Analysis behavior of soil resistivity profiling base on UniMAP condition

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Abstract: The main purpose of the earthing is to ensure that every electrical equipment, house and human are safe when lightning strikes. Lightning phenomenon occur can produce high voltage and current and it can cause electrical equipment damage and life danger. Therefore, this project will analyze the behavior of the soil. The main purpose of this project was to select the soil structure and the depth of the electrode suitable for grounding system in UniMAP. Additionally, this project will also analyze the soil resistance for grounding systems using MATLAB Software. From the result it can shows the best point for located grounding rod to ensure optimum grounding system.

1. Introduction

In an electrical installation, an earthing system or grounding system associates explicit parts of that establishment with the Earth's conductive surface for security and useful purposes. The perspective is the Earth's conductive surface. The decision of grounding system can influence the safety and electromagnetic similarity of the establishment. Controls for grounding system fluctuate impressively among nations, however many pursue the suggestions of the International Electrotechnical Commission. Directions may distinguish extraordinary cases for earthing in mines, in patient consideration regions, or in perilous regions of modern plants.

A grounding system must have great electrical conductivity, be mechanically hearty, have the capacity to withstand rehashed blame and flood flows and be impervious to erosion. Previous research, grounding system has been begun since 1820 where long separation electromagnetic telegraph system utilized at least two wires to transmit signal and return currents. In year of 1836 to 1837, a German researcher named Carl August Steinheil had found that the earth (ground) could be used as a return path to finish the circuit, by that the Earth function as return conductor in the telegraph system, making the prior return wire unnecessary [1].

The grounding system is one of the imperative parts of the electrical system to give an assurance amid blame or lightning happen. It is additionally essential to give low impedance current way when the fault happens. Grounding system additionally limits the ground potential ascent during a fault. There are two factors that influence grounding performance which is type of electrode used and soil characteristic [2]. These days, every electric machine, from the littlest to the biggest hardware, will use the grounding system with the end goal to keep a peril and furthermore to complete the circuit [3].
The main reason for the grounding system is to secure human, electrical machine and building from electrical shock because of lightning or another type of electricity that dangerous.

2. Methodology

Wenner Four Pin Arrangement Method applies same spacing between vertical electrodes. This method used four terminals, two for current infusion and two for voltage estimation. The four electrodes organize in straight lines; the two external terminals are a present electrode and two inward electrodes to quantify the voltage drop of soil resistance. For this experiment, it will have three different spacing which is 2m, 3m, and 4m, to get the best grounding point. Figure 1 shows the arrangement for the Wenner four pin Method.

![Figure 1. Wenner Method Arrangement.](image1)

![Figure 2. Site measurement at UniMAP Ulu Pauh.](image2)

![Figure 3. Grid mark by using raffia.](image3)

![Figure 4. Plan view at site measurement.](image4)

After measurement and get the data of soil resistance (Ω) apply formula below to get the soil resistivity (Ω-m) value:

\[ \rho = 2\pi aR \] (Ω-m)

Where:
\( \rho \) = soil resistivity (Ω-m)
\( a \) = distance between adjacent rod (m)
\( R \) = earth resistance (Ω)

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 choose this place because of open filed and it is near PPKSE block at UniMAP. Figure 2, 3 and 4 shows the location of the research, marking point using raffia and topology of site measurement, respectively.
3. Results and Discussions

There is some comparison that has been made to compare soil resistivity in this area. It has three different spacing which is 2m, 3m, and 4m, to get the best grounding point.

| ROW | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|-----|----|----|----|----|----|---|---|---|---|---|---|
| -5  | 2.93 | 3.22 | 3.19 | 3.43 | 3.76 | 4.11 | 3.68 | 3.73 | 4.40 | 4.65 | 4.50 |
| -4  | 3.03 | 3.08 | 3.02 | 3.58 | 4.22 | 4.13 | 3.68 | 4.01 | 4.33 | 4.42 | 4.35 |
| -3  | 3.02 | 3.10 | 3.21 | 3.43 | 3.58 | 3.40 | 3.78 | 3.91 | 4.03 | 4.12 | 4.20 |
| -2  | 3.45 | 3.21 | 3.09 | 3.11 | 3.65 | 4.19 | 4.02 | 4.17 | 3.21 | 4.14 | 4.38 |
| -1  | 3.17 | 3.01 | 3.44 | 3.18 | 3.75 | 3.42 | 3.13 | 4.15 | 3.23 | 4.18 | 4.41 |
| 0   | 2.81 | 2.95 | 3.14 | 3.32 | 3.16 | 3.48 | 3.73 | 3.84 | 3.69 | 3.55 | 4.15 |
| 1   | 3.21 | 3.18 | 3.27 | 3.36 | 3.32 | 3.14 | 3.61 | 4.01 | 4.16 | 4.10 | 4.27 |
| 2   | 3.01 | 3.24 | 3.45 | 3.70 | 4.08 | 4.14 | 3.98 | 4.07 | 4.12 | 4.45 | 4.11 |
| 3   | 2.87 | 3.14 | 3.26 | 3.89 | 3.67 | 3.98 | 3.48 | 3.54 | 3.93 | 3.86 | 3.87 |
| 4   | 2.98 | 3.46 | 3.24 | 3.87 | 3.42 | 3.94 | 3.42 | 3.72 | 3.44 | 3.57 | 4.67 |
| 5   | 3.55 | 3.48 | 3.87 | 3.74 | 3.94 | 3.74 | 3.73 | 3.18 | 3.75 | 3.76 | 3.42 |

