Electrical Signal Propagation in Four Probes System
Measuring at The Range of 20Hz - 600Hz

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Abstract. The electrical-supply on the earth's surface are propagate from the positive electrode to the negative electrode. The electrons flow from the negative electrode to the positive electrode. In the conductor wire, an electric current tends to pass through the wire shell. The charge density decreases in proportion to the depth, the increase in frequency, and the material permeability. Based on these factors, practically, the conductor surface is often extended by making fibbers. If one of the trajectories on the earth gives an electric voltage, then the earth is not a perfect conductor, the earth as a large object with a surface is predicted to be relatively difficult to deliver an alternating electric current. Based on the previous statement, the granting of an electric current, and will more difficult to flow when the frequency is increased. The aim of this research is to find out the phenomena of earth resistance in the range of 20Hz-600Hz. It is expected that this data are useful for determining the frequency of effective exploration or also as a consideration when interpreting data. The study is conducted by giving an electric field to two electrodes with a measured current. Two electrodes are plugged into the ground for injecting current, and two others electrodes to pick up voltage which was reached. The measurements were made with an oscilloscope. The frequency was varied while recording the current that flow. The current flowed from the square wave current source that could be varied from 20Hz to 600Hz. From this experiment, it is found that the voltage decreases relatives along with the increase in the frequency.

1. Introduction
Electrical signals propagate due to the electric field. The flow of electrons or ions in an object is dependent on the conductivity of the object. If the copper wire with a diameter of 1mm, then due to the electric field, electrons in the copper wire will flow. Its flow depends on the electric field applied to the object and its current density. If a 5mm diameter copper wire is given an electric field, electrons in the copper wire will flow. The flow in this 5mm diameter wire is easier than the flow of electrons in the 1mm diameter copper wire. Its flow depends on the electric field applied to the object and its current density. If the electric current is applied to two pieces of plate parallel to the non-conductor material between the two plates of the plate, then the electric charge will flow briefly then stop. The load will fully fill the two plates and cannot continue to flow. This event is a phenomenon of capacitors. The earth can be electrified, but more difficult than copper wire. Because the earth is made...
up of materials that are not full conductors. The earth contains rocks, salt, and many other materials that cannot be mentioned one by one.

If the earth is given an electric field, then the electric field will hit the rocks making up the earth, which constituents can be either good conductors, poor conductors, insulators, or electric cells. The composition also varies. The arrangement can be in the form of resistors, capacitors, inductors, or complex arrangements of various components. If it is a conductor, then electricity will occur in these rocks. If the conductor is bad, the electric current will be more difficult to flow, and so on. If the arrangement is similar to capacitors and resistors, then the bias will be like a low pass filter or high pass filter, or other filters.

2. Background

A simple capacitance-resistance model (CRM) that characterizes the connectivity between reinjection and production wells can determine an injection scheme that maximizes the sustainability of the geothermal reservoir asset (Akin, 2014). The capacitance resistive model (CRM) is takes into account implicitly the geological and reservoir parameters, is used to find inter-well connectivity by layer (independent reservoir), optimize injection rates with the complement of net sand maps and petro-physical and production test data, and check the consistency of the solutions with all the available data to support the decisions (Gamarra & Borsani, 2019).

Earth’s capacitive and receptive factors are interesting to study. Noting the nature of the earth that can be electrified, possessing self potential, having capacitive or polarisative properties, and a very diverse array of earth, this research was conducted by injecting an electric current whose frequency is varied, with the aim of knowing the electrical properties of the measured area. The starting point for thinking is, if the earth is purely resistive, then the electrode voltage is relatively constant for various frequencies. Because of the resistor,

\[ V = IR \]

while the value of R is fixed. In this equation, it appears that the voltage at the ends of the receiver is not affected by frequency.

The amount of resistance R is:

\[ R = \frac{\rho l}{A} \]

where,

- \( R \): resistance
- \( \rho \): electrical resistivity

\( A \): cross section

And \( \rho = \frac{m}{n e^2 \tau} \)

where:

- \( \tau \): waktu rata-rata terjadinya tumbukan
- \( e \): muatan elektron
- \( m \): massa elektron
- \( n \): jumlah tumbukan per satuan volume

In a series of resistors and capacitors arranged in series, the voltage at the end of the capacitor is:

\[ v_c = V \left( 1 - e^{-\frac{t}{\tau}} \right) = V \left( 1 - e^{-\frac{1}{\tau}} \right) \]
voltage at the end of the resistor:

\[ v_R = V e^{-\frac{t}{CR}} = V e^{-\frac{t}{\tau}} \]

while the current flowing:

\[ i = I e^{-\frac{t}{CR}} = I e^{-\frac{t}{\tau}} \]

