Earth Resistance and Earth Construction To Interference Currents On Swamp Land

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A B S T R A C T

To protect electrical power installation equipment, especially that in open areas where it is particularly vulnerable to both technical and non-technical disturbances, such as those frequently brought on by lightning surge currents that result in large fault currents, it is crucial to build a grounding installation. A good and trustworthy grounding system is required to flow this significant fault current, both in terms of a low grounding resistance value and the grounding system's design. There are several high voltage transmission towers or electrical power installation tools in open spaces, and they are built on a variety of soil types, including 150 kV transmission towers built on swamp land. The measurements on the shampooing marsh terrain yielded the maximum and minimum values, with the maximum value occurring at a depth of 1 meter and a earth resistance value of 25.70 Ω and the minimum occurring at a depth of 2 meters and a earth resistance value of 12.10 Ω, respectively. Based on the findings of these measurements, a grounding grid construction employing four electrode rods of two distinct types copper-coated iron rods and galvanized iron rods each measuring 3.5 meters in length was designed using the CYMGRD application. Through the CYMGRD application, a different Ground Potential Rise (GPR) is obtained; with the same fault current of 10234.6 Ampere, the GPR value for the copper-coated rod construction is 54.7871 volts as opposed to the galvanized rod construction's 55.0625 volts.

Keywords:

Earth Resistance, Swamp Land, Ground Rise Potential (GPR), CYMGRD

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1. INTRODUCTION

Installing a grounding or grounding system with high reliability and in accordance with standards set forth by PUIL 2000 and PUIL 2011 as well as IEEE 81 standards in 2012 and IEEE 80 standards in 2000, which will enhance the performance of electrical equipment used for both the generation and distribution of electrical energy[1]-[2], is necessary to protect people and create safety and dependability of electrical power installation equipment. [3]-[4] It is well recognized that it is impossible to produce energy in a system for generating it totally free of any disruptions, whether they be technical or not [5]-[6]. For the safety of people and electrical equipment, the ground resistance value needs to be as low as possible[7] so that, in the event that an electric current leaks to a metal component of the equipment that shouldn't have a voltage, it won't endanger people who unintentionally touch the component in the field[8]. The two system functions of the grounding system are to ground the power system's neutral point and to ground equipment[9]. The power system's neutral point serves as a safety system or network, while grounding equipment protects against touch voltage from electric shock or ground potential rise (GPR) [10]-[11], In order to ensure the security of the grounding system on electrical equipment, the ground electrode rod is implanted perpendicularly before being buried at a specific depth in the ground [12]-[13]. The design of an optimum grounding system in line with the characteristics of the soil type or soil resistivity around the electrical equipment is also necessary to ensure the security and dependability of electrical equipment[14]-[15]. In this study, a direct survey and measurement of space are required to determine the resistance value. This is especially true in swamp land, where there are numerous transmission towers and other electrical power installation equipment that firmly rest on swamp land and are used to distribute electrical energy along 150 kV high voltage lines. The value of the grounding resistance will be inputted to be simulated in order to produce an ideal grounding construction, particularly when there is a fault current, employing direct measurement in the field using the 3 point method [16]-[17] on marsh land. Additionally, the community's proximity to the location of the electric power installation is one of the factors requiring a dependable and secure grounding installation to safeguard the neighborhood from the risks of electric shock, which can have an adverse effect on human health[18]-[19]. The value of the Ground Potential Rise (GPR)[20] at the position of the fault current can be determined by taking measurements in the field, designing the building of a grounding installation, and using the CYMGRD program to determine the contour of the soil that is passed by the fault current.

2. RESEARCH METHODS

In order to determine what will happen by comparing the outcomes of the research problem, the grounding resistance research in wetlands that acts as a location for high voltage electrical energy distribution employs an experimental research methodology. Surveys, field observations, and direct measurements in the field, specifically in swampy areas close to the Keramasan Substation in Palembang, are necessary to get the most accurate research results. The measurement technique employed is the three-point measurement technique[21], and two auxiliary electrodes are utilized in conjunction with a grounding resistance measuring device, the Kyoritsu Digital Earth tester R1450A[22]. Regarding the information gathered from measurements made at various depths using rod electrodes of a certain type that are galvanized round iron rod electrodes. The CYMGRD application will be used to input the measurement data and simulate it in order to produce an analysis of soil resistivity and grounding construction with the ideal grid system and the least Ground Potential Rise (GPR) value[23]-[24]. Equation (3) [25]-[26] can be used to get the grounding resistance using a single rod electrode in Figure 1:

