Real-time Measurement for Controlling Grounding Resistance

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Keywords: Grounding resistance, real-time, monitoring system, LabVIEW

Abstract: Grounding is the protection system that is useful for transferring the leakage current from an electrical system to the ground through a grounding electrode buried in the ground. Types of grounding electrodes can be in the form of rod electrodes, plate electrodes, mesh-connected electrodes or other forms. In order for the grounding system to function properly, it must be ensured that the grounding system has very small earth resistance, close to zero. In addition, earth resistance value is influenced by soil resistivity, mineral content, soil moisture and temperature particularly due to weather changes. Indonesia has two seasons, the dry season and the rainy season. During the dry season, soil temperatures increase, causing the soil to dry up and the earth resistance to increase as well. Therefore, to prevent an increase in the value of earth resistance due to weather change, a grounding system that can be monitored and controlled automatically is needed. The proposed grounding resistance monitoring system is developed in LabVIEW environment. The voltage applied to the electrodes will cause current to flow to the ground, so the earth resistance value can be measured. Experimental results show that the earth resistance value can be measured in real-time, and the data obtained can be used as feedback to control the earth resistance value.

1 INTRODUCTION

In an electrical system, the safety of equipment and users or operators against leakage currents and the danger of thunder is the first priority (Vilacha, Otero, Moreira, & Miguez, 2015). Therefore, an grounding system must be used as part of a safety system. Grounding system is a system that is intentionally made to connect parts of the equipment that are secured with a grounded conductor, to prevent the touch voltage being too high (Lee, Chang, & Jiang, 2015).

The main purpose of the earthing system is to provide safety for the system and the personnel involved in it. There are two main things in the grounding system, namely a grounding system must have a ground resistance value close to zero and prevent potential differences (voltage) between the electrical system and other elements during operation(Caetano, Lima, Paulino, Boaventura, & Cardoso, 2018). In the electrical system, to provide protection for components from damage caused by high voltage and leakage currents, a good isolation and grounding system is needed (Androvitsaneas, Alexandridis, Gonos, Dounias, & Stathopulos, 2016).

The distance between the grounding electrodes is one of the important subjects in the design of the earthing system(Harid et al., 2015; *IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines*, 1997). The greater the distance between the earth electrodes, the earth resistance value is also greater. In this study, another important subject is the depth of the electrodes burial. The deeper, the smaller the earth resistance value(Garip & BAL, 2014; *Powering and Grounding Electronic Equipment*, 2005).

Some grounding methods that have been developed at present are the use of grounding electrodes, associated grounding systems, meshed (mesh) grounding systems, and plate grounding systems(Guo et al., 2014).

The amount of grounding resistance value depends on the specific soil resistance at that location and the type and dimensions of the grounding system installed. A location makes it possible to have different soil structure, both horizontally and vertically(Clark et al., 2014).

Increasing the value of grounding resistance can pose a risk to human safety or components in the system(Clark et al., 2014). To prevent this situation, there are many different ways to reduce the resistance

Ismujianto, ., Aji, A., Isdawimah, . and Nadhiroh, N.
Real-time Measurement for Controlling Grounding Resistance.
DOI: 10.5220/0009910800002905
In *Proceedings of the 8th Annual Southeast Asian International Seminar (ASAIS 2019)*, pages 120-125
ISBN: 978-989-758-468-8

value between grounding electrodes and the surface touch ground. To get the ideal grounding conditions studies need to be conducted to meet the standard earth resistance values(Jafari, Kanabar, Member, & Sidhu, 2019).

In this study, a grounding resistance measurement method is applied continuously, so that resistance values can be monitored in real time. Not only grounding resistance data, ambient temperature is also measured. The monitoring results will be used as a baseline in controlling ground resistance values to overcome changes in grounding resistance values due to weather change.

2 SYSTEM ESTABLISHMENT

Grounding resistance plays a large role in planning a good earthing system. The most effective method of improving the quality of a grounding system is to make the ground resistance value (R_g) as small as possible, ideally zero ohms(Mohos & Ladanyi, 2015; Saleh et al., 2015). This R_g value depends on the resistivity of the soil type (ρ), the length of the ground electrode (L) and the cross-sectional area (A) of the ground electrode(Shariatinasab & Gholinezhad, 2017; Yamamoto, Yoshioka, Sumi, Yanagawa, & Sekioka, 2015). The value of R_g on the ground rod is expressed in the following equation:

$$R_g = \frac{\rho}{2\pi L}[\ln(\frac{4L}{A}) - 1] \quad (1)$$

According to the equation above, one of the most influential factors in determining the value of Rg is the factor ρ. The value of ρ is influenced by soil conditions, where the more moist the smaller the ρ is. Not only that, the resistance value of soil types is also influenced by acidic pH, soil temperature, salt content, soil density, weather, and soil type.