The Table 1 shows the Wenner Four Pin Method for 2 meter. All the reading of the soil resistivity for 2 m length from the reference point at all 121 point at the site using Wenner Four Pin Method. From the data of the table, the average reading of the soil resistivity is 3.65 ohm has been determined. At the same time, the point with the maximum value of soil resistivity which is 4.67 ohm and the minimum value of soil resistivity which is 2.81 ohm also has been determine. 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 soil resistivity at several point has been clearly shown. The red regions represent the lowest reading of soil resistivity and the orange regions represent the highest reading of soil resistivity. The next figure which is Figure 6 shows the isometric view of the model, the figure clearly show all the point that involve in this project. The point in the red region are mean the best value of soil resistivity with 2 m length from the reference point by using Wenner Four Pin Method.
This Wenner Four Pin Method is repeat for 3 m length from the reference point at all 121 point at the site. The Table 2 shows the Wenner Four Pin Method for 3 meter. From the data of the table, the average reading of the soil resistivity is 2.60 ohm has been determine. At the same time, the point with the maximum value of soil resistivity which is 3.86 ohm and the minimum value of soil resistivity which is 1.50 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 soil resistivity at several point has been clearly shown. The red regions represent the lowest reading of soil resistivity and the orange regions represent the highest reading of soil resistivity. The next figure which is Figure 8 shows the isometric view of the model, the figure clearly show all the point that involve in this project. The point in the red region are mean the best point of soil resistivity with 3 m length from the reference point by using Wenner Four Pin Method.

| ROW | COLUMN (Ω) |
|-----|------------|
| 0   | 1.50 2.98 2.87 2.65 2.74 2.56 3.25 2.69 2.97 2.44 2.58 |
| 1   | 2.57 2.54 2.84 2.36 2.08 2.25 2.69 2.46 2.85 3.35 3.09 |
| 2   | 2.43 2.74 2.25 2.47 2.73 2.74 2.34 2.36 2.79 2.21 3.66 |
| 3   | 2.78 2.67 2.23 2.56 2.58 2.23 2.57 2.46 2.68 3.86 2.44 |
| 4   | 2.45 2.57 2.89 2.25 2.54 2.98 2.76 2.25 2.09 2.53 3.01 |
| 5   | 2.69 2.89 2.36 2.84 2.26 2.05 2.51 2.72 3.15 2.87 2.79 |

**Figure 7.** Three dimensional of profiling method (3 m).

**Figure 8.** Isometric view of profiling method (3 m).

Table 3. all the reading of the soil resistivity for 4 m length from the reference point

| ROW | COLUMN (Ω) |
|-----|------------|
| 0   | 1.78 1.79 1.42 1.67 1.78 1.94 2.13 2.01 2.08 2.12 2.08 |
| -1  | 1.68 1.61 1.62 1.73 1.82 1.90 1.94 1.97 2.01 2.14 2.09 |
| -2  | 1.74 1.69 1.78 1.84 1.81 1.99 2.01 2.09 2.06 2.15 2.08 |
| -3  | 1.89 1.68 1.49 1.77 1.48 1.89 1.67 1.81 1.65 1.47 2.15 |
| -4  | 1.48 1.78 1.47 1.46 1.68 1.71 1.98 1.88 2.21 1.15 2.01 |
| 0   | 1.65 1.60 1.87 1.84 1.97 1.47 1.97 2.15 1.87 2.02 1.74 |
The last length of the Wenner Four Pin Method is 4 m. From the Table 3 shows all the reading of the soil resistivity for 4 m length from the reference point at all 121 point at the site using Wenner Four Pin Method. From the data of the table, the average reading of the soil resistivity is 1.78 ohm has been determine. At the same time, the point with the maximum value of soil resistivity which is 2.30 ohm and the minimum value of electrode resistivity which is 1.07 ohm also has been determine. The Figure 9 shows the three dimension model of profiling that obtain by using MATLAB Software method. From the figure also, the pattern of the soil resistivity at several point has been clearly shown. The red regions represent the lowest reading of soil resistivity and the orange regions represent the highest reading of soil resistivity. The next figure which is Figure 10 shows the isometric view of the model, the figure clearly show all the point that involve in this project. The point in the red region are mean the best point of soil resistivity with 4 m length from the reference point by using Wenner Four Pin Method.