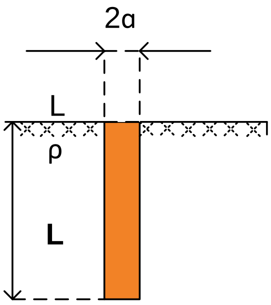


FIGURE 1. Shows that electrodes are positioned parallel to the ground.

$$R = \frac{\rho}{2\pi C} \tag{1}$$

$$\frac{1}{C} = \frac{1}{L}\left(Ln\frac{4L}{a} - 1\right) \tag{2}$$

$$R_{d1} = \frac{\rho}{2\Pi.L} \text{In} \left(\frac{4L}{a} - 1 \right) \tag{3}$$

where: :

R_{d1} : Resistance for a single electrode rod positioned parallel to the ground (Ohm)
L : Electrode rod length (meters)
a : Electrode radius (meter)
ρ : the typical soil resistivity (Ohm-m)

In 2012, the Soil Resistivity Wenner method was used to determine the soil resistivity in the electric power system in accordance with the IEEE 81 standard.

$$(\rho) = 2 \pi a l R \tag{4}$$

3. RESULTS AND DISCUSSION

The shampooing substation is located in a freshwater marsh with a pH of 6.75. This information was gathered through survey results and field observations. The Earth resistance with one electrode implanted perpendicularly in the swamp soil according to the soil resistivity value according to PUIL 2000 and PUIL 2011 using the formula 3 can then be used to calculate the data on the condition of the swamp land and the data on the material of the grounding equipment.
We gathered the following information for this study:

TABLE 1. Types of soil, measuring instruments and specifications of electrode rods

Information	Electrode type and size
Electrode Shape	Round rod
Electrode Material	Galvanized plated iron (Zinc Coated Steel)
Electrode Length	200 cm (2 meter)
Electrode Diameter	16,56 mm : 0,01656 meter
Rod electrode radius	0,00828 meter
Type of soil	Swamp Soil Resistivity : 30 Ω
Electrode embedding depth	- 1 meter - 1,5 meter - 1,75 meter - 2 meter
Earth Tester	Kyoritsu R 1450 A Digital
Resistivity Soil Tester	ETCR 2000C

The following information comes from calculations and measurements of grounding resistance made on marsh terrain in the Keramasan Substation environment:

TABLE 2. Results of Measurement and Calculation of Grounding Resistance

No	Rod Electrode Depth (meters)	Calculation Result of Electrode Rod (Ω)	Measurement Results of Electrode Rod (Ω)
1.	1	24,75	25,70
2.	1,5	17,79	21,10
3.	1,75	15,67	14,10
4.	2	14,03	12,10

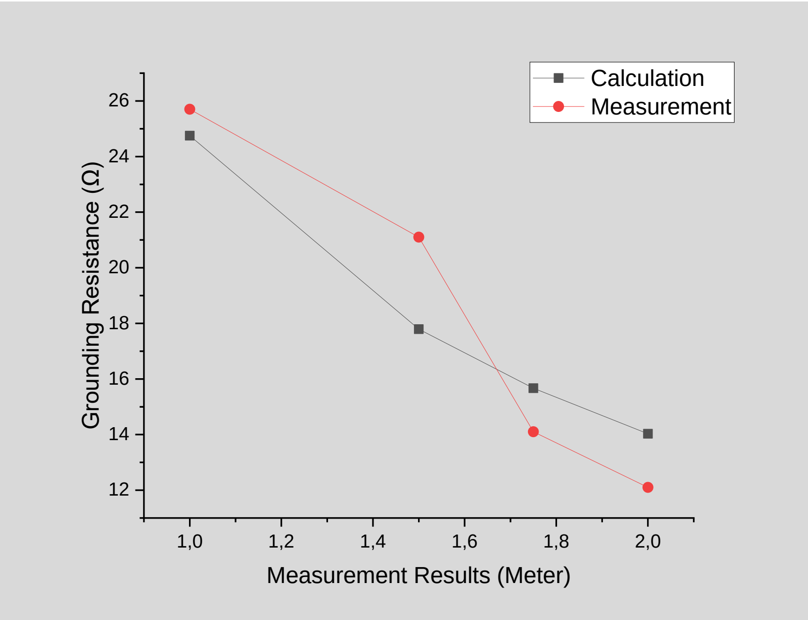


FIGURE 2. Results of Measurement and Calculation of Grounding Resistance in Swamp Land

The calculation results are greater at the rod electrode at a depth of 2 meters with a value of 14.03 Ω while the ground resistance value is smaller from the results of direct measurements in swamp land. This difference between the calculation results and the results of direct measurements in the field can be seen in the results of measurements and testing in the ground resistance swamp land. Compared to the calculation's 12.10 Ω findings.
While the following information comes from calculations and measurements of soil resistivity conducted on swamp terrain at the Keramasan Substation:

TABLE 3. Soil Resistivity in Swamp Land Using the Wenner Method.

