The Design of Resistivity Tool for Subsurface Based on Microcontroller

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Abstract. The objective of this research was to detect groundwater, to provide information of subsurface structures, and to determine the thickness of each layer. Geoelectric method used is the resistivity method. Where the subsurface material resistivity data is obtained by injecting an electric current from the earth's surface below the surface, its current and potential are measured on the earth's surface. The data recording technique used sounding method (1D), which we measure data below the measurement point. The electrode configuration was a Wenner configuration in which the distance of the electrode at the ground surface has the same distance. With a laboratory test unit using a container made of glass 100x10x40 cm³ which contains clay, sand, and water. Due to the complexity of subsurface materials, IPI2Win as data processing software resistivity. From data processing, it can be seen that there were three layers of subsurface material with successive thicknesses of clay (4 cm), sand (12 cm), and water (8 cm). It can be concluded that the tool is able to detect the number of subsurface layers and the thickness of each layer. It could also determine the difference of the type resistivity of each layer type detected.

1. Introduction
Geographical location in Indonesia causes the territory of Indonesia to have a monsoon climate or called the seasonal wind, which affects the changing seasons. Because it is located in the tropics, the seasonal changes in Indonesia occur two seasons namely the rainy season and dry season. The rainy season often results in landslides or floods or long dry seasons are often detrimental to the population, especially to farmers where much of the farmland becomes dry, livestock dies as the grass becomes dry. Water is a basic human need, without human water can not survive. The availability of clean water is difficult to obtain when floods occur, flooding not only water, but also carrying waste, sewage, factory or chemical waste, oil (oil, gasoline, diesel, kerosene, etc.) that can contaminate the source of clean water. However, clean water will be difficult in the case if the prolonged dry season occurs such as a well or a dry water volume is small. Therefore it is necessary to search groundwater by finding the location that has the feasibility of ground water to be made wells drill [1].

In this case there are several methods that can be used to determine the potential of ground water. One of them is the geo-electric method that studies the nature of electric current in the earth. The advantage of this method is that it can be used to conduct shallow, non-destructive exploration in its detection. The detection above the surface of the earth includes measurements of current and electromagnetic potential fields that occur both naturally and by injection of currents into the earth.
Geoelectric by using resistivity method is to inform the structure of the underground surface layer [2, 3].

Basically all objects have a resistivity type (resistivity) is the ability of a material to conduct an electric current that depends on the magnitude of the field and current density. The greater the resistivity of a material the greater the electric field required to generate a current density. The unit for resistivity is ohm-meter (Ω.m). Every object such as land, water and air has a different resistivity. From the different values of resistivity, each object or material can be differentiated using a geo-electric method. One application of this type of resistivity location method is to search for groundwater location [4].

In geophysical methods, observational data is a response of subsurface geological conditions. The response arises because of the variation of physical parameters i.e. the conductive properties that reflect the formation or subsurface geological structures. The model is a representation of the geological state by the magnitude of the physics so that problems can be simplified and the responses can be estimated or calculated theoretically. The quantities or variables used to characterize the model are called model parameters that generally consist of physics parameters and their variation to position. Therefore the method of type resistivity is capable of determining the groundwater location located on the underground surface, which in use will help the parties working in searching the location of the springs are located [5].

The above issues encourage authors to create an underground monitoring tool capable of detecting and giving an overview or display on a PC or laptop display screen in the form of a one dimensional display (1D) using IPI2Win software on the structure of the subsurface layer, as well as objects to be searched or researched. So as to facilitate the user in identifying and analyzing a location on the ground surface (earth) [6-10].

The objective of this research was to detect groundwater, to provide information of subsurface structures, and to determine the thickness of each layer. The method used is geoelectric resistivity method with Wenner configuration.

2. Methods
At this stage, in figure 1, there are several block diagrams that will explain the design of the hardware.

![Figure 1](image-url)
In the A-block section is a sub-system for designing current measurements that are injected at the soil surface. The function of pressing the hold key is to hold the data so that the display on 16x2 LCD will give notification of the status button. In the B-block is a sub-system for designing voltage measurements on the ground surface of the hold button press function is to hold the data so that the display on 16x2 LCD will give notification of the status button.

3. Results and discussion
After going through the design process, this chapter will describe the results of geoelectric instrument testing with the media to be tested is clay, sand and water. The precision measurement of geoelectric devices using a microcontroller will be compared to a geoelectric device using two multimeters in which one digital multimeter measures voltage and the other for measuring the current. Before doing the measurement, the geoelectric device using the microcontroller is calibrated for the accuracy of the measurement and to know the percentage of error.

