Analysis on Behavior Grounding Electrode Resistance base on Profiling Method

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Abstract. An earthing system or known as grounding system in an electrical installation where by the grounding system connects specific parts of that installation with the Earth's conductive surface for safety and functional purposes. It is the process of transferring the immediate discharge with the aid of the low resistance wire of the electrical energy directly to the earth. It is really an important role playing in electrical system part as grounding system give protection during fault or lightning occur. In addition, grounding system also give protection for human electrical appliance and building from electrical shocks due to electrical fault or lighting occur. In this research will shows that to identify the best location to install the grounding electrode. This method is used on 10 x 10 meters which is 121 point will be investigated. The result of 0.3m, 0.6m, and 0.9m were analyzed using MATLAB software to produce profiling and shows the perfect location to install the Grounding system electrode.

1. Introduction

Grounding is a very important part for all electrical system either for small system or for big system since the electricity was discover a long time ago [1]. Nowadays, there are several type of materials for grounding electrode are used to distribute the heat transfer distribution to the ground. Normally in Malaysia, the type of materials for grounding electrode use are copper, galvanized steel, stainless steel or carbon graphite. The most favored material is copper because it has good conductivity and is corrosion resistance to many of salts exist in the soil [2]. The material of grounding electrode must be effective and efficient to propagate current to ground and the propagation current will be obstructed [3].

In addition, although the material is a very good conductor and applicable as grounding electrode the aging or the life expectancy of material become the major problem. Regardless of the material itself, the thicker coating would provide better corrosion protection, therefore the life expectancy of material is longer [4]. In order to analyze the performance of the grounding system the best technique in detecting the heat transfer distribution of grounding system is Finite Element Method which is give more accurate result compact to engineering formulas for the fast design of grounding system and applicable for large and complex grounding system [5].

There are lot of factors to consider when to determine which grounding system electrode is the best to provide effectiveness and safe electrical grounding. The ability of these electrodes to resists corrosion determine their useful service life. According to the Fire Protection Research Foundation established the National Electrical Grounding Research Project (NEGRP), 1995 to document the performance of grounding system electrode over time. The NEGRP evaluated the variation of grounding electrode earth
resistance at different geographic locations and explore the effects of several of the dominant variables over a period of 10 years. Other than that, the electrode used must have good properties in conducting the electricity to flow huge amount of currents with low resistance.

2. Methodology
Fall-of-Potential Method is used to determine the electrode resistivity. This method is commonly not suited to large grounding installations, as the stake partitions expected to guarantee a precise estimation can be extreme. The Fall of Potential method involves a check to make sure that the test electrode is place in the right position in the ground [6]. It is advisable that this check be carried, as it is really the only way of ensuring a correct result. For this experiment, it will have three different depths which is 0.3m, 0.6m, 0.9m to get the best depth for the electrode. The resistance of rod can be calculated by using the equation (1).

\[ R = \frac{\rho}{2\pi l} (\ln \left( \frac{hl}{d} \right) - 1) (\Omega) \]  \hspace{1cm} (1)

Where:
\( \rho \) = soil resistivity (\( \Omega \cdot m \))
\( l \) = length (m)
\( d \) = diameter (m)
\( R \) = resistance of a rod (\( \Omega \))

To undergo this research, the place around UniMAP which is near the UniMAP Mosque is used to measure soil and electrode resistivity. The reason why chooses this place because of open filed and it is near PPKSE block at UniMAP. Figure 1, 2, 3 and 4 shows the Fall-of-potential method arrangement, location of the research, marking point using raffia and topology of site measurement, respectively.

![Figure 1. Fall-of-Potential Method Arrangement.](image-url)
3. Results and Discussions
There is some comparison that has been made to compare soil resistivity in this area. It has three different depths which is 0.3m, 0.6m, and 0.9m, to get the best grounding point.
Table 1. Fall-of-Potential Method (0.3 Meter Depth).

| ROW | COLUMN (Ω) |
|-----|------------|
| -5  | 167.5      |
| -4  | 171.8      |
| -3  | 166.1      |
| -2  | 180.1      |
| -1  | 153.4      |
| 0   | 184.5      |
| 1   | 176.2      |
| 2   | 145.4      |
| 3   | 184.5      |
| 4   | 152.2      |
| 5   | 181.1      |

Figure 5. Three dimensional of profiling method (0.3 Meter Depth).

Figure 6. Isometric view of profiling method (0.3 Meter Depth).

