(\frac{T_m - T_a}{K_o + T_a}\right)\right]} \right)} \qquad (3)$$

Where A is the minimum cross-sectional area of the earthing grid conductor (mm^2)

$i^2 t$:is the energy of the maximum earth fault ($A^2 s$)

T_m:is the maximum allowable (fusing) temperature (^0C)

T_a:is the ambient temperature (^{0}C)
$\alpha_{T:}$ is the thermal of resistivity (0C^{-1})
$\rho_{T:}$ is the resistivity of the earthing conductor (μΩ. cm)
K_0: is a constant denoted by$\left(\frac{1}{\alpha_T} - 20^0C\right)$

TCAP: Is the thermal capacity of the conductor per unit volume (Jcm^{3}$^{\circ}$C^{-1})

The material constants $T_{m,}\alpha_{r,}\rho_T$ and T_{CAP} for common conductor materials can be found in IEEE Std 80 Table 1. For example, commercial hard-drawn copper has material constants:

i. $T_{m,}$ = 1084 ^{0}C
ii. $\alpha_{r,}$ = 0.00381 ^{0}C
iii. ρ_T= 1.78 μΩ. cm
iv. TCAP = 3.42Jcm^{3}$^{\circ}$C^{-1}

- Touch and Step Potential Calculations

Earthing grid conductors must be at least a certain size to ensure that they can withstand a maximum earth fault current. Similarly, to when a normal power cable fails, an adiabatic short circuit causes a rise in temperature in earthing grid conductors. Note that the earthing grid conductors' temperature limit differs from that of a normal cable because the insulation will not be permanently damaged. This is the minimum conductor size specified in IEEE Standard (Std) 80 for earth faults, and it's as follows:

- Touch voltages:

There is a dangerous potential difference between the earth and a metallic object that a person is touching

- Step voltages:

There is a dangerous voltage gradient between the feet of a person standing on earth. The earthing grid can be used to dissipate fault currents to remote earth and reduce the voltage gradients in the earth. The touch and step potential calculations are performed in order to assess whether the earthing grid can dissipate the fault currents so that dangerous touch and step voltages cannot exist.

- Safe Earthing System Criteria Analysis

When the mesh and step are calculated then compared them respectively, to the maximum tolerable touch and step voltage conditions as:

$$E_m < E_{touch}$$
$$E_s < E_{step}$$

Then the earthing grid design is safe, otherwise we repeat the processes and effect a redesign of the earthing grid analysis in order to:

i. To lower the grid resistance that redesigns the earth grid that is adding more grid conductors, more earthing electrodes increase the cross-sectional area of the conductor.
ii. To limit the total earth fault current.
iii. To consider soil treatments to lower the resistivity of the soil.
iv. Greater use of high resistivity surface layer materials.

- Ground Potential Rise (GPR)

Normal thinking assumes there is no difference between the nearby earth and the distant earth (i.e. they are at the same potential). Local potential gradients are created by the earth's current flow and earth faults (where the fault current flows back through remote earth). The greatest potential difference between a location and the distant earth is the rise in ground potential (GPR). Because this is a maximum potential difference, it's critical to keep in mind that earth potentials near the fault will fluctuate.

The maximum GPR is calculated as:

$$\mathrm{GPR} = I_G R_g \qquad (3.22)$$

Where GPR: is the maximum ground potential rise (V)
I_G: is the maximum grid current found earlier in Step 4 (A)
R_g: is the earthing grid resistance found earlier in Step 3 (Ω)

- Earthing Grid Design Verification

This earthing grid design is safe for both touch and step potential, so we must now verify that. The grid design consideration is safe for effective operation if the maximum GPR calculated above does not exceed the touch or step voltage limits (from Step 5).

There will be some additional analysis needed to verify whether the design condition for the calculation of maximum mesh and step voltages as per IEEE Std 80 Section 16.5 is met if it does exceed the touch and step voltage limits.

- Mesh Voltage Calculation Analysis

The mesh voltage is the maximum touch voltage within a mesh of an earthing grid and is derived from IEEE Std 80 Equation 80 as given as:

$$E_m = \frac{\rho_s K_m K_i I_G}{L_m} \quad (3.23)$$

Where:

ρ_s: is the soil resistivity (Ω.m)

I_G: is the maximum grid current found earlier in Step 4 (A)

K_m: is the geometric spacing factor

K_i: is the irregularity factor

L_m: is the effective buried length of the grid

The geometric spacing factor K_m is calculated from IEEE Std 80 of Equation 81 given as:

$$K_m = \frac{1}{2\pi}\left(\left[\text{In}\left(\frac{D^2}{16h \times d}\right) + \frac{(D+2h)^2}{8D\times d} - \frac{h}{4d}\right] + \frac{K_i}{K_h}\text{In}\left[\frac{8}{\pi(2n-1)}\right]\right) \quad (3.24)$$

Where:

D: is the spacing between parallel grid conductors (m).

