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# Design and Fabrication of a Portable Resistivity Meter for Ground Water Exploration.

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**ABSTRACT**
The cost of brand new resistivity meters(Scintrex, Bison, ABEM) has gone up astronomically, consequently many institutions that need this equipment for teaching and research purposes can not afford the price. This predicament compelled the authors to look for electronic components that are available in local markets and shops to fabricate this meter. This simple resistivity meter was then designed and constructed using components purchased locally. It measures the resistance directly. A comparison test was conducted with this meter using the ABEM Terrameter SAS 300 as the standard meter. The field testing exercise was conducted on an open field with a flat terrain. The results/data from the two instruments are very comparable and almost the same for a spread of AB/2 = 100m. Beyond this spread, the difference in readings is much. Hence, the use of this system is limited to shallow investigations where the target depth is not more than fifty metres(50m). Efforts are being made to improve on its performance.
**Keywords:** Resistivity, Meter, Comparison, Components, Equipment.

## I. INTRODUCTION

The soil resistivity is a measure of how much the soil resists the flow of electricity. It is a critical factor in the design of systems that rely on passing current through the Earth's surface. An understanding of the soil resistivity is necessary to design the grounding system in an electrical substation. It is needed for the design of grounding electrodes for substations and High-voltage direct current transmission systems (Zhang et al., 2013).The earth is used to conduct fault current when there are ground faults on the system in most substations. There is some maximum step voltage must not be exceeded to avoid endangering people and livestock. Though the soil resistivity value is subjected to great variation, due to moisture, temperature and chemical content. To achieve this objective, a suitable low resistance connection to earth is desirable (Ingeman et al., 2016; Igboama and Ugwu, 2011). However, this is often difficult to achieve and depends on a number of factors such as soil resistivity, stratification, size and type of electrode used, depth to which the electrode is buried, chemical content and moisture of the soil under study. These investigations include a number of geotechnical and geophysical tests sufficient for defining the soil/rock characteristics, groundwater conditions, and other existing features of importance to foundation design (Adepelumi and Akinmade, 2013). Several geophysical methods are routinely used to image the subsurface of the earth in support of subsoil investigations. Commonly employed geophysical methods include seismic tomography, ground penetrating radar, electrical resistivity, electromagnetic and gravity methods (Oluwafemi, 2012). However, in terms of spatial resolution, cost-effectiveness and target definition, ground penetrating radar and electrical resistivity methods ranked first and second respectively. In view of this, electrical resistivity method was used to investigate the subsurface stratigraphic relationships or variation of subsurface materials in federal polytechnic Offa Kwara State, Nigeria, as an aid to construction engineers. Geo-electrical measurements are an important and integral component of geophysical investigations connected with environmental problems (Oyedele and Ekpoette, 2011; Adelusi et al., 2012). In recent years, electrical resistivity surveys have progressed

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rapidly from the conventional sounding survey, which provides layer depths and resistivity values at a single place, to techniques which provide two-dimensional electrical pictures of the subsurface. Four-electrode profiling has been employed in soil practices since 1931 for evaluating soil water content and salinity under field conditions. An electrical cell used to measure the conductivity of soil solution or saturated soil pastes were developed (Nadler, 1982; Rhaodes, 1989) The method of four-electrode profiling was also used for evaluation of some other soil properties, such as soil water content (Edlefsen and Anderson, 1941; Kirkham and Taylor, 1949), structure bulk density, porosity, and texture (Banton et al., 1997; Klasner and Calengas, 2013; Gilbert et al., 2019). In the present study, we fabricated a resistivity meter using available materials that could measure soil resistivity or its inverse. This was necessitated by the high cost of importation of ready-made products today.

## II. MATERIALS AND METHOD

The design of the resistivity is based on the electrical resistivity method. The theory of design employed is based on the principle that the measurement of current can be measured directly and being divided by induced voltage from the ground. This method is a modified to previous techniques using a constant, either by a regulator or manually fixing it during probing. A basic circuit block diagram is shown in Fig. 1. The basic block diagram comprises of the potential measuring circuit, the current measuring circuit and the Arduino microcontroller controlled display circuit to give the various measurements like the current and voltage sent to the ground. These values were used by the Terrameter is made to calculate the soil resistivity and the soil conductance automatically. The block diagram of the design of the Terrameter is shown in Figure 1. It comprises of the followings:

a) Transmitting and Receiving Electrode
b) High Voltage DC circuit consists of
i. The inverter circuit ii. The voltage multiplier circuit
c) ADS1116 has differential inputs
i. Current measuring circuit ii. Induced Voltage circuit
d) The microcontroller and display unit

