

Automated Geophysical Field Calculator For Schlumberger Electrode System (Sescal v1.2)

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Abstract

The aim of this paper is to establish a simple, quick and yet consistent and reliable approach for solving the geometric factor (k) and the Apparent Resistivity (ρ_a) based on the various electrode configurations for geophysical field survey available using the various measured quantities of the current electrode and potential electrode spacing respectively.

The computer program is a simple development based on scripting. Swish script is the major driver along side the hyper text messaging language (html) developed and housed in flash-java containers.

Its main features are the potential electrode spacing, current electrode spacing, the instant resistance reading (V/I) (this is usually the reading from the measuring device, usually a terrameter), the Geometric factor and the Apparent Resistivity (ρ_a). The ability to modify the basic quantities like current electrode spacing, the potential electrode spacing and the V/I to suit individual field practice makes a unique program / software.

On execution of the program, it was found that both the geometric factor (k) and the apparent resistivity (ρ_a) values are automatically displayed once the respective field data were input accordingly and the execute button clicked. It was tested for values of $L = 1.0, 1.47, \dots, 100$ and $l = 0.5, \dots, 500$.

Keywords: Apparent Resistivity (ρ_a), Geometric factor (k), potential electrode spacing (l), current electrode spacing (L) flash content, hyper text messaging language and java environment

1.0 Introduction

Geophysical survey involves the use of one or more of the methods of investigation in searching or probing the earth for some parameters that are diagnostic of existence of some natural and mineral and non-mineral resource alike for further investigation or interpretation or outright extraction / exploitation .

Invariably, the end result is always a final analysis from the draw board of the initial calculations and expertise put together and I must say here that the finesse with which these two are handled determines the millions gained or millions lost in any work environment and or even research environments.

Electrical resistivity method is one of the most widely used geophysical methods in sedimentary and basement complex terrain. This method is commonly used for detailed geologic and hydrogeologic exploration which includes; groundwater, geologic and subsurface foundation studies, aquifer delineation, lithologic boundary differentiation and geothermal activities. [1]

Generally, resistivity survey technique involves the passing of current into the ground by means of a pair of electrodes called current electrodes and measuring the potential difference by means of another pair of electrodes called potential electrodes [2]. Of these methods, the Schlumberger, the Wenner and dipole have come to bear a very significant role in their respective usefulness to which they have been well adapted mainly, VES, CVES and profiling.

An in-depth analysis of the development was an attempted assembly between the very many electrode system types. But the process showed a wide range of differences between the various geophysical electrode arrays types, thus producing a common source calculator was initially a wide goose chase.

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However, the generalized Schlumberger electrode system was finally adopted and thus used as the prototype for the calculator SESCOAL v1.2 developed based on the generalized Schlumberger field array [3], where the accepted procedure of passing current into the earth by means of a pair of current electrodes and measuring the potential drop through a second pair of potential electrodes was used.

2.0 Theoretical Background

The theory of electrical resistivity of a layered earth [4] is well known and has been extensively described [4 – 6].

In conventional field operations, the inner (potential (M &N)) electrodes remain fixed, while the outer (current (A & B)) electrodes are adjusted to vary the distance L . The spacing l is adjusted when it is needed because of decreasing sensitivity of measurement. The spacing l should at most always be less or equal to $0.4L$ or the potential gradient assumption is no longer valid. Again, the l spacing may sometimes be adjusted with L held constant in order to detect the presence of local inhomogeneities or lateral changes in the neighborhood of the potential electrodes [7]

The Schlumberger, electrode system as used in this work also described elsewhere [1,4,8] has the following quantities based on the generalized system as shown in the figure 1:

- A = current electrode 1
- B = current electrode 2
- M = potential electrode 1
- N = potential electrode 2

When the above is put together, it will give ;

$$V = IR \quad \text{(Ohms Law)} \quad (2.1)$$

$$R = \frac{V}{I} \quad \text{(Terrameter Reading)} \quad (2.2)$$

Where V = Potential Difference in Volts (v)

I = Current in Amperes (A)

R = Resistance in Ohms (Ω)

$$\frac{AB}{2}(L) \text{ (current electrode Spacing)} ; \frac{MN}{2}(l) \text{ (potential electrode spacing)}$$