H: the depth of buried grid conductors (m)

d: is the cross-sectional diameter of a grid conductors (m)

K_h: is a weighting factor for depth of burial which gives as:

$$K_h = \sqrt{1+n} \quad (3.25)$$

K_{ii}: is a weighting factor for earth electrodes/rods on the corner mesh

i. $K_{ii} = 1$ for grids with earth electrodes along the grid perimeter or corners
ii. $K_{ii} = \frac{1}{2n^{n/2}}$ for grids with no earth electrodes on the corners or on the perimeter

n is a geometric factor.

The geometric factor n is calculated from IEEE Std 80 of Equation 85 given as:

$$n = n_a \times n_b \times n_c \times n_d \quad (3.26)$$

$$n_a = \frac{2L_c}{L_p} \quad (3.27)$$

Where:

$$\left.\begin{aligned} n_b &= 1, \text{for square grids otherwise, } n_b = \sqrt{\frac{L_p}{4\sqrt{A}}} \\ n_c &= 1, \text{for square and rectangular grids otherwise, } n_c = \left[\frac{L_x L_y}{A}\right]^{\frac{0.7A}{L_x L_y}} \\ n_d &= 1, \text{for square, rectangular and L} - \text{shaped gridsother, } n_d = \frac{D_m}{\sqrt{L_x^2 + L_y^2}} \end{aligned}\right\} \quad 3.28$$

Where:

L_c: is the total length of horizontal grid conductors (m)

L_p: is the length of grid conductors on the perimeter (m)

A: is the total area of the grid (m^2)

L_x: and L_y are the maximum length of the grids in the x and y directions (m)

D_m: is the maximum distance between any two points on the grid (m)

The irregularity factor K_1 is calculated from IEEE Std 80 of Equation 89 is given as:

$$K_1 = 0.656 + 0.172n \quad (3.29)$$

When n is the geometric factor as considered in equation (3.25)

The effective buried length L_M can also be obtained.

For a grids with few or no earthing electrodes (and none on corners or along the perimeter) is given as:

$$L_m = L_c + L_R \quad 3.30$$

Where:

L_c: is the total length of horizontal grid conductors (m)

L_R: is the total length of earthing electrodes/rods (m)

- For grids with earthing electrodes on the corners and along the perimeter:

$$L_m = L_c + \left[1.55 + 1.22\left(\frac{L_r}{\sqrt{L_x^2 + L_y^2}}\right)\right] L_R \quad 3.31$$

Where:

L_c: is the total length of horizontal grid conductors (m)

L_R: is the total length of earthing electrodes/rods (m)

L_r: is the length of each earthing electrode/rod (m)

L_x: and L_y are the maximum length of the grids in the x and y directions (m)

- Step Voltage Calculation Analysis

The maximum allowable step voltage is calculated from IEEE Std 80 of Equation 92 given as:

$$E_s = \frac{\rho_s K_s K_i I_g}{L_s} \quad 3.32$$

Where:

ρ_s: is the soil resistivity (Ω.m)

I_g: is the maximum grid current found earlier in Step 4 A

K_s: is the geometric spacing factor

K_i: is the irregularity factor (as derived above in the mesh voltage calculation)
L_s: is the effective buried length of the grid
The geometric spacing factor K_s is based on IEEE Std 80 of Equation 81 is applicable for buried depths between 0.25m and 2.5m as:

$$K_s = \frac{1}{\pi}\left[\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D}(1 - 0.5^{n-2})\right] \qquad (3.33)$$

Where D is the spacing between parallel grid conductors (m)
h: is the depth of buried grid conductors (m)
n: is a geometric factor (as derived above in the mesh voltage calculation)
The effective buried length Ls for all cases can be calculated by IEEE Std 80 of Equation 93 given as:

$$L_s = 0.75L_c + 0.85L_R \qquad (3.34)$$

Where:
L_c: is the total length of horizontal grid conductors (m)
L_R: is the total length of earthing electrodes/rods (m)
Now that the mesh and step voltages are calculated, compare them to the maximum tolerable touch and step voltages respectively.

