# Analysis of the Grounding System in the Hexagon Building, Faculty of Engineering, Mulawarman University

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**Abstract.** This research aims to evaluate the feasibility of the grounding system
in the Hexagon Building, Faculty of Engineering, Mulawarman University. The
quality of the grounding system is determined based on the measured resistance
value, where the ideal value is in the range of 0 to 5 $\Omega$. Several factors that
influence the grounding resistance value include electrode depth, number and
distance between electrodes, conductor size, and soil type characteristics. The
grounding resistance value is obtained through direct measurement using an
Earth Tester with the three-point method. It is hoped that the results of this
research will provide an overview of the effectiveness of the grounding system
at this location. The measurement results showed that the average value of
grounding resistance in the Hexagon Building at the first point was 29 $\Omega$.
Furthermore, the grounding resistance value at the second point was recorded at
31 $\Omega$, while at the third point it was 27 $\Omega$. All three far exceed the set standards.
This is due to the planting of grounding electrodes that are not deep enough.
Based on the analysis, it can be concluded that to achieve a grounding resistance
value of $\leq 5$, an electrode planting depth of 12 is required.

**Keywords:** Earth Tester, Electrodes, Grounding Quality Analysis, Grounding
System, Three Point Method

## 1    Introduction

The grounding system is a crucial component in the design and construction of an
electric power system to protect buildings from lightning. Adequate protection must be
installed to ensure the safety and reliability of the building. Although the material and
design are up to standard, suboptimal grounding resistance can reduce the effectiveness
of the protection system. Therefore, a reliable grounding system is essential to ensure
that buildings are optimally protected from potential damage due to lightning [1].

The grounding system aims to protect electrical equipment from electrical surges, including due to lightning strikes, by ensuring a safe flow of electrical current to the ground. Low soil resistance values are essential to achieve effective protection. Based on the General Requirements for Electrical Installations (PUIL) 2011, the ideal soil resistance value is ≤ 5 Ω. Research shows that some buildings, such as the University of Civilization and FPP UNP, have met this standard with an average prisoner score below 5 Ω [2, 3]. In addition, the use of microcontroller-based monitoring methods and the addition of additives are also effective in gradually reducing the soil resistance value, ensuring that the grounding system remains optimal and safe [4].

The grounding resistance value is affected by a variety of factors, including electrode depth, number of electrodes, distance between electrodes, and soil type. Research shows that deeper electrode depths tend to result in lower resistance values, as seen in measurements at the University of Civilization building, where the resistance value reaches 0.93 Ω at a depth of 12 m [2]. In addition, soil conditions also have a significant effect; Moist and wet soils show much lower resistance values compared to dry soils [5]. The increase in the number of electrodes also contributes to lowering the resistance value, with measurements showing that double electrodes produce better values than single electrodes, especially if the distance between the electrodes is in the range of 5 to 10 [6]. In addition, the use of additives such as bentonite can increase soil moisture and decrease grounding resistance significantly, compared to NaCl [7]. Some of the studies on grounding prisoners have been conducted before.

This research has been conducted to measure soil resistance at different soil conditions and electrode depths. One study showed that both single and double electrodes, the value of resistance tended to decrease with the depth of the electrode planting. The increase in the number of electrodes also contributes to a decrease in the resistance value, although the distance between the electrodes needs to be considered, with a distance of between 5 to 10 recommended for optimal results. This study found that swamp soils provide the best resistance value compared to other soils, such as watery soils, clay soils, and rocky soils [6].

Other studies also confirm that the deeper the electrode is planted, the smaller the grounding resistance value produced. Of the six measurement locations, a depth of 75 cm showed the lowest resistance value, which was 1.5 Ω, while at a depth of 100 cm it also produced a low value, with the lowest value reaching 1.4 Ω for the parallel electrodes. However, this study notes that the use of two electrodes in parallel does not have a significant effect on reducing the grounding resistance value [8].

This research at FT UNMUL is very important to find out how deep the electrodes must be planted in rocky soil so that the soil resistance value can be lowered to a safe level. Thus, this study will not only provide recommendations regarding the optimal depth of the electrode rod but will also assess the feasibility of the grounding system currently used in FT UNMUL. The results of this study are expected to make an important contribution to improving the safety and reliability of electrical systems in academic environments that are vulnerable to lightning strikes [2, 3, 7].

## 2    Materials and Methods

Every time you conduct research, tools and materials are needed to support this research activity. In addition, there are methods that need to be carried out in this study. The tools and materials and methods used in conducting this research.