We can arrange the above to get the generalized Schlumberger relation.

$$\rho a = \pi \left[\frac{L^2}{l} - \frac{l}{4} \right] \frac{V}{I} = \pi a \left[\left(\frac{L}{l} \right)^2 - \frac{1}{4} \right] \frac{V}{I} \quad (2.3)$$

From equation 2.3, the Apparent Resistivity (ρa) of the generalized Schlumberger relation can be deduced as ;

$$\rho a = (K) \frac{V}{I} \quad (2.4)$$

Where (K) the geometric factor is given by:

$$K = \pi \left[\left[\frac{L^2}{l} - \frac{l}{4} \right] \right] \quad (2.5)$$

Equation 2.5 is simplified further to give the K relation that was used in this program as

$$K = \left[2\pi (L^2 - l^2) \right] \quad (2.6)$$

Equations (2.1), (2.2), (2.4), (2.5) and (2.6) form the main internal architecture of SESCOAL.

3.0 Methodology

A generalized Schlumberger field layout model is first developed and it is comprised of the form, layout and measurements. Hence a workable model for the apparent resistivity and geometric factor was obtained after the first testing.

The program started with declaring of variables, statics, containers and inputs of dynamic quantities etc

After declaring the current, potential, resistance, geometric factor and apparent resistivity as text objects, the quantities are then given their unique properties that will differentiate them for their respective functions:

Each **text object** has one of the following properties:

Input property, Static Property, Dynamic Property, Target property, Maths property.

While the following **operations properties** were also given to the respective statements.

Target property, Operator Property, Name Property

```
// Declare current electrode 1 as current .text = static quantity (.text)
{ Current.text }
// Declare Potential electrode 1 as potential .text = static quantity (.text)
{ Potential . text }
// Declare current electrode 2 as current = input quantity (.dynamic .text)
// Declare potential electrode2 as potential = input quantity (.dynamic .text)
// Declare current input to hold both static and dynamic content as a variable.
{ currentVar }
// Declare potential input to hold dynamic and static content as a variable.
{ potentialVar }
```

Next, Declare the V/I field to also hold both dynamic content and static content.

The **Events** procedures are given as follows:

The events used here were the On Press, On Release and trace events:

```
On(Press);
On(Released);
Trace (trace){ }
```

They are all button related.

The, onpress (button pressed) works with the trace expression, hence we then introduce a container or variable expression below.

$$K = \left[2\pi (L^2 - l^2) \right] \quad (2.7)$$

$$\rho_a = K \frac{V}{I}. \quad (2.8)$$

Once, the onrelease, (Button Released), action triggered, the above relations are executed and the containers emptied.

The final script that will execute multiple lines of action unit is:

```
//
On (Press) {
//
// trace ("Button Pressed") ;
// (((current.text * current.text) -
// (potential.text * potential.text)
// )
// )
// *
// (Math.PI)
→/
// (2 * potential.text)
//
} End
```

4.0 Results and Discussion

Figure 2, displayed the results of the program when 1.0 is input as the Current electrode distance and 0.5m is input as the potential electrode distance, and 2.9 ohms is input as the resistance value from the terrameter.

It displayed 2.35619449019 as the geometric factor and 6.83296402155 ohm meter as the apparent resistivity.

Similarly, figure 3, displayed the results of the program when 1.47 is input as the Current electrode distance and 0.5m is input as the potential electrode distance, and 2.11 ohms is input as the resistance value from the terrameter.

It displayed 6.00326940174 as the geometric factor and 12.6668984376 ohm meter as the apparent resistivity.

In case of wrong entry or general miss type etc, the process to effect change or cancel or reset the whole operation is also a very simple and straight forward one. In this case only the on(press) is modified with the trace statement, and introducing an expression of continuity and the cancel procedure will look like:

```
On (press) { trace. ("Button Pressed");
resVar = "";
currentVar = "";
potentialVar = ""; End
```

Hence, the above script, resets or cancel the dynamics input of the variables once the action is triggered by the onpress event.

Figure 4, displays the result of the cancel procedure.