Step – Voltage;
E step = (1000+6ρ_s) 0.116/$\sqrt{t}$ Volts (5)

- Touch Voltage Analysis

E touch = (RB + O.5 R_F) I_B = (1000 + 1.5ρ_s) 0.116/ $\sqrt{t}$ (6)

- Test for Validity Check 1

Since, the length in the preliminary value of "Lp" design parameter is more than the conductor – length required ('L conductor') for purpose of control of gradient. Then the design is 'safe' from the consideration of mesh – potential (Em).

- Determination of step potential that is tolerable

Tolerable, E step $= (1000 + 6\,\rho_{ss})0.116\sqrt{t}$ volts
Where;
$\rho_{ss} = 3000 \quad \Omega - \text{m}, t_c = 0.5$
Hence,
E step = $(1000 + 6\ X\ 3000)\text{x}\frac{0.116}{\sqrt{0.5}} = 3117$ V
Estep, potential tolerable
Similarly

$$K_s = \frac{1}{\pi}\left[\frac{1}{2h} + \frac{1}{D+h} + \frac{1}{D}\ (1 - 0.5^{n-2})\right]$$

Where: $\pi = 3.142,\ \ h = 0.5,\ D = 5.25,\ n = 10$
Hence;

$$K_s = {}^1\!/_{3.142}\left[\left(\frac{1}{2\text{x}0.5} + \frac{1}{5.25 + 0.5} + \frac{1}{5.25}(1 - 0.5^8)\right]\right.$$

$K_s = 0.434$
Similarly
E step Potential $=\rho_s K_s K_{i\frac{I}{L}}$ $volts$
Actual
Where; $\rho_s = 55, km = 0.856, Ki = 2.376, I - 5000A,\ L = 647.5m$ which is preliminary design length for grid control.
Hence;
E step potential $= 55 \text{ x } 0.434 \text{ x } 2.376 \text{ x } 5000/647.5 = 437.95V$
(Actual)
Similarly,
E step potential (Tolerable) = $3{,}117V$

- Test for Validity Check 2

Since; E step potential tolerable is greater than E step potential Actual then, grid design is safe from the consideration of step potential point of view analysis.
But from the relationship
Tolerable E touch $= (1000 + 1.5\rho_{ss})\text{x}\,0.116/\sqrt{0.5} = 902V$
Hence,
Tolerable touch, $= (1000 + 1.5 \text{ x } 3000)\text{x}\,0.116/\sqrt{0.5} = 902V$
Determination of E_{touch} Actual equation is given as;
E touch = $\rho_s k_m k_i I / L$
Substituting, we have as:

$$= 55 \times \frac{0.856 \times 2.366 \times 5000}{647.5} = 860.2 volts$$

Since E_{touch} potential tolerable > E_{touch} potential actual PR
The design is safe from the consideration of touch potential point of view.

- Determination of GPR Evaluation

GPR = $I_G R_G = 5000\ \times\ 0.703$
GPR = $3515V$
Since GPR is very high, it is therefore necessary to guard personnel and communication equipment

against transferred potential problems at substation. This mean that the addition of some ground rod distributed over the grid area will increase the safety margin.

- Test for Consideration Check

If the GPR is less than tolerable mesh – voltage, it is considered as a SAFE – DESIGN.
That's, if
GPR < E mesh voltage tolerable safe condition
It is considered and declared safe (safe design)
GPR $= I_G R_G$

3.18.10 Initial Parameters Data Collected from Study Case: Trans-Amadi transmission substation 132/33KV

Table 1: The Distance and the Earth Resistance Values of Pit 1

S/No	Distance (M)	Resistance (Ω)
1	4	1.17
2	8	1.24
3	12	1.39
4	16	1.40
Actual Earth Resistance for Pit 1		1.17

Source: Research desk, study area

Table 2: The Distance and the Earth Resistance Values of Pit 2

S/No	Distance (M)	Resistance (Ω)
1	4	1.21
2	8	0.57
3	12	0.64
4	16	0.70
Actual Earth Resistance for Pit 2		0.57

Source: Research desk, study area

Table 3: The Distance and the Earth Resistance Values of Pit 3

S/No	Distance (M)	Resistance (Ω)
1	4	1.25
2	8	1.29
3	12	1.41
4	16	1.50
Actual Earth Resistance for Pit 3		1.25

Source: Research desk, study area

Table 4: The Distance and the Earth Resistance Values of Pit 4

S/No	Distance (M)	Resistance (Ω)
1	4	0.69
2	8	0.45
3	12	0.34
4	16	0.28
Actual Earth Resistance for Pit 4		0.34

Source: Research desk, study area

Table 5: The Distance and the Earth Resistance Rating of Pit 5

S/No	Distance (M)	Resistance (Ω)
1	4	4.49
2	8	3.22
3	12	2.73
4	16	2.50
Actual Earth Resistance for Pit 5		2.73