![Figure 9. Three dimensional of profiling method (4 m).](image)

![Figure 10. Isometric view of profiling method (4 m).](image)

| COLUMN (Ω) | -5 | -4 | -3 | -2 | -1 | 0  | 1  | 2  | 3  | 4  | 5  |
|------------|----|----|----|----|----|----|----|----|----|----|----|
| 1          | 1.78 | 1.94 | 1.51 | 1.41 | 1.74 | 1.49 | 1.84 | 1.45 | 1.48 | 1.87 | 2.09 |
| 2          | 1.70 | 1.98 | 1.90 | 1.07 | 1.71 | 1.78 | 1.80 | 1.57 | 1.48 | 1.15 | 1.10 |
| 3          | 1.89 | 1.76 | 1.54 | 1.68 | 1.76 | 1.47 | 1.46 | 1.67 | 1.45 | 1.40 | 2.05 |
| 4          | 1.40 | 1.65 | 1.84 | 1.43 | 1.47 | 1.76 | 1.69 | 2.17 | 1.57 | 2.30 | 2.22 |
| 5          | 1.87 | 1.97 | 1.71 | 1.65 | 1.54 | 1.77 | 1.98 | 1.82 | 1.85 | 2.00 | 1.89 |

Table 4. Average reading at every point for Wenner Four Pin Method.

| ROW | COLUMN (Ω) | -5 | -4 | -3 | -2 | -1 | 0  | 1  | 2  | 3  | 4  | 5  |
|-----|------------|----|----|----|----|----|----|----|----|----|----|----|
| -5  | 2.27       | 2.41 | 2.36 | 2.53 | 2.63 | 2.81 | 2.79 | 2.88 | 3.24 | 3.38 | 3.15 |
| -4  | 2.21       | 2.30 | 2.37 | 2.64 | 2.82 | 2.83 | 2.71 | 2.95 | 3.16 | 3.27 | 3.14 |
| -3  | 2.25       | 2.33 | 2.47 | 2.67 | 2.73 | 2.74 | 2.93 | 3.01 | 3.07 | 3.19 | 3.08 |
| -2  | 2.41       | 2.35 | 2.23 | 2.56 | 2.54 | 2.74 | 2.60 | 2.78 | 2.35 | 2.59 | 3.10 |
| -1  | 2.26       | 2.41 | 2.42 | 2.48 | 2.62 | 2.41 | 2.44 | 2.73 | 2.82 | 2.82 | 2.99 |
| 0   | 1.99       | 2.51 | 2.63 | 2.60 | 2.62 | 2.50 | 2.98 | 2.89 | 2.84 | 2.67 | 3.37 |
| 1   | 2.52       | 2.55 | 2.54 | 2.38 | 2.38 | 2.29 | 2.71 | 2.64 | 2.83 | 3.11 | 3.15 |
| 2   | 2.38       | 2.65 | 2.53 | 2.41 | 2.84 | 2.89 | 2.71 | 2.67 | 2.80 | 2.60 | 2.96 |
| 3   | 2.51       | 2.52 | 2.34 | 2.71 | 2.67 | 2.56 | 2.50 | 2.56 | 2.69 | 3.04 | 2.79 |
| 4   | 2.28       | 2.56 | 2.66 | 2.52 | 2.48 | 2.89 | 2.62 | 2.71 | 2.37 | 2.80 | 3.30 |
Table 4 shows the average reading at every point for Wenner Four Pin Method. From the data, the minimum value of soil resistivity is 1.99 ohm which is the best point to proceed with grounding system. The coordinate of the point are at (0, -5). Meanwhile, the maximum value of soil resistivity is 3.38 ohm which mean the worst point to proceed with installation of the grounding system. The coordinate of the point are at (-5, 4).

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.

Acknowledgments

Authors wishing to acknowledge assistance or encouragement from colleagues, special work by technical staff or financial support from School of Electrical System Engineering, Universiti Malaysia Perlis.

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