Voltages Transient Analysis in Electric Grounding Systems

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Abstract. This paper discusses the problem of voltages transient analysis in electric grounding systems if there is a high voltage fault. With the help of the finite element theorem, the segments of the grounding systems are buried in the earth are examined, and the parameters are calculated. By using the traveling wave theory, it can be determined that the replacement circuit of the grounding rod segments, then by analyzing the electrical circuit, the voltage transient at each finite node can be calculated at the time of the fault, where the magnitude voltage transient of the fault must be known. The above method can be applied to determine the voltages transient analysis in electric grounding systems for both the rod grounding system and the grid grounding system. This voltages transient analysis in electric grounding systems is analyzed for equipment security and personal safety.

1. INTRODUCTION

1.1 Background
Analysis of the voltages transient analysis in electric grounding systems from the grounding of the electric power system when there is a high voltage fault due to the switching process[1], the lightning crash is very important to be known in the effort to protect electrical installations. An important aspect of the construction of electric power installation equipment such as substations [2] in the electricity sector is the security aspect of a person who will later work around the equipment and aspects of the continuous flow of electric power.

1.2 Formulations
In this study, the researchers limited themselves only to research the voltages transient analysis in electric grounding systems [3], [4] on the electric grounding system when high voltage fault occurs due to the switching process, lightning crash related to the security aspect [5], [6] of personal, where they will work around the equipment and the safety aspects of the equipment for the continuation of electricity flow [7],[8].

1.3 Identification
Identification of problems in the analysis of the switching voltage on the electric grounding system include:
• rod grounding,
• grid grounding,
• soil type prisoners,
d. maximum lightning current when lightning crash on electric power equipment, lightning crash models include the step function, the lightning function, and the switching function,

f. finite element mathematical models,

g. solving linear equations with inverse matrices,
h. analysis of voltage transient at each node ground rod and grid ground buried.

1.4 Research Objectives and Authenticity
The target of this reset is to get the results of voltages transient analysis in electric grounding systems during fault with using simulation in the form of a step function, lightning function, and switching function.

1.5 Research Uses
The usefulness of the research voltages transient analysis in electric grounding systems is expected to be useful for making basic contributions in the field of protection system science in supporting the development of science and technology. In this study, we limit ourselves only to the analysis of voltages transient analysis in electric grounding systems on the power electrical system. Expectations from the results of this research could contribute to the electrical protection system. Activity description: the activity description is shown in Figure 1. to Figure 5., where the analysis voltages transient analysis in electric grounding systems is an important part of the electric protection system.

2. RESEARCH METHOD
Fig. 4 is an illustration of this research method, where measurement data is needed which is then calculated the value of the voltage transient with the linear equation [9], inverse matrix and voltage graph of the function of time during the transient. For this reason, the researcher tries to make a research method in the form of flowcharts analyzing the switching voltage on the electric grounding system as follows[10], [11] The research method used is the completion of the electrical circuit [12], [13], [14] grounding system with finite element method and analyzing the voltages transient analysis in electric grounding systems on the power electrical system during fault in the form of using the maximum lightning crash current in Indonesia and by using the lightning crash equation in the form of the step function, lightning function and switching function [15].

![Grounding rod](image1)

**Figure 1.** Grounding rod

![Equivalence circuit](image2)

**Figure 2.** Equivalence circuit Grounding

![Equivalent circuit](image3)
From Figure 3. For the earth rod the admittance matrix is obtained:

\[
\begin{align*}
Y_{i,j} & \neq 0 \\
Y_{i,j+1} & \neq 0 \\
Y_{i+1,j} & \neq 0 \\
\text{other} & = 0
\end{align*}
\]

for \( i = \text{integer} \)

\[Y.V(t) = i(t) + b(t-h)\]

\(Y\) is the admittance, \(U\) (\(t\)), i.e. the voltage, \(i\) (\(t\)) current and \(b\) (\(t-h\)) the previous current.