Source: Research desk, study area

Table 6: The Distance and the Earth Resistance Rating of Pit 6

S/No	Distance (M)	Resistance (Ω)
1	4	0.24
2	8	0.55
3	12	0.72
4	16	0.80
Actual Earth Resistance for Pit 6		0.24

Source: Research desk, study area

Table 7: The Earth Resistance Rating of each Pit 7

S/No	Earth Resistance for Each Pit	Resistance (Ω)
1	1	1.17
2	2	0.57
3	3	1.25
4	4	0.34
5	5	2.73
6	6	0.24
7	7	0.42
Actual Earth Resistance for Pit 7		0.24

Source: Research desk, study area

Initial Design of 330KV Trans-Amadi transmission substantial (OHL) grounding case study parameters are given as:
Slope Coefficient, U = 0.55
Potential Probe Distance, DPT = 10.97M
Actual Resistance, R = 0.59Ω
75MVA 330/132KV Transformer = 0.20Ω
Lightning Arresters = 0.20Ω
Line Gantry = 0.20Ω
300KVA 33/0.415KV Earthing Transformer - 0.20Ω
Transformer Body = 0.43Ω

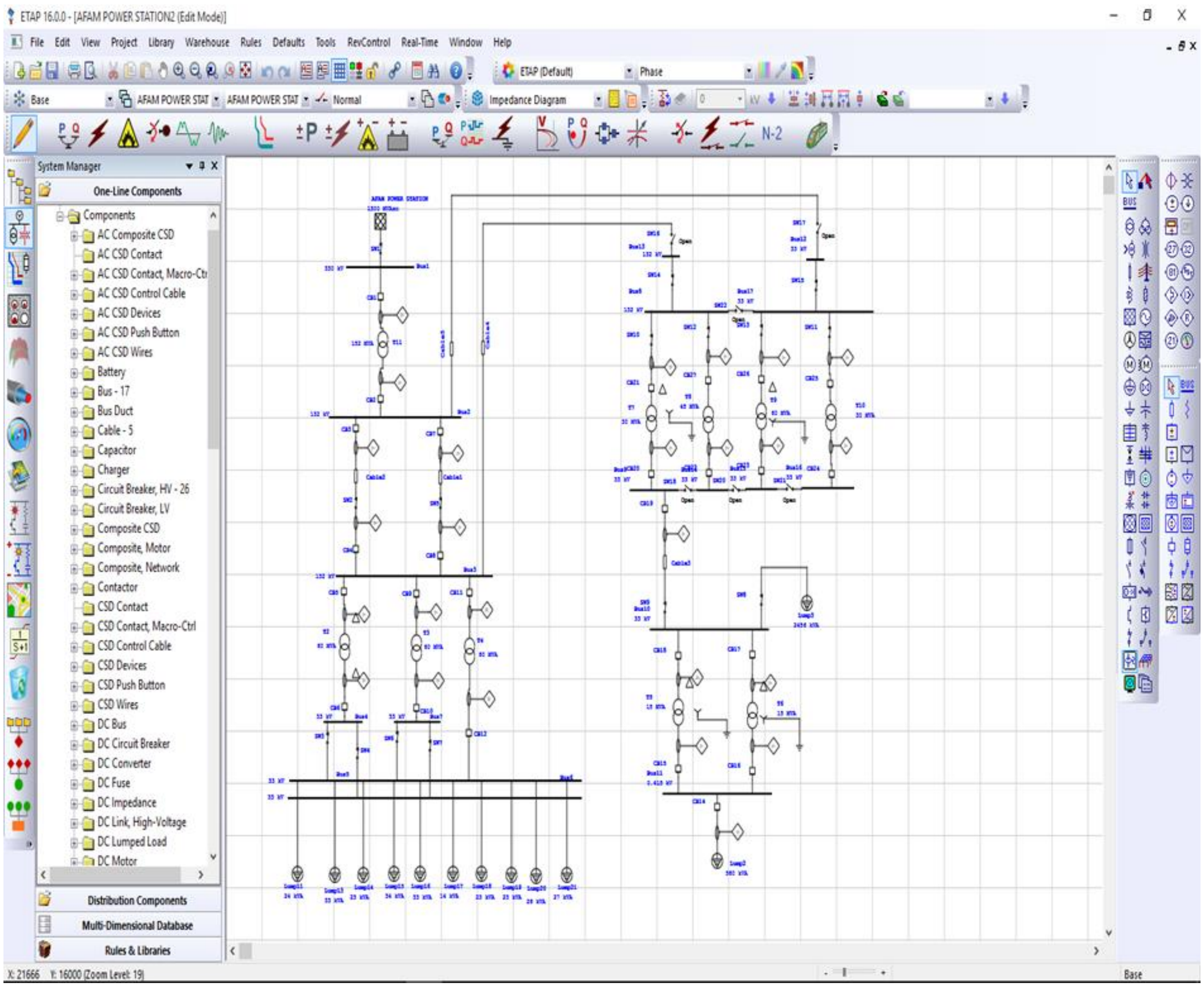

Figure4: Existing network from Afam power station to Port Harcourt Mains Zone-2 (132/33KV), without simulation