### 2.1    Research Procedures

The steps in conducting this research are as follows:

1. Prepare an Earth Tester, Cables, Meter, & Aids.
2. Stick in the first nail where the distance is 3-5 from the grounding place to be measured. Then the second nailing which is 3-5 away from the first nailing place.
3. Connect the green wire to the grounding measured with a clamp and connect to the earth tester measuring device on the green port.
4. Connect the yellow wire to the first nail with a clamp and connect directly to the earth tester measuring tool on the yellow port.
5. Connect the red wire to the second nail with a clamp and connect it directly to the earth tester on the red port Set the range switch on the earth tester on the x100 Ω. Press the "Press to tess" button.

### 2.2    Research Tools and Materials

The tools and materials used to support this research are the Earth Tester as a test tool to measure grounding resistance, the Test Cable is a cable from the earth tester component to connect the earth tester with the electrode, 2 electrode rods, a hammer and a meter. The electrode rod used is a metal rod that is stuck into the ground, and a meter is used to measure the distance between the electrode rods.

**Table 1.** Research Tools

| No | Equipment | Amount | Unit |
|----|-----------|--------|------|
| 1 | Earth Tester Kyoritsu 4105A | 1 | Unit |
| 2 | Electrode Rod | 1 | Unit |
| 3 | Auxiliary Electrode | 2 | Unit |
| 4 | Measurement Cable (Green) | 10 | Metre |
| 5 | Measurement Cable (Yellow) | 10 | Metre |
| 6 | Measurement Cable (Red) | 10 | Metre |
| 7 | Hammer | 1 | Unit |
| 8 | Tape Measure | 1 | Unit |

### 2.3    Research Methods

The research method studied is a type of quantitative research. The research stages consist of observation, documentation, literature study and three-point measurement. The

formula used to calculate the grounding resistance value in this study uses the following formula [3].

$$R = \frac{p1}{2\pi L}\left(ln\frac{4L}{a} - 1\right) \tag{1}$$

where R is the Grounding Detention (Ohm), $p$ is the Soil type resistance (Ohmmeter), $L$ is the Electrode Length (Meter), and $a$ is the Radius Electrode/Penalty Electrode (Meter).

Based on the General Requirements for Electrical Installation 2011 (PUIL 2011) soil type resistance of various soil types can be seen in Table 2.

**Table 2.** Soil type resistance

| No | Soil Type | Soil Type Detention (Ωm) |
|----|-----------|--------------------------|
| 1 | Swamp Land | 10-30 |
| 2 | Clay and farmland | 100 |
| 3 | Wet Sand | 200 |
| 4 | Wet Gravel | 500 |
| 5 | Dry sand/gravel | 1000 |
| 6 | Rocky soil | 3000 |

## 2.4    Research Location

The research was carried out at 09.00 – 10.40 WITA, Tuesday 08 November 2022 in front of the Hexagon Building, Faculty of Engineering, Mulawarman University.

## 3    Results

This research was carried out in the field, namely the courtyard of the Hexagon Building, Faculty of Engineering. So this study measured prisoners in the land system. The measurement was carried out using a three-point method. In this measurement, the force used to measure the resistance is an earth tester with a medium that will later be measured through an electrode rod and two grounding nails. These measurements were taken on three plots around the Hexagon Building. The measurement results can be seen in Table 3 as follows.

**Table 3.** Measurement Results

| No | Distance (meters) | Resistance of the Ground Electrode at the Point (Ω) | | |
|----|-------------------|-------------|--------------|-------------|
| | | First Point | Second Point | Third Point |
| 1 | 3 | 29 | 31 | 27 |
| 2 | 4 | 29 | 31 | 27 |
| 3 | 5 | 29 | 31 | 27 |

Table 3 shows the results of measuring the resistance of the ground electrode at three different points, namely the first point, the second point, and the third point. Measurements are taken at varying distances, ranging from 3 , 4 , to 5 from the ground electrode. The results of prisoners at each point were relatively constant at each distance, which was 29 Ω at the first point, 31 Ω at the second point, and 27 Ω at the third point. From these data, it can be concluded that the change in distance from the electrode does not significantly affect the ground resistance value at the site, which remains consistent across the three measurement points.

**Table 4.** Calculation Results

| No | Depth (meters) | Resistance Rating (Ω) |
|----|----------------|------------------------|
| 1 | 0.5 | 29.73 |
| 2 | 1 | 17.50 |
| 3 | 2 | 10.07 |
| 4 | 8 | 3.18 |
| 5 | 12 | 2.25 |

Table 4 shows the results of soil resistance measurements based on varying electrode rod depths. At a depth of 0.5, the resistance value was recorded at 29.73 Ω. When the depth is increased to 1 meter, the resistance drops significantly to 17.50 Ω. Further, at a depth of 2 m, the resistance decreases to 10.07 Ω, and at a depth of 8 m, the value drops further to 3.18 Ω. At the highest depth, which is 12 m, the resistance reaches the lowest point of 2.25 Ω. From this data, it can be concluded that the deeper the electrode is planted, the more the soil resistance decreases significantly. This is due to the increased contact of the electrode with the deeper, more moist ground, thus allowing for better conductivity.