In addition, the Rg value can be improved by enlarging the cross-sectional area, namely by changing the shape of the ground rod to the shape of the ground mesh(Kumar & Bharadwaj, 2015). R_g value on the ground mesh is equal to:

$$R_g = \frac{\rho}{2\pi L}\left[\ln\left(\frac{8w}{0.5w+h}\right) - 1\right] \quad (2)$$

In this study measurements of ground resistance at 2 grounding points that have been buried and not connected to the lightning protection system. The grounding system used in this research is a ground mesh system installed in the area of the Jakarta State Polytechnic Electrical Engineering Laboratory as shown in Figure 1. Both grounding points are buried at the same depth, which is 1.5 meters, and have the same soil conditions. At the first point no treatment was added to the burying of the ground mesh, while at the second point the addition of bentonite powder was made to reduce the ground resistance value(Manikandan, 2015). Therefore, 2 different earth resistance values are obtained.

Figure 1. Ground Mesh Location and Wiring

The system developed in this study is in accordance with the working principle of the earth tester meter, as shown in Figure 3. The P electrode is mounted as far as 10 meters from the earthing point, while the C electrode is mounted as far as 20 meters from the earthing point. Then the measurement of earth resistance is made using the inline method. The current is injected into the earth electrode circuit with 2 auxiliary electrodes, then voltage measurements are taken. The results of the measured voltage distribution (V) and the injected current (I) show the value of Rg, as stated in the following equation:

$$R_g = \frac{V}{I} \quad (3)$$

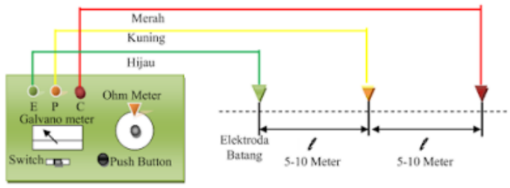


Figure 3. Earth Tester Configuration

2.1 Hardware

The implementation of the measurement of grounding resistance continues is developed in the LabVIEW environment. LabVIEW is a programming language in the form of graphical languages (Nicola et al., 2016). This graphical language, like visual basic, can be used to conduct data acquisition and analysis. Figure 4 shows the hardware system architecture in this study.

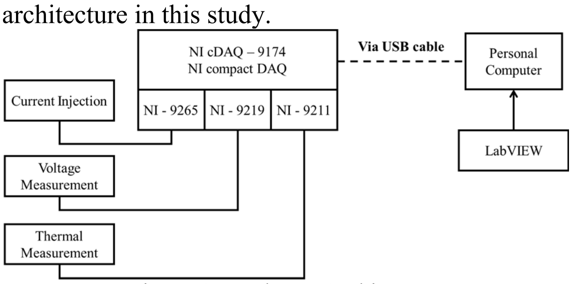


Figure 4. Hardware Architecture

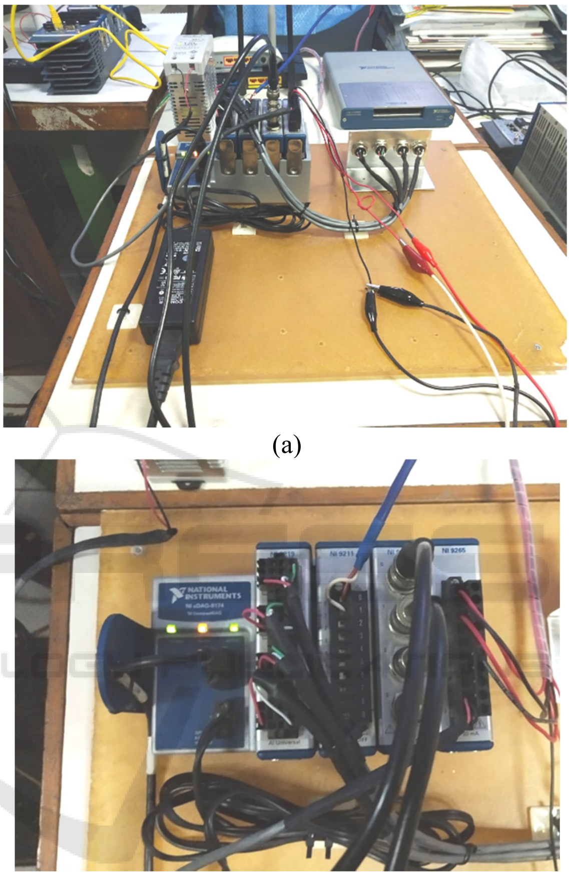
National Instrument Data Acquisition Card (NI-cDAQ) 9174 is used to carry out physical data acquisition such as injection of current, voltage and temperature (*NI cDAQ ™ -9174 NI CompactDAQ Four-Slot USB Chasis*, 2013). The NI-9265 module is a current output module(*NI 9265 Datasheet*, 2015). Each analog channel has a DAC (digital-to-analog converter) that can produce current injection. NI-9219 module is a 4-channel C series universal analog input module that can be used to measure voltage(*NI 9219 Datasheet*, 2017). Whereas NI-9211 is C series temperature input module which is used to measure ambient temperature(*NI 9211 Datasheet*, 2015).