The table 1 shows the Fall-of-Potential Method for 0.3 Meter depth. All the reading of the electrode resistivity for 0.3 m depth of the electrode is bury in the ground at all 121 point at the site using Fall-of-Potential Method. From the data of the table, the average reading of the electrode resistivity is 170.04 ohm has been determining. At the same time, the point with the maximum value of electrode resistivity
which is 199.3 ohm and the minimum value of electrode resistivity which is 141.2 ohm also has been determined. The figure 5 shows the three-dimension model of profiling that obtain by using MATLAB Software method. From the figure also, the pattern of the electrode resistivity at several point has been clearly shown. The red regions represent the lowest reading of electrode resistivity and the orange regions represent the highest reading of electrode resistivity. The next figure which is figure 6 shows the isometric view of the model, the figure clearly shows all the point that involve in this project. The several point in the red region are mean the best point to bury the electrode with 0.3 m depth in the ground using Fall-of-Potential Method.

| COLUMN (Ω) | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|------------|----|----|----|----|----|---|---|---|---|---|---|
| ROW        |    |    |    |    |    |   |   |   |   |   |   |
| -5         | 102.0 | 112.5 | 98.7 | 89.3 | 101.9 | 111.2 | 92.7 | 91.0 | 86.4 | 79.9 | 95.1 |
| -4         | 98.3 | 107.4 | 102.1 | 98.9 | 105.9 | 87.2 | 101.1 | 118.3 | 95.9 | 75.4 | 81.3 |
| -3         | 105.7 | 98.5 | 86.7 | 98.8 | 73.2 | 81.5 | 98.1 | 107.7 | 112.5 | 87.3 | 91.0 |
| -2         | 115.1 | 98.7 | 91.0 | 95.9 | 87.3 | 85.1 | 91.5 | 79.9 | 81.3 | 83.4 | 97.1 |
| -1         | 95.2 | 104.9 | 89.3 | 78.1 | 79.2 | 91.4 | 88.6 | 90.1 | 105.6 | 98.2 | 95.5 |
| 0          | 99.1 | 87.6 | 105.3 | 95.2 | 83.1 | 75.9 | 81.3 | 98.9 | 85.7 | 101.9 | 93.5 |
| 1          | 103.2 | 97.9 | 99.8 | 86.7 | 79.6 | 85.9 | 74.3 | 87.9 | 112.9 | 76.8 | 81.3 |
| 2          | 98.9 | 106.3 | 100.9 | 83.5 | 91.6 | 76.0 | 83.9 | 79.7 | 89.9 | 110.1 | 99.0 |
| 3          | 112.1 | 102.1 | 98.7 | 91.0 | 85.8 | 93.2 | 81.7 | 78.9 | 76.0 | 80.1 | 90.1 |
| 4          | 109.2 | 87.6 | 91.1 | 84.5 | 79.1 | 86.0 | 90.4 | 98.5 | 101.7 | 104.3 | 98.7 |
| 5          | 100.3 | 89.7 | 88.3 | 79.1 | 92.1 | 99.6 | 109.7 | 103.2 | 96.6 | 81.9 | 91.3 |

Table 2. Fall-of-Potential Method (0.6 Meter Depth).

Figure 7. Three dimensional of profiling method (0.6 Meter Depth).
Figure 8. Isometric view of profiling method (0.6 Meter Depth).

The table 2 shows the Fall-of-Potential Method for 0.3 Meter depth from the reference point at all 121 point at the site. From the data of the table 2, the average reading of the electrode resistivity is 93.07ohm has been determine. At the same time, the point with the maximum value of electrode resistivity which is 118.3 ohm and the minimum value of electrode resistivity which is 73.2 ohm also has been determine. The figure 7 shows the three-dimension model of profiling that obtain by using MATLAB Software method. From the figure also, the pattern of the electrode resistivity at several point has been clearly shown. The red regions represent the lowest reading of electrode resistivity and the orange regions represent the highest reading of electrode resistivity. The next figure which is figure 8 shows the isometric view of the model, the figure clearly shows all the point that involve in this project. The point in the red region are mean the best point to bury the electrode with 0.6 m depth in the ground using Fall-of-Potential Method.

Table 3. Fall-of-Potential Method (0.9 Meter Depth).