## 4      Discussion

The results of the soil resistance measurements from the two tables above show the relationship between the measurement distance and the depth of the electrode to the soil resistance. In the first table, measurements of ground resistance at three points (with distances of 3, 4, and 5 meters from the electrodes) yield relatively constant values of about 29 Ω, 31 Ω, and 27 Ω. These results indicate that the change in distance does not have a significant impact on the resistance value, which remains stable at each point.

Meanwhile, the second table shows that the ground resistance is greatly affected by the depth of the electrode. With the increase in electrode depth from 0.5 meters to 12 meters, the ground resistance is drastically reduced from 29.73 Ω to 2.25 Ω. This indicates that the depth of the electrode is a critical factor in lowering the soil resistance value.

Based on international standards, such as PUIL 2011, the ideal ground resistance value for a grounding system is below 5 Ω, especially for safe electrical grounding applications. In measurements with a depth of 8 meters and 12 meters, the soil re-

sistance has met these standards (3.18 $\Omega$ and 2.25 $\Omega$, respectively). However, at shallower depths (below 2 meters), the resistance value is still above 5 $\Omega$, so it does not meet the recommended safety standards. Thus, in order to achieve a resistance value that conforms to the standard, the electrode must be planted at a sufficient depth, at least 8 meters or more.
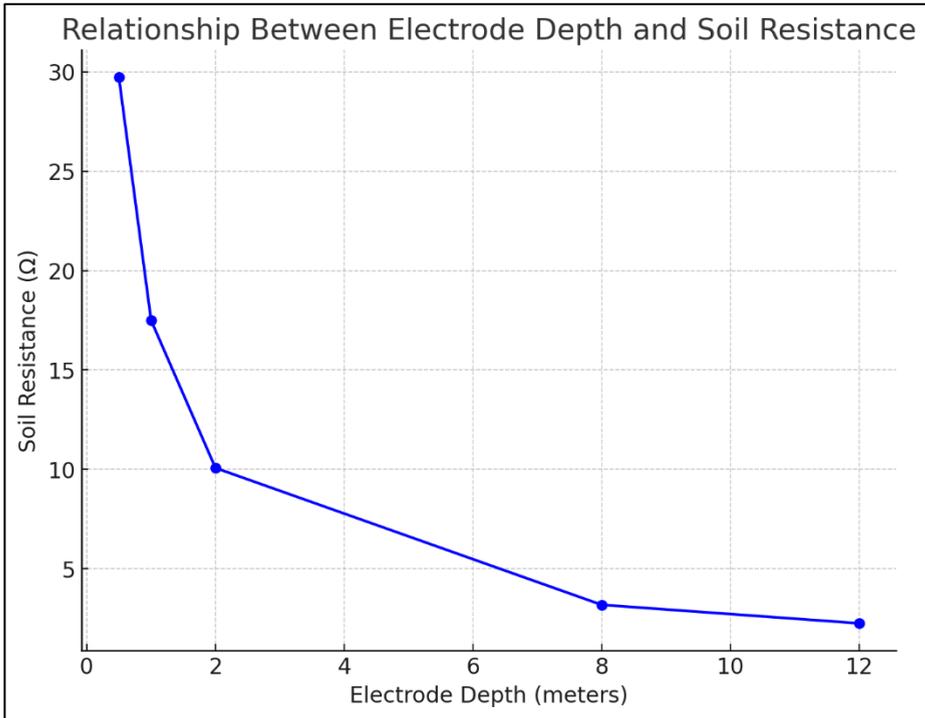


**Fig. 1.** Relationship between Electrode Depth and Soil Resistance

The graph above shows the relationship between the depth of the electrode rod and the ground resistance. It is seen that the deeper the electrode is planted, the resistance of the soil decreases significantly. At shallower depths (0.5 to 2 meters), the resistance is still quite high, but when the electrode reaches a depth of 8 to 12 meters, the resistance drops drastically to a lower value, indicating an increase in the effectiveness of the grounding system at greater depths.

## 5 Conclusions

From the measurement results and the graphs displayed, it can be concluded that the depth of the electrode has a significant influence on the soil resistance. At shallower depths (0.5 to 2 meters), the ground resistance is still high, which means the electrodes are not effective enough for a safe earthing system. However, when the depth of the

electrode is increased to 8 meters or more, the ground resistance drops drastically below 5 Ω, which is in line with the safety standards for electrical grounding. Therefore, to achieve an optimal and standard-compliant grounding system, the electrodes must be planted at a sufficient depth, at least 12 meters or more.

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