A geoelectric appliance that uses two multimeters where for a multimeter voltage meter there is no additional circuit configuration, whereas for a multimeter current meter, the positive probe is connected to a positive pole 12V supply and the negative pole becomes supply to inject on the ground surface object.

Figure 2. (a)The composition of the soil layer on the test (b) Geoelectric appliance using microcontroller.

In figure 2(a), the following measurement uses two layers of soil is the first layer or the top layer is clay and the inner layer is sand and in the second layer there is a space that contains water. In figure 2(b), a geoelectric tool using microcontroller, however description above picture that is:
- LCD 1 and 2: displays current and voltage measurement values.
- ON / OFF: switch to discharge or disconnect the supply on the system.
- HOLD 1and 2: to hold current and voltage measurement data that appears on LCD.
- Number 1 and 2: is a positive probe also a negative probe to measure the current.
- Number 3 and 4: is a positive probe is also a negative probe for current injection on a ground surface object. With a positive current probe configuration connected to the negative supply probe 12 V then the negative probe from the supply will be used as a current injection on the ground surface.
- Number 5 and 6: is a positive probe is also a negative probe to measure the voltage.

The calculation process to get the type of resistivity measurement data that has been obtained, in the process using Ms. Excel. With the initial measurement point generated $\rho = 33.76248 \, \Omega \cdot m$ (with multimeter digital) and $\rho = 35.03847 \, \Omega \cdot m$ (with microcontroller) the results can be compared with reference data, where for this type of rock is included in the clays type and the final measurement point is generated $\rho = 661.6858 \, \Omega \cdot m$ (with multimeter digital) and $\rho = 620.852 \, \Omega \cdot m$ (with microcontroller) it
can be compared with reference data, where for rocks with this resistivity value is mineral type surface water. Then the measurement data obtained is the voltage data and current data is processed using IPI2Win software.

Calculation process using an application that is for exploration geoelectric that is IPI2Win. The result of the calculation here is obtained with the initial measurement result \( \rho = 50.669 \, \Omega \cdot m \) (a) and \( \rho = 52.584 \, \Omega \cdot m \) (b). The result can be compared with reference data, where for this type of rock is included in clays type and the final measurement point is \( \rho = 993.03 \, \Omega \cdot m \). And then \( \rho = 931.75 \, \Omega \cdot m \) can be compared with reference data, where for rocks with this resistivity value is mineral type surface water.

When resistivity results are obtained then proceed with the distribution of measurement points into a graph. Then from the results of the graph can be obtained the percentage of measurement error obtained. Showing the point of distribution of the test, this result is obtained after the input data has been processed.

Based on measurement data that has been obtained from 24 test points ranging from the distance of the test point 2 cm to 25 cm, gives a good result because it is able to provide information about the structure of the subsurface layer.

- Based on calibration of current meter between digital multimeter with microcontroller has difference of error equal to 2.44%. And calibration of measuring instrument of voltage between digital multimeter with microcontroller have difference of error equal to 1.83%. Therefore, measuring instruments using microcontroller produce measurement approaching the measurement value using digital multimeter. It can be concluded that the calibration result is quite good because the error rate is still below 5%. So that the measuring tool using a microcontroller can be used properly.

- Based on the figure 4(a) of the measurement graph and the error correction it gets is 25.01% when compared to the figure 4(b) of the graph and the error correction obtained by 20.1%. Then the measurement using a digital multimeter also microcontroller has a fairly close error. But we can see the error rate using microcontroller is smaller than the digital multimeter. Regarding the underground layer can be known level of coating thickness in the figure 4(c) (d). For clay has a layer thickness of 4, for sand has a thickness of 12, and for water has a layer thickness of 8 (cm).

4. Conclusion
Based on calibration result of measuring instrument has small difference of error with digital multimeter so that result of measurement by using microcontroller approaching measurement value using digital multimeter. Based on the experiment results it can be seen that there are three layers below the surface, the first layer is clay (thickness 4cm), the second layer is sand (thickness 12cm) and the third layer is water (thickness 8cm) with a total thickness of 24 cm. Based on the result of measurement data compared with reference data shows unsuitable result, that is for water layer has very high resistivity value (700 \( \Omega \cdot m \)) when compared with reference value for water (natural water) with a resistivity range of 1-100 \( \Omega \cdot m \). From the above point, the goal to be achieved from making geoelectric equipment using microcontroller is only able to detect the number of layers of underground surface and the depth or thickness of the layer. However, this tool is still not perfect because there is a failure in determining the difference of detected type resistivity. For the development process and address some of the problems that occur are given suggestions.

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