| COLUMN (Ω) | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|------------|----|----|----|----|----|---|---|---|---|---|---|
| -5         | 67.6 | 61.1 | 50.8 | 65.3 | 44.4 | 71.5 | 60.7 | 53.1 | 63.1 | 65.6 | 66.4 |
| -4         | 58.3 | 60.0 | 68.9 | 51.4 | 69.6 | 56.7 | 74.6 | 43.0 | 66.3 | 57.0 | 52.7 |
| -3         | 49.2 | 42.8 | 62.5 | 54.8 | 50.3 | 65.8 | 73.9 | 78.0 | 57.5 | 41.9 | 76.8 |
| -2         | 78.4 | 77.9 | 46.4 | 58.0 | 75.9 | 46.7 | 45.7 | 66.5 | 54.1 | 60.2 | 43.4 |
| -1         | 42.4 | 41.3 | 65.6 | 49.4 | 43.6 | 60.1 | 71.6 | 57.7 | 79.6 | 40.9 | 67.3 |
| 0          | 73.2 | 74.8 | 53.4 | 52.5 | 63.7 | 62.0 | 65.8 | 68.1 | 79.8 | 70.6 | 69.3 |
| 1          | 57.3 | 74.5 | 47.6 | 63.7 | 42.2 | 45.5 | 52.9 | 50.4 | 65.2 | 79.8 | 69.3 |
| 2          | 76.3 | 56.2 | 41.1 | 77.5 | 44.5 | 63.2 | 77.0 | 62.8 | 51.9 | 71.0 | 72.0 |
| 3          | 55.1 | 78.3 | 74.2 | 51.4 | 74.8 | 76.3 | 66.9 | 47.9 | 47.7 | 40.6 | 50.5 |
| 4          | 74.5 | 74.7 | 68.3 | 48.9 | 59.2 | 40.8 | 63.0 | 47.6 | 52.4 | 49.1 | 53.0 |
| 5          | 55.2 | 44.4 | 72.2 | 56.6 | 71.7 | 59.2 | 48.1 | 79.3 | 54.1 | 49.7 | 41.1 |
The last depth of the Fall-of-Potential Method is 0.9 m. From the table 3 shows all the reading of the electrode resistivity for 0.9 m depth of the electrode is bury in the ground at all 121 point at the site using Fall-of-Potential Method. From the data of the table, the average reading of the electrode resistivity is 59.96 ohm has been determining. At the same time, the point with the maximum value of electrode resistivity which is 79.8 ohm and the minimum value of electrode resistivity which is 40.6 ohm also has been determine. The figure 9 shows the three-dimensional model of profiling that obtain are using MATLAB Software method. From the figure also, the pattern of the electrode resistivity at several point has been clearly shown. The red regions represent the lowest reading of electrode resistivity and the orange regions represent the highest reading of electrode resistivity. The next figure which is figure 10 shows the isometric view of the model, the figure clearly shows all the point that involve in this project. The several point in the red region are mean the best point to bury the electrode with 0.9 m depth in the ground using Fall-of-Potential Method [7].
Table 4. Average reading at every point for Fall-of-Potential Method.

| COLUMN (Ω) | -5  | -4  | -3  | -2  | -1  | 0   | 1   | 2   | 3   | 4   | 5   |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| -5         | 112.37 | 110.20 | 108.60 | 114.43 | 95.83 | 111.10 | 109.37 | 103.27 | 108.40 | 100.50 | 110.87 |
| -4         | 109.47 | 115.20 | 117.87 | 109.03 | 118.47 | 103.07 | 114.70 | 112.67 | 108.67 | 94.90 | 102.97 |
| -3         | 107.00 | 107.67 | 97.77 | 104.37 | 98.10 | 103.07 | 104.87 | 116.73 | 110.60 | 101.80 | 117.33 |
| -2         | 124.53 | 113.93 | 107.30 | 112.50 | 114.33 | 101.70 | 107.10 | 99.03 | 104.33 | 103.83 | 96.67 |
| -1         | 97.00 | 110.53 | 114.10 | 100.90 | 94.40 | 103.70 | 112.87 | 104.90 | 117.03 | 102.40 | 114.50 |
| 0          | 118.93 | 115.23 | 101.33 | 109.93 | 109.63 | 96.57 | 96.20 | 113.77 | 100.90 | 123.60 | 121.13 |
| 1          | 112.23 | 115.47 | 110.70 | 105.93 | 97.43 | 101.33 | 100.07 | 118.20 | 111.97 | 103.10 | 104.20 |
| 2          | 106.87 | 114.70 | 98.53 | 116.50 | 108.27 | 93.73 | 116.60 | 105.37 | 102.93 | 119.33 | 119.57 |
| 3          | 117.23 | 119.27 | 118.47 | 108.77 | 115.37 | 112.43 | 113.25 | 108.85 | 101.83 | 91.03 | 111.27 |
| 4          | 111.97 | 106.57 | 109.27 | 103.00 | 97.10 | 100.90 | 106.50 | 98.73 | 111.33 | 108.20 | 107.23 |
| 5          | 112.20 | 106.13 | 114.67 | 101.67 | 106.70 | 105.67 | 111.87 | 113.50 | 99.90 | 97.23 | 104.23 |

Table 4 shows the average reading at every point for Fall in Potential Method. From the data, the minimum value of electrode resistivity is 91.03 ohm which is the best point to proceed with grounding system. The coordinate of the point is at (3,4). Meanwhile, the maximum value of electrode resistivity is 124.53 ohm which mean the worst point to proceed with installation of the grounding system. The coordinate of the point is at (-2, -5).

4. Conclusion and Recommendation
This project focuses on soil resistivity to find out the best place for grounding system. Based on the results obtained, it can be concluded that the behavior of the earth is different at certain point and different value of resistivity. Thus, the soil resistivity must be checked first before proceed with grounding system. From this software, all the point that involve in this project can be observe clearly. This is idea for electrical engineer select which point is the best for locating Grounding rod and it may reduce the cost of grounding installations.

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