The three physical parameters (current, voltage and temperature) are then acquired by NI cDAQ - 9174. cDAQ communicates with personal computers via USB cable type B. So users can obtain data in real-time and continuously. The working principle of this system is in accordance with the working principle of the grounding resistance meter as explained above. Figure 5 shows the use of the NI-module in this study.

2.2 Software

In principle, the software developed in this study, reads all measurements taken. Communication between software and hardware takes place through Ni CDAQ-9174.

Figure 6 shows the software flowchart. Programming is divided into 2 parts, namely the data acquisition process and the data logging process. In the data acquisition process, after being given an injection of current to the ground of 15 mA, the measured voltage will be averaged every 10 measurements, so that Vmean is obtained. Temperature measurements are carried out to determine the ambient temperature when measuring. Because the characteristics of temperature change are very slow, no average temperature is needed. The output of the data acquisition process is the earth resistance value at both points (R_{GA} and R_{GB}) and ambient temperature (T). The obtained data processed in the form of time function waveform graphs.



(a)

(b)

Figure 5. NI module installation (a) side view (b) top view

Data logging process is the process of storing data in the form of a .txt file. Data storage is done in 1 minute intervals. Measuring ground resistance has been carried out for several days in October 2019. The output of this data logging process is a spreadsheet file containing measurement data, as shown in Figure 7.

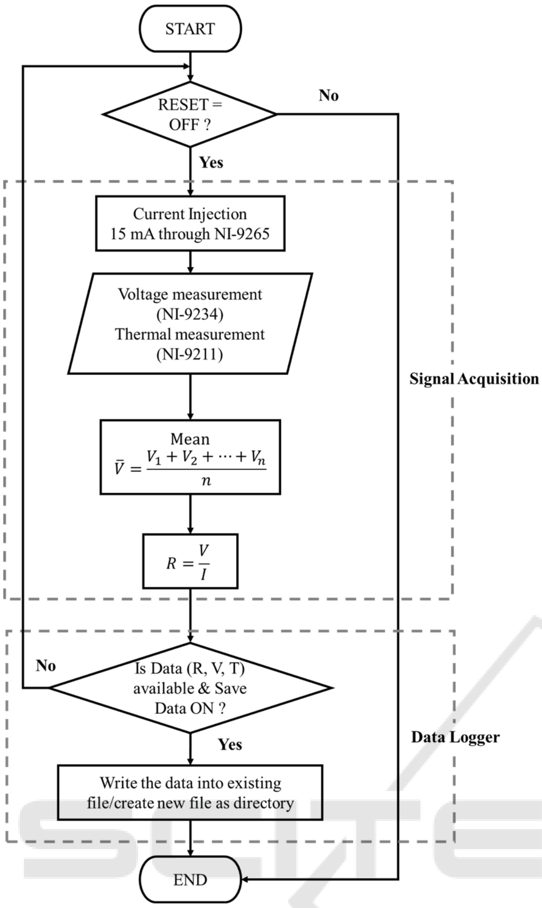


Figure 6. Flowchart of the Software

GROUND RESISTANCE MONITORING SYSTEM
Date: 26-10-2019
Location: Electrical Laboratory of PNJ