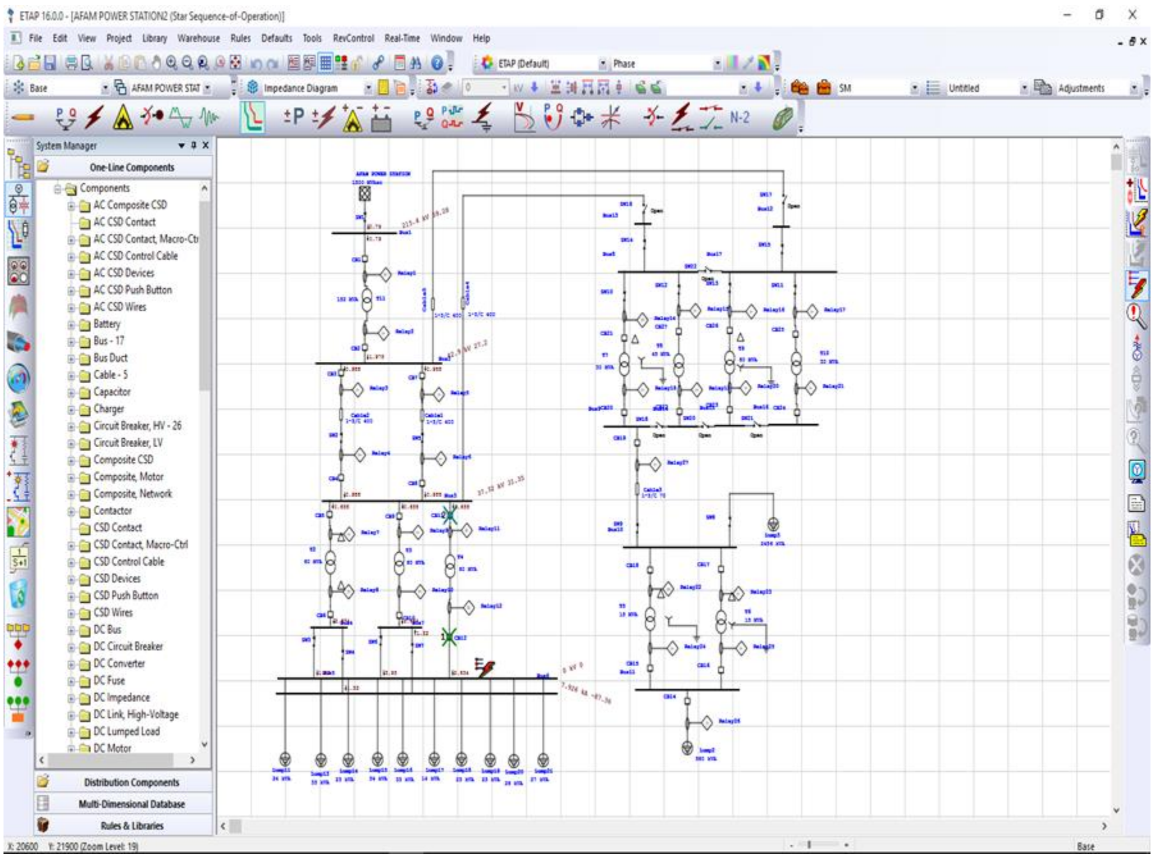

Figure 5: Existing Network from Afam power Station to Port Harcourt Mains Zone 2 (132/33kV), (with Simulation)

III. RESULTS AND DISCUSSION

- Simulation Results for Soil Earthing Condition and Investigation

Transformers at an electrical substation, which is part of an electricity generation, transmission, and distribution system, convert high voltage to consumer voltage. Substations include generating, transmission, distribution, and switching yard substations, which are used for voltage conversions, transmission line connections, control center monitoring, and power line/apparatus protection, as well as switch yards for network design.