However, the cancel process is tailored to affect only the dynamic input rather than the dynamic output.

Hence it was also discovered that SESCAL has a 100% accuracy based on a 2 decimal correctness and non-zero value greater than values for potential electrode spacing.

The range is found in the following neighborhood;

Current electrode:	1.0 m	- 9999.9 m
Potential electrode:	0.1 m	- 999.9 m
Resistance Reading:	0.1mΩ	- Infinity

The Instant reading (V/I) input is designed to hold values in the range of 0.1 milliohms to infinity based on the capability of the measuring device. (eg. Terrameter)

Interestingly, the Geometric factor (k) and the Apparent Resistivity (ρ_a), are both unlimited by the output values as a relation to the range of data input at the dynamic input levels which may be beyond the capability of some short programs of its class developed for the same purpose.

However, it must be noted that Negative Resistive reading is as a result of unblended frequency (high noise to signal ratio) hence the negative sign should be ignored when imputing the resistance terameter values from the field.

Conclusively, more field measurements testing is recommended to increase the near-zero percentage error of the program while more research work is also encouraged for the SESCAL to increase its capabilities to the level of graph display, as this is its only limitation for now.

Beyond this, SESCAL is well suited for any field work in the realm of Schlumberger, Wenner and the Dipole.

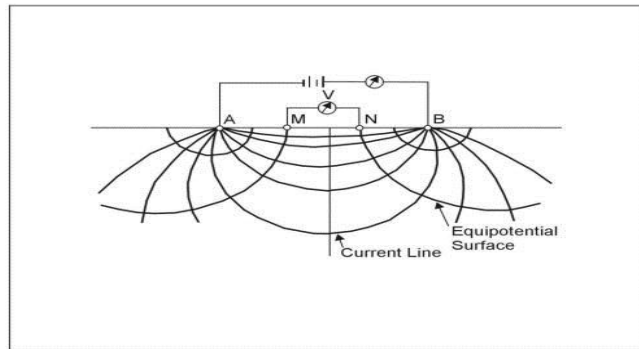


Fig. 1: Field Arrangement of the Generalized Schlumberger Electrode Configuration

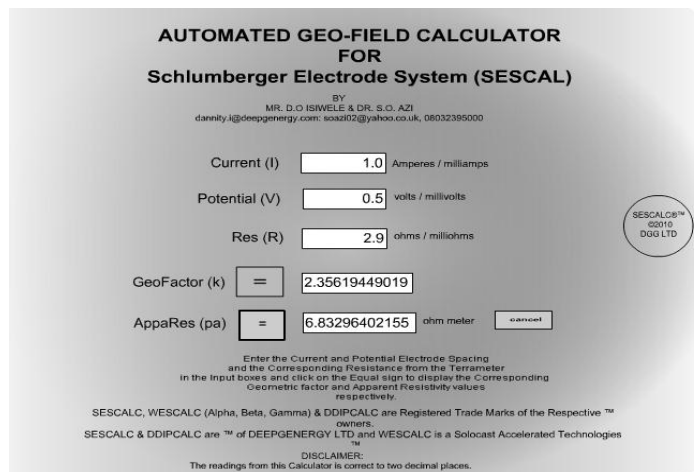


Fig. 2 A screenshot of the Program on execution {L = 1.0, l = 0.5}

**AUTOMATED GEO-FIELD CALCULATOR
FOR
Schlumberger Electrode System (SESCAL)**

BY
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Current (I) Amperes / milliamps

Potential (V) volts / millivolts

Res (R) ohms / milliohms

GeoFactor (k)

AppaRes (pa) ohm meter

Enter the Current and Potential Electrode Spacing and the Corresponding Resistance from the Terrameter in the input boxes and click on the Equal sign to display the Corresponding Geometric factor and Apparent Resistivity values respectively.

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SESCALC & DDIPCALC are TM of DEEPENERGY LTD and WESCALC is a Solocast Accelerated Technologies TM

DISCLAIMER:
The readings from this Calculator is correct to two decimal places.

Fig. 3 A screenshot of the Program on execution {L = 1.47, l = 0.5}

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Fig. 4 Screenshot of calling up the Cancel Procedure

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