No	Rod Electrode Depth (meters)	Soil Resistivity The calculation results (Ωm)	Soil Resistivity Measurement results (Ωm)
1.	1	155,41	202,3
2.	1,5	111,71	150,1
3.	1,75	98,40	129,4
4.	2	88,10	116,8

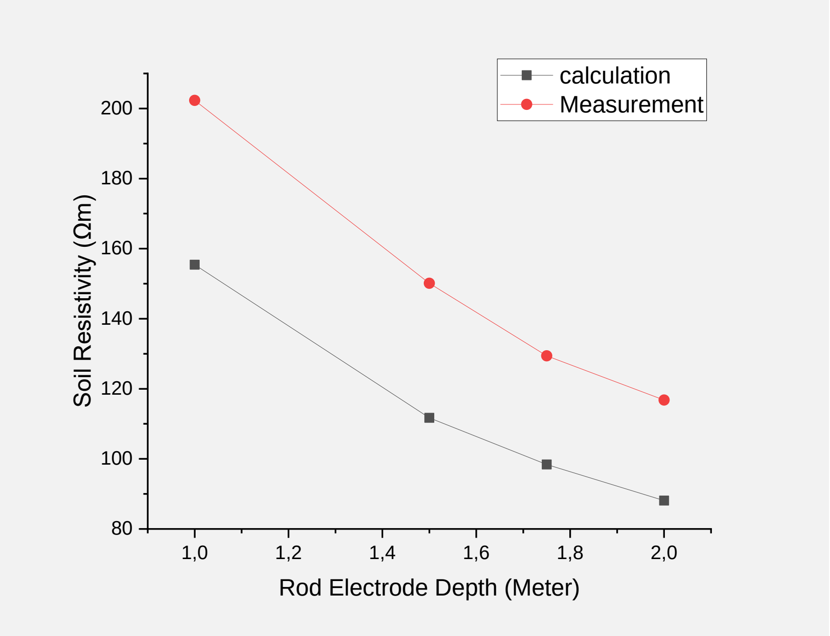


FIGURE 3. Soil Resistivity Graph of Swamp Land

The value of the calculation and measurement of soil resistivity in swampy areas shows that the calculation is less accurate than direct measurements using the ECTR 2000C, particularly at a depth of 1 meter of the rod electrode, which is 155.41 Ωm, whereas with direct measurements at a depth of 1 meter the soil resistivity is obtained at 202.3 Ωm.

The CYMGRD application is utilized to achieve an optimal grounding construction against fault currents, particularly grounding at the foot of the 150 kV high voltage transmission tower for this research. Fault current data collected from the Keramasan Substation data can be inputted in the CYMGRD program in addition to data from the outcomes of grounding resistance measurements.

After entering the grounding resistance data into the CYMGD application, the grounding grid construction is designed with a grid size of 6 x 6 meters and a grounding rod electrode depth of 3.5 meters with various types of rod electrodes, in accordance with the requirements of the 150 kV transmission tower leg.

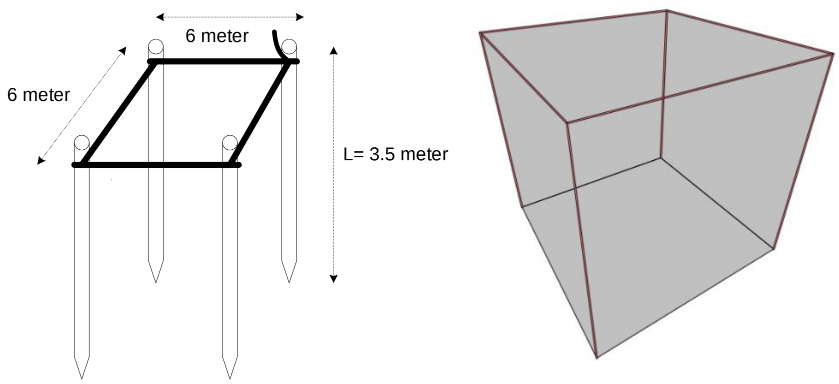


FIGURE 4. Grounding System Grid Design with 4 electrode rods

Regarding the CYMGRD simulation of ground resistance, step, and touch potential in freshwater marsh area, the round galvanized iron rod (Zinc Coated Steel) electrode utilized is the kind used with the following input parameter data:

TABLE 4. Ground Potential Rise input and output parameters.