Detecting lighting surges on transmission substation facilities/equipment is a sign that the earthing system is adequate for a safe and dependable electricity supply. Because of the incidence of lighting strike on substation equipment/facilities, it is better to determine system security safety for touch and step potential, particularly for the study case (Trans-Amadi, Zone-2 Port Harcourt main), The maximum ground potential rise (GPR) numerical value must be compared to other touch and step potential limit parameters. If the calculated maximum GPR exceeds the earthing variables of touch and step potentials limits, the condition is declared, it is claimed that the soil earthing condition of the grid design is dangerous for the utility of the transmission substation of 132/33KV Port Harcourt main. It is running in a safe condition if the maximum GPR calculated is less than the soil variable of touch and step voltage.

More research is needed to validate the design scenario and ensure the sufficiency of an effective earthing system for a stable electric power supply free of lighting surges. Obviously, if the greatest ground potential rise (GPR) does not exceed the established touch and step potentials limits, the earthing condition of the soil parameters is regarded as suitable for the interactions of lighting surges without causing damage to transmission substation facilities/equipment. As a result, the verification tool for mesh-potential and step voltage earthing design in accordance with IEEE std

80, section 16.5 of the standards code of practice as it applied to an effective earthing design.

The numerical values of mesh potential step and touch voltage must be compared to the maximum permitted touch and step potential after they have been obtained. That is, the mesh potential is the greatest value of the touch potential within the substation yard, but the maximum touch voltage within a mesh of the grounding grid must be determined in order to verify and certify any breaches under this research.

- Presentations of Simulated Graphs for Soil Earthing Conditions and Investigation

The soil existing data for the study case were collected and implemented into standard equations (in line with standard equations of IEEE std 80, section 16.5) for the purpose of verification of existing earthing soil conditions, which are presented in figure 1, 2 and 3

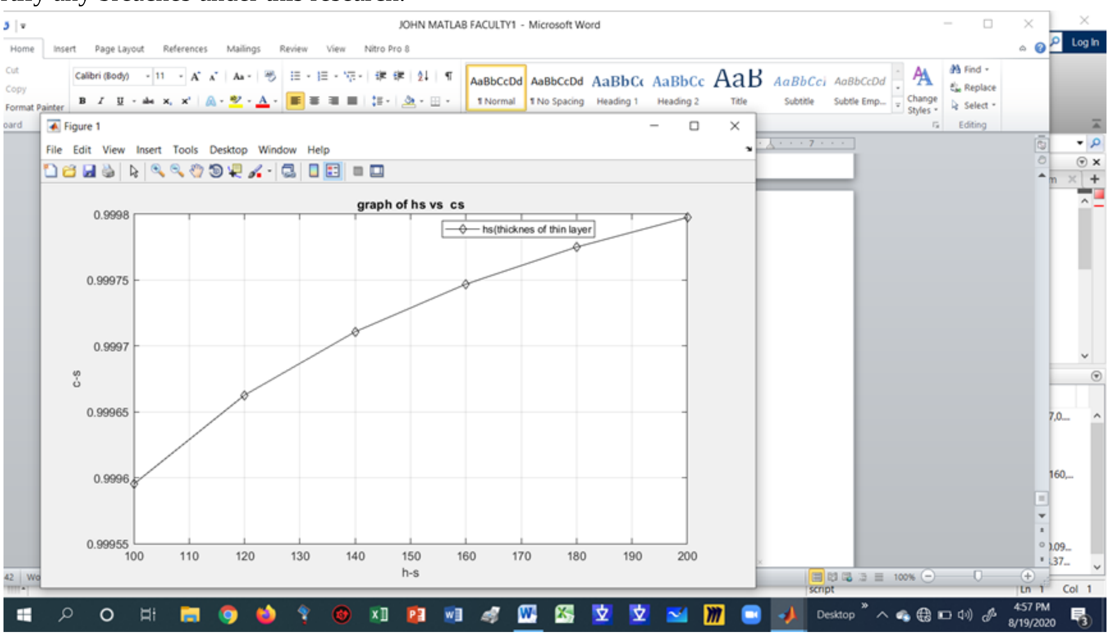

Figure 1: Shows the plot of surface layer derating –factor (Cs) and thickness (h-s) of the surface layer (mm)

In figure 1, the rate of change in Cs (surface derating factor), which is related to the varied quantity of surface layer material resistivity (h-s) due to lighting surges incidence on the transmission substation under examination, exhibits an exponential increasing down behavior. The exponential growth is due to the penetration of lighting surges on transmission station as a result of poor earthing state of the soil derating factor (Cs) by virtue of the rapid rate of the changing variable of resistivity of surface layer materials (h-s). The soil design parameters and substation data were reviewed for different values of resistively of surface layer material (h-s) which suggest better earthing condition that can interacts with incidence of lighting surges, which are presented.