(Bird, 2001)

If the area of the electrode voltage is capacitive, the voltage between the electrodes will decrease with increasing frequency. Because on a capacitive system,

\[ X_C = \frac{1}{\omega C} \]

From the equation, it appears that the capacitive reactance value decreases with increasing frequency. If the electrode voltage is inductive, the voltage between the electrodes will increase with increasing frequency. Because on the inductive system,

\[ X_L = \omega L \]

However, if the arrangement consists of series or parallel or series of complex, the voltage value needs to be added by a vector. In a complex arrangement model, the capacitor and inductor can act as a pair which co-filling and emptying the current applied. In this case the resonance system. If the voltage electrode is planted in the capacitor-inductor pair, the electrode voltage will be the highest or lowest among other frequency data depending on the arrangement of series or parallel.

3. **Experiment Design**

In this study, the current is injected by a solid state switch circuit. The solid state switch is controlled by a microcontroller. The duration of the current forward, silent, or backward can be set. In this study, each cycle was 25%. Voltage is measured at the voltage electrode implanted in the middle between the two current electrodes. The illustration of this research system is as follows.
In the picture above, points are drawn with the notation P, Q, A, M, N, B. In the first quarter cycle, during the interval t seconds, the voltage at point P is greater than at point Q. As a result the current flow of P-A-M-N-B-Q. At the second quarter cycle, during the interval t seconds, the voltage at point P is equal to the voltage at point Q. As a result, there is no current flowing from anywhere or anywhere. At the third quarter cycle, during the interval t seconds, the voltage at point P is lower than at point Q. As a result, the current flow Q-B-N-M-A-P occurs. In the fourth quarter cycle, during the interval t seconds, the voltage at point P is equal to the voltage at point Q. As a result, there is no current flowing from anywhere or anywhere. This is the cycle that is controlled by the control unit. As a result, current can flow from A to B, or from B to A, or rest depending on the control unit. The price of t depends on the control. As a result, the current flow period from A to B and from B to A can be controlled according to the desired frequency.

The direction and magnitude of the current flow can be sensed by the hall sensor. Hall sensor produces a voltage that is proportional to the amount of current flowing. The hall sensor also produces a voltage polarity that is proportional to the direction of the current flowing. When the arsenic flows, electrons pass through the earth. But earth's material has resistive, or capacitive, or inductive properties. As a result, at the point M-N voltage arises. If the passing current is controlled back and forth from A to B and from B to A periodically, with a period that can be varied, the voltage at M-N will also be different.

The point between M and N is measured by the voltage, first amplified. Strengthening results are measured with a digital storage oscilloscope. The oscilloscope in addition to measuring the M-N voltage, also measures the hall sensor voltage. Thus the digital storage oscilloscope can display the voltage and phase M-N, and also the hall sensor.

From this step, the magnitude of the frequency of the current injected to A-B is varied. It is expected that with this variation obtained the price of M-N voltage that does not remain dependent on the earth's structure between M-N. The frequency in this study varies in the range of 20Hz-600Hz.
4. Results and Discussions
From the results of the measurement of current injection on A-B, and the M-N voltage obtained the measurement results as shown in Figure 1 below.

Figure 1. 600Hz Current Injection (channel 2, blue) and M-N Voltage (channel 1, yellow).
Figure 2. M-N Voltage at 600Hz Frequency, at 1.32V.

For other frequencies, the same methods and measuring devices obtain prices as shown in the following Table 1.

| Current Frequency (Hz) | Voltage (V) |
|------------------------|-------------|
| 20                     | 2.32        |
| 120                    | 1.88        |
| 220                    | 1.8         |
| 320                    | 1.64        |
| 420                    | 1.4         |
| 520                    | 1.48        |
| 600                    | 1.32        |
Figure 3. Graph of Voltage Electrode Voltage with Frequency Variations of 20-600Hz

Looking at the graph above, the M-N voltage tends to decrease along with the applied frequency. The data is somewhat different at the 520Hz frequency. Predicted, this is due to lack of observer in placing the oscilloscope cursor. The reason for the influence of noise is very small. Because 520Hz is not an odd or even multiple of the PLN electricity frequency, either 1 phase, 2 phase or 3 phase. The frequency of PLN at the test site is 50Hz. So that noise that might arise near the 520 Hz frequency is 450Hz, 500Hz, or 550Hz. Paying attention to the frequency prices arising from the PLN grid in its effect on the results of this study the data is relatively small, except at the 600Hz frequency only. Because the frequency has been set outside the multiple of the electrical frequency grid.

5. Conclusion
From the results of these experiments, the M-N electrode voltage has a tendency to go down with the frequency imposed on the current electrode.

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