Input Parameter ground resistance, step dan touch potensial (Body Weight 50 kg) Swampland	
Bus ID	150 kV
Nominal frequency	50 herzt
LG Fault Current	10234.6 A
Remote contribution	100%
Upper Layer Thickness	3.28 m
Upper Layer Resistivity	175.16 Ωm
Lower Layer Resistivity	0.01 Ωm
Electrode :	
Rod	Zinc Coated Steel - Diameter 16.56 mm
Conductor	Copper commercial hard-drawn – 16 mm
Lengt Rod	3.5 meter
Total Length Conductor	24 meter
Total Length of Primary Rods	14 meter

A prospective contour on marsh land will be produced from the output of the input parameters, as shown in the table above:

Output Parameter	
Ground Potensial Rise	55.0625 Volts
Calculated ground Resistance	0.00521655 Ω
Equivalent Impedansi	0.00521655 Ω

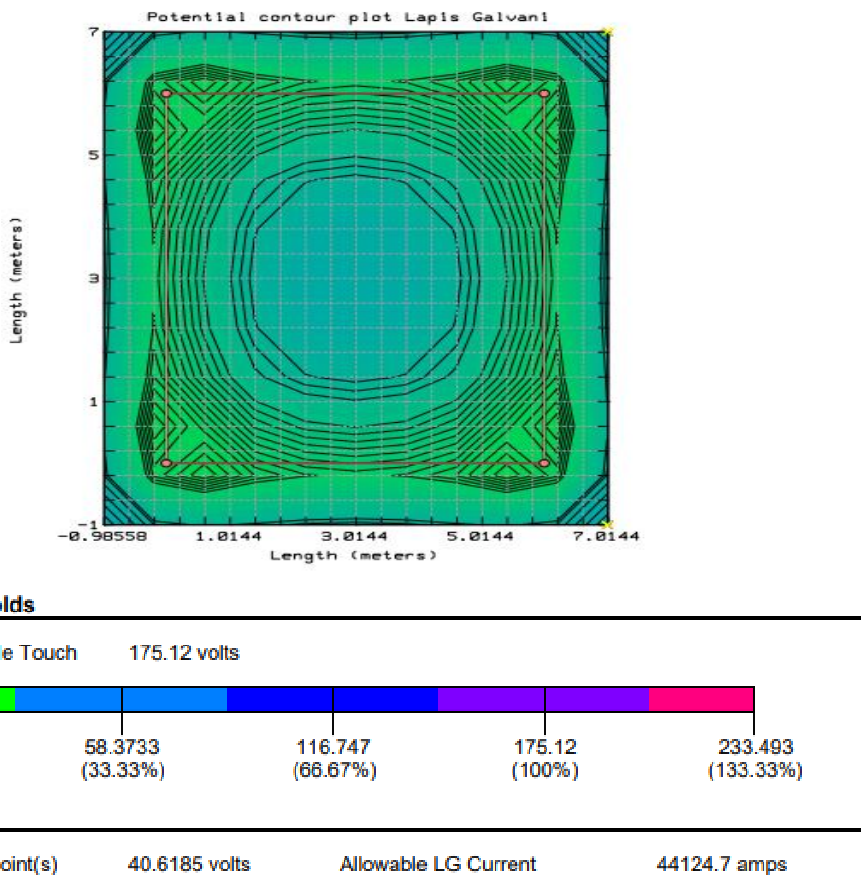


FIGURE 5. Potential Contour with Galvanized Rod Grounding Construction

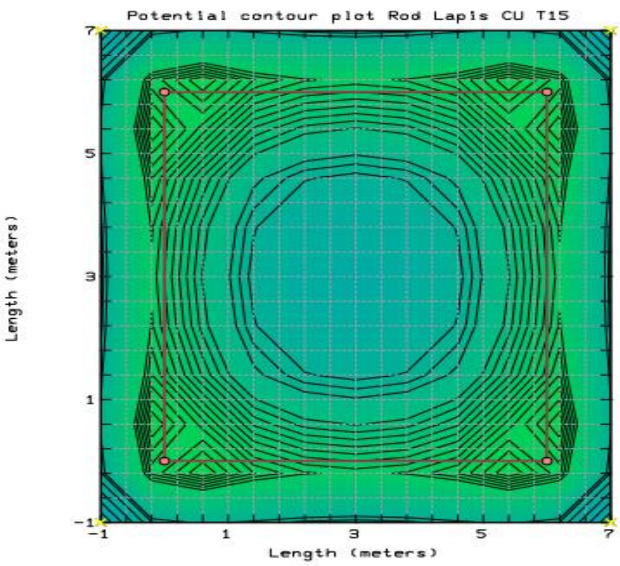
The risk outside the tower is relatively safe for living things with a maximum touch voltage inside the tower of 175.12 volts and a risk of step voltage of 208.34 volts, according to the results of the resulting potential contour image with a rod depth of 3.5 meters capable of flowing fault currents to the ground of 10234.6 Ampere.
In order to simulate ground resistance, step potential, and touch potential in freshwater swamp terrain using CYMGRD, various electrode types employing copper-coated round iron rods were used, along with the following input parameter data:

TABLE 5. Ground Potential Rise input and output parameters.

Input Parameter ground resistance, step dan touch potensial (Body Weight 50 kg) Swampland	
Bus ID	150 kV
Nominal frequency	50 herzt
LG Fault Current	10234.6 A
Remote contribution	100%
Upper Layer Thickness	3.28 m
Upper Layer Resistivity	175.16 Ωm
Lower Layer Resistivity	0.01 Ωm
Electrode :	