Rod grounding substation system, \(\rho = 11.78 \, \Omega \cdot m\), segment \(n = 10, l = 6m / \text{stem}\), \(i_{\text{max}} = 34kA\), step, lightning \(1.2 / 50 \, \mu s\), switching \(350/2500 \, \mu s\) as table 1.

| No. | \(Y_{1,1}\) [\(\Omega\)] | \(Y_{n,n}\) [\(\Omega\)] | \(Y_{i,j+1}\) [\(\Omega\)] | \(Y_{i+1,j}\) [\(\Omega\)] | \(Y_{ij}\) [\(\Omega\)] |
|-----|----------------|----------------|----------------|----------------|----------------|
| 1   | 0.3466515      | 0.3466515      | -0.1695675     | -0.1695675     | 0.5162189      |

From Figure 5. For earthen weaving, an admittance matrix is obtained:

\[
\begin{align*}
Y_{i,j} & \neq 0 \\
Y_{i,j+1} & \neq 0 \\
Y_{i,j+7} & \neq 0 \\
Y_{i+1,j} & \neq 0 \\
Y_{i+7,j} & \neq 0 \\
\text{other} & = 0
\end{align*}
\]

for \( i = \text{integer} \)

\[Y.V(t) = i(t) + b(t-h)\]

\[
\begin{bmatrix}
Y_{1,1} & \cdots & Y_{1,7} \\
\vdots & \ddots & \vdots \\
Y_{7,1} & \cdots & Y_{7,7}
\end{bmatrix}
\begin{bmatrix}
V_1 \\
\vdots \\
V_7
\end{bmatrix}
= \begin{bmatrix}
V_1 \\
\vdots \\
V_7
\end{bmatrix} + \begin{bmatrix}
i_1 \\
\vdots \\
i_7
\end{bmatrix}
+ \begin{bmatrix}
b_1 \\
\vdots \\
b_7
\end{bmatrix}
\]

\(Y\) is the admittance, \(U\) (\(t\)), i.e. the voltage, \(i\) (\(t\)) current and \(b\) (\(t-h\)) the previous current.

Grid grounding substation system, \(\rho = 11.78 \, \Omega \cdot m\), segment \(nxn = 49, l = 20 \, m / \text{wicker rod}\), \(i_{\text{max}} = 34kA\), step, lightning \(1.2 / 50 \, \mu s\), switching \(350/2500 \, \mu s\) as table 2.
Table 2. Admittance grid $\rho = 11.78 \, \Omega\cdot m$, $nxn = 7 \times 7 = 49$, $l = 20 \, \text{m} / \text{rod of grid}$, $i = 2, \ldots, n-1$, $j = 2, \ldots, n-1$, other $Y_{i,j}$ is zero $\Omega$

| No. | $Y_{1,1}$ [$\Omega$] | $Y_{n,n}$ [$\Omega$] | $Y_{i+1,i}$ [$\Omega$] | $Y_{i+7,i}$ [$\Omega$] | $Y_{i,j+1}$ [$\Omega$] | $Y_{i,j+7}$ [$\Omega$] | $Y_{i,j}$ [$\Omega$] |
|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 1   | 1.4689566      | 1.4689566      | -0.4874932     | -0.4874932     | -0.4874932     | -0.4874932     | 1.9564498      |

3. RESULTS AND DISCUSSION

3.1 Results

The results obtained are in the form of switching voltage data and switching voltage statistics on the electric grounding system during interruption of step, lightning, and switching. Here are the results of the calculation of lightning strikes at the substation system of the grounding rod, $\rho = 11.78 \, \Omega\cdot m$, segment $n = 10$, $l = 6 \, \text{m} / \text{rod}$, $I_{\text{max}} = 34\, \text{kA}$, step function, lightning function $1.2 / 50 \, \mu\text{s}$, switching function $350/2500 \, \mu\text{s}$.

Furthermore, the results of the calculation of lightning crash on the substation of the grid earthing system, $\rho = 11.78 \, \Omega\cdot m$, segment $n = 49$, $l= 20 \, \text{m grid}$, $I_{\text{max}} = 34\, \text{kA}$, step function, lightning function $1.2 / 50 \, \mu\text{s}$, switching function $350/2500 \, \mu\text{s}$ as figure 7.

![Figure 7](image_url)

**Figure 7.** The calculation results

3.2 Discussion

In building a substation, there are two main things we must to be attending, including:

a. equipment security from the influence of natural phenomena, such as lightning crash and switching system.

b. security for personal own. If both conditions have not yet enough. To fulfill the two conditions above, a grounding system is needed. If the grounding system requirements from the results of field measurements have not yet met the minimum requirements that must be added, that is the grounding system must be added either in combination with a rod and grid buried grounding system or vice versa.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions
The electric grounding system is a necessity in the construction of substations. For this reason, there are two main things that we must be attended to, including:

a. equipment security from the influence of natural phenomena, such as lightning crash and switching system.
b. security for personal own.

4.2 Suggestions
In planning the construction of substations, the requirements must be prepared, namely for overvoltage protection and personal safety must be calculated by the conditions specified IEEE or the standards of each country.

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