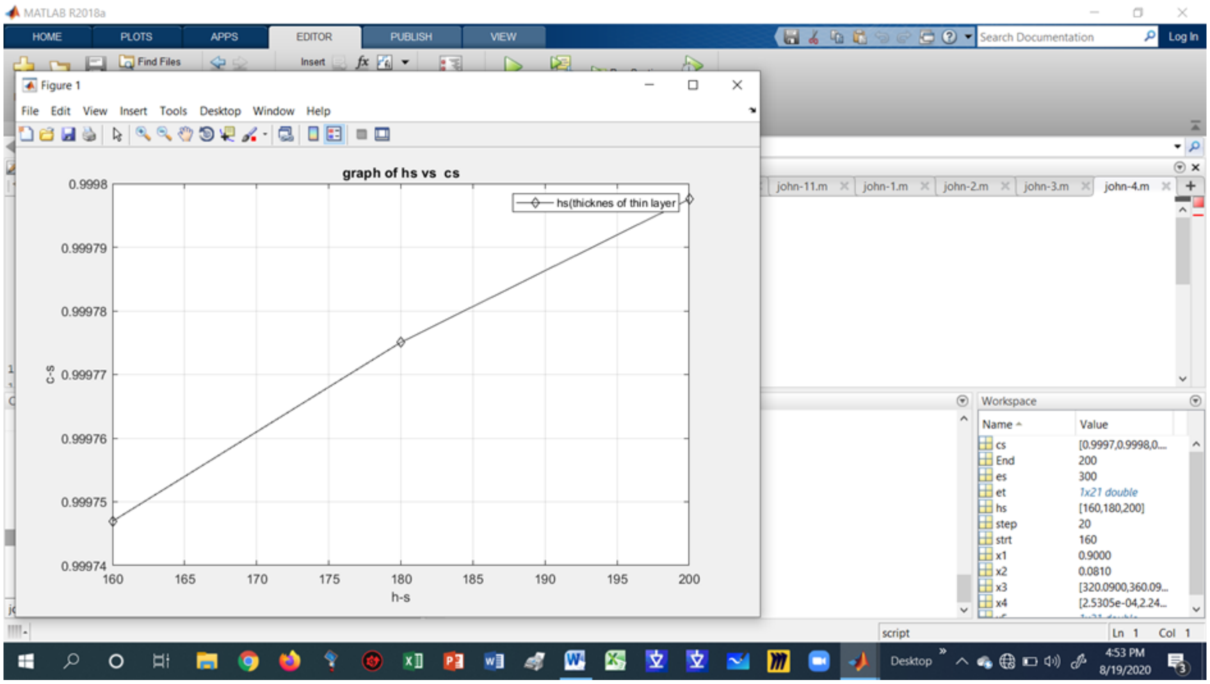

Figure 2: Shows the improved earthing condition for an incidence lightning surges on station.

The graph presentation of the surface derating factor (c_s) and thickness of surface layer materials (hs) presented. In figure 2 shows improved condition of the soil earthing state in the case of incidence of lightening surges or any form of faults occurrence on the transmission facilities and equipments by increasing the thickness of surface layer materials (h-s) for better resistivity (Ωm) from the existing data of (60mm, 1200Ωm) to (100mm, 4500Ωm). The graph demonstrates an exponential transient lighting surges to linear behavior for improved earthing conditions, with the purpose of maintaining a known voltage level at any portion of an electrical system to prevent overcurrent or excessive voltage on appliances or equipment. The physical composition of the soil, moisture, dissolved salts, particle size and distribution, seasonal change, current amplitude, and other factors all affect the earth resistance value.