Rod	Copper Clad Steel 20% - Diameter 16.56 mm
Conductor	Copper commercial hard-drawn – 16 mm
Lengt Rod	**6.7871** meter
Total Length Conductor	24 meter
Total Length of Primary Rods	14 meter

Using copper-coated rod electrodes, the output of the input parameters will produce a potential contour on swamp land, as shown in the table above:

Output Parameter	
Ground Potensial Rise	54.7871 Volts
Calculated ground Resistance	0.00521655 Ω
Equivalent Impedansi	0.00521655 Ω



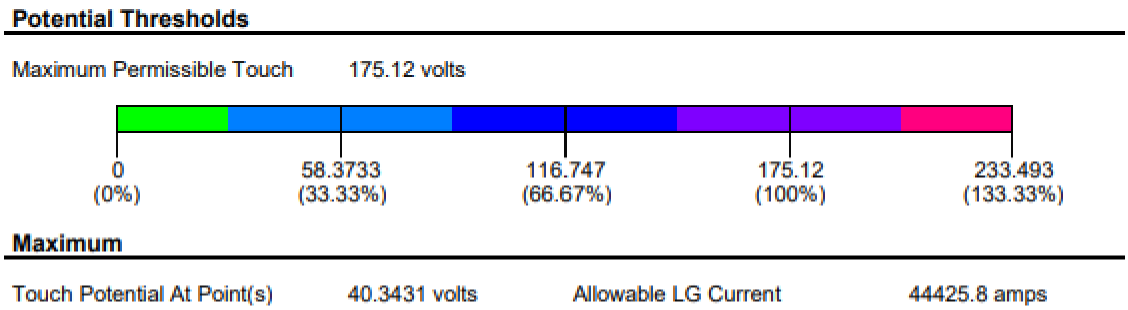


FIGURE 6. Potential Contour with Copper Plated Rod Grounding Construction

The risk outside the tower is relatively safe for living things with a maximum touch voltage inside the tower of 175.12 volts and a risk of step voltage of 208.34 volts, according to the results of the resulting potential contour image with a rod depth of 3.5 meters capable of flowing fault currents to the ground of 10234.6 Ampere.

4. CONCLUSION

There is a difference in the value of soil resistivity between calculations and direct measurements in the field using the ECTR 2000C based on the results of the measurement of ground resistance in the field. The minimum value obtained at a depth of 2 meters is 12.10 Ω, which is different from the calculation results of 14.03 Ω. The value of the earth resistance obtained depends on how much of the embedded rod electrode is present. The grounding architecture that will be employed is impacted by a good grounding resistance value. Galvanized iron rod electrodes and copper-coated iron rod electrodes were used to simulate the grounding construction. According to the Ground Potential Rise (GRP) value, copper-coated rod electrodes performed slightly better than galvanized-coated rod electrodes, with a difference in GPR value of 0.2754 volts.

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