Time	TEMP (C)	RGA (ohm)	RGB (ohm)
16:12:00	32.4	20.6	23.5
16:13:00	32.5	20.6	23.5
16:14:00	32.1	20.7	23.5
16:15:00	32.2	20.6	23.5
16:16:00	31.6	20.6	23.5
16:17:00	31.3	20.6	23.5
16:18:00	31	20.6	23.5
16:19:00	30.8	20.6	23.5
16:20:00	30.9	20.6	23.5
16:21:00	30.5	20.6	23.5
16:22:00	30.4	20.6	23.5
16:23:00	30.5	20.6	23.5
16:24:00	30.5	20.6	23.5
16:25:00	30.5	20.7	23.5
16:26:00	30.3	20.6	23.5
16:27:00	30	20.6	23.5
16:28:00	30	20.6	23.5
16:29:00	30	20.6	23.5

Figure 7. Spreadsheet file from data logging

3 RESULTS AND DISCUSSION

Real-time measurement of grounding resistance software successfully shows and records the earth resistance value, as shown in Figure 8.

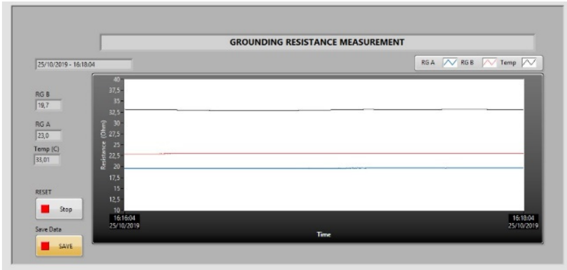


Figure 8. Display of Measurement Software

On the front panel, it can be seen the date of measurement, the magnitude of grounding resistance at points A and B (R_{GA} and R_{GB}), and ambient temperature (T). Not only that, the three physical parameters are displayed in the waveform graph. The front panel is also equipped with a "Reset" and "Save Data" button. The reset button functions to repeat the measurement, while the save data button must be activated if the data is stored according to the specified folder directory.

The continuous testing of the performance of the grounding measurement system was carried out during October 2019. The measurement results are shown in Figure 9 and Figure 10.

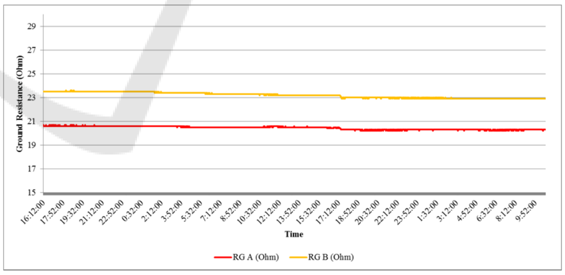


Figure 9. Graphic of R_{GA} and R_{GB}

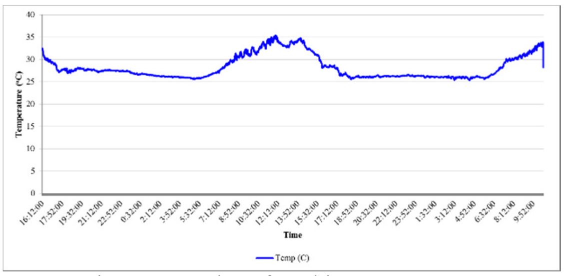


Figure 10. Value of Ambient Temperature

Based on the graph above, the average value during measurements in October showed an R_{GA} value of 23.2 Ohms; R_{GB} of 20.4 Ohms; and ambient temperature of 28.2 ^oC. Grounding resistance value is still very high, this is because special controlling treatments have not been done to reduce the value of earthing resistance. The R_{GA} value is greater than the R_{GB} value due to the addition of bentonite at point B. In figure 10, ambient temperature does not show a significant impact on the measurement of grounding resistance.

In general it can be stated that the measurement system developed in the study works well, so that it is able to measure the value of earth resistance at both points. Measured data, it can be recorded at intervals every 1 minute.

4 CONCLUSIONS

In this study, the development of a real-time and continuous grounding resistance measurement system shows excellent results. The measurement system was developed in LabVIEW language and uses a reliable sensor module and output module. From the data taken, it is found that the earth resistance at both earthing points is still far from ideal, the R_{GA} of 23.2 Ohms; R_{GB} of 20.4 Ohms. In subsequent studies the data obtained can be used as feedback to control the grounding resistance value.

ACKNOWLEDGEMENTS

This research was funded by the Jakarta State Polytechnic under contract number 215 / PL3.18 / PN / 2019 in the Decentralized Research Program "Skim Penelitian Produk Terapan".

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