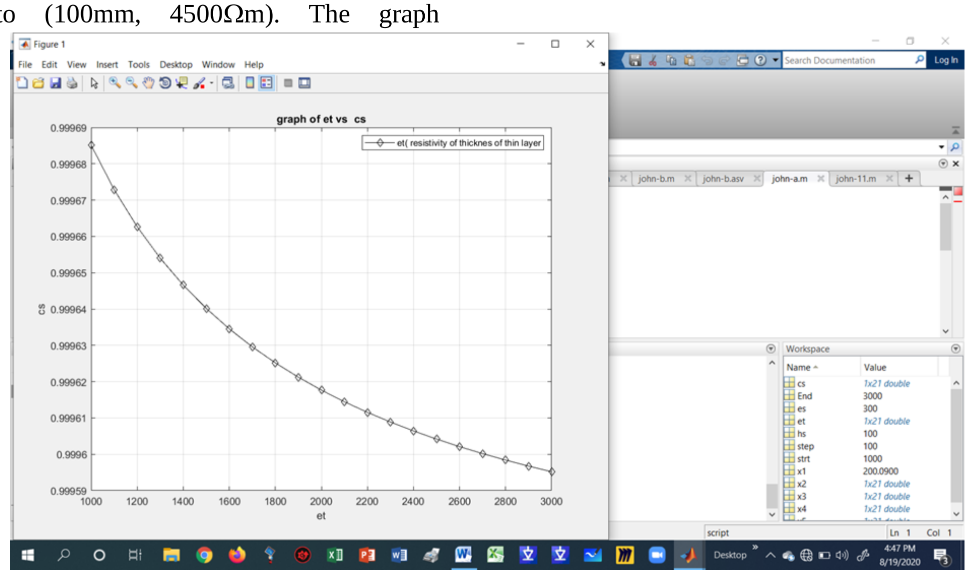

Figure 4: Shows the exponential decreasing down of surface layer (c_s) derating factor and thickness of surface layer materials (h_s)

Finally, the interactions between the surface derating factor (cs) and the surface layer materials' resistivity were simulated, and the lighting surge (or any other type of fault occurrence in the system) was represented by increasing the thickness of the surface layer materials over the ground surface with high resistivity property materials such as gravel, crush rock, and so on. This is because the surface layer elements increase the resistance of the soil to contact with a person's feet when they tread on it. As a result, the magnitudes of current flow and the impact of hazardous contact and step voltage are minimized in the event of a lightning strike (natural phenomenon).

In order to reduce ground potential rise (GPR) and thus avoid dangerous touch and step voltages, an appropriate earthing grid should have low resistance and a strong affinity for interactions with lightning surges and any type of fault occurrence, with regard to remote earth. The resistance of the earthing grid is determined by the design of the earthing grid. Because the layer is not thick enough to provide constant resistance in all directions, the effective resistance of a person's feet in relation to the earth when standing on a surface layer is not the same as the surface layer resistance. As a result, the surface layer derating factor (Cs) must be used to evaluate the current status of the transmission substation earthing condition in order to compute the effective foot resistance to earth with varying thicknesses of surface layer materials (hs).

In terms of the surface derating factor (Cs), the study case's current soil condition is poor, falling between 0.3 and 0.4. Essentially, knowing the surface derating factors (Cs) that influence the qualities of soil resistivity, the surface layer's resistivity must be sufficient to withstand.

CONCLUSION

The reliability of electric power supply from one level to another required efficient protection of power system equipment to the consumers. This means that continuous improvement of lighting performance can be considered very important in order to avoid huge equipment failures and damage during lightning strike, results into financial losses to the transmission companies etc. Since the power system facilities are exposed to lightning incidence surges this variability necessitate strong attention to the vast varieties of faults scenario which is a major target to the lightning strike. This research work is targeted to collect numerical data (lightning strike incidence history), the existing soil-earthing parameters for lightning surge protection were analyzed for improvement from (60mm, 2,500m) to (100mm, 4500m) in terms of surface layer thickness and thin layer resistivity in order to have a better soil derating factor to match the interactions of lightning strike occurrence in the event of thunderstorm or any faults occurrence. In an electrical transient analyzer, the research case was modeled (ETAP) and MATLAB simulations application tool that described and shows the exponential transient behavior due to lightning strike in the study case under investigation in the event of faults occurrence which were clamped down to the desired linear description of the simulated results which indicate improved earthing state for lightning strike in accordance with the IEEE std, 80 section 16.5 of the code of practice which define the provision of adequate of earthing design considerations

REFERENCES

[1] Choi, J. K., Ahn, Y. H., Woo, J. W., Jung, G. J., Han, B. S., & Kim, K. C. (2005). Evaluation of Grounding Performance of Energized Substation by Ground Current Measurement. International Conference on Power Systems Transients (IPST'05) In Montreal, Canada on June 19-23, 2005, Paper No. IPST05 - 128.

[2] IEEE Standard 142-2007: Recommended Practice for Grounding of Industrial and commercial power systems. Chapter 4 page 164.

[3] Lukong, P. N. (2014). Biochar Production and Analysis for Soil Enhancement and Climate Change Mitigation. M. Eng. Thesis. University of Maroua: Cameroon.

[4] Lukong, P. N., Noel, D., Lendzemo, W. V. & Fagbenro, J. A. (2015). An efficient method for electrical earth resistance reduction using biochar. *International Journal of Energy and power Engineering.* Science Publishing Group.

[5] Siow, C. L., Chandi, G. & Mohd, Z. A. (2013). Electrical earthing in troubled environment. *Elsevier,* pp 118.