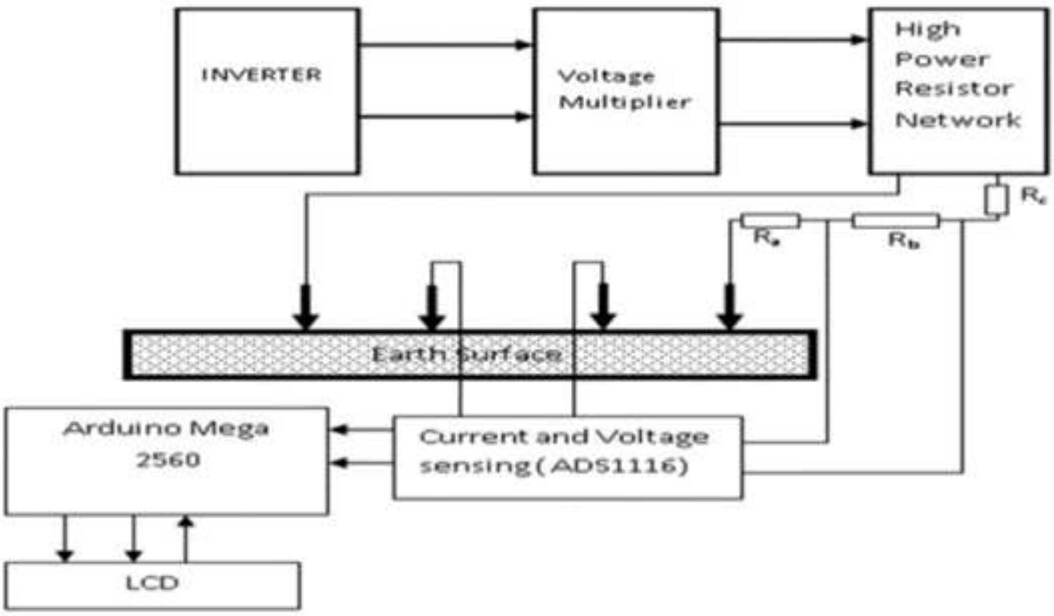


Figure 1: Block Diagram of a terrameter

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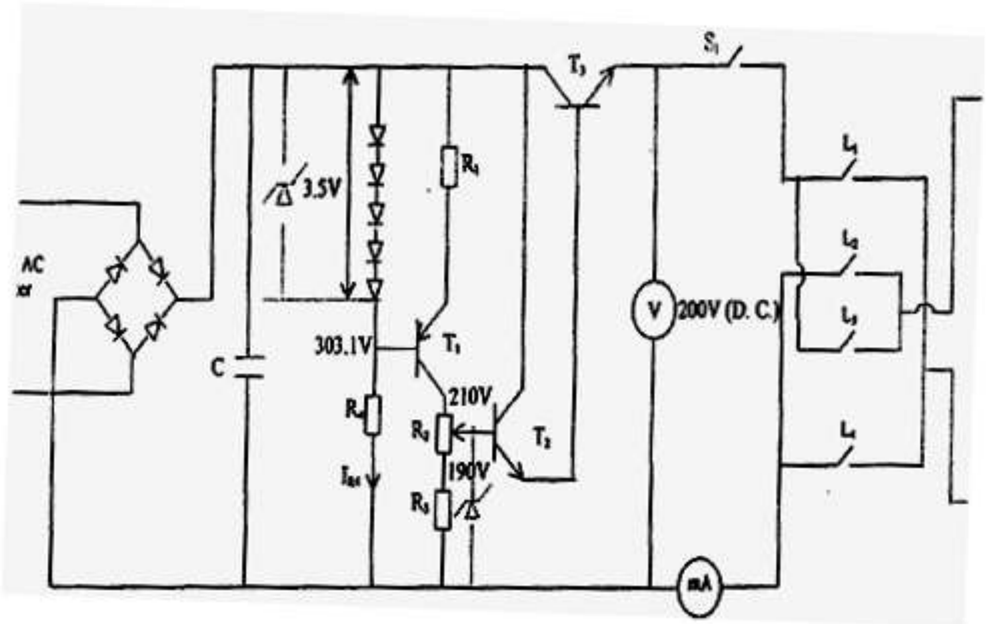


Fig. 2 Circuit diagram of the instrument

## III. RESULTS AND DISCUSSION

The constructed terrameter and the standard terrameter were installed side by side with the same current, electrode spacing. An analog ammeter is connected in series with potential probe and corresponding output voltage drop measure by differential input of ADS1116 linked to microcontroller with display was recorded for standardization of current measuring unit. The induced voltage between the two mid probes were measured using high input impedance meter and second differential of ADS1116 . After calibration is done, data were collected at various sites within Federal Polytechnic Offa, to represent available data for theterrameter. The instrument was to collect data that was used to examine it performance at the different site with current electrode spacing using Schlumberger method. The data collected are shown in Table 1 and the graphs where shown in Fig. 3 and Fig. 4 respectively. The evaluation of the data collected shows that the correlation to that of the constructed terrameter is 90% in agreement with the imported terrameter,

Table 1: Sample Data with Error Analysis for the study Area

| Current Electrode Spacing (L(m)) | Potential Electrode Spacing (l(m)) | StardardTerrameter (Ohms) | Constructed Terrameter (Ohms) | MEAN DEVIATION |
|---|---|---|---|---|
| 1 | 0.5 | 200.25 | 200.15 | 0.10 |
| 2 | 0.5 | 190.87 | 190.50 | 0.35 |
| 3 | 0.5 | 180.55 | 180.50 | 0.05 |
| 5 | 0.5 | 177.65 | 177.42 | 0.23 |
| 6 | 0.5 | 168.43 | 167.93 | 0.50 |
| 6 | 1.0 | 155.78 | 156.34 | 0.56 |
| 8 | 1.0 | 146.34 | 147.87 | 1.53 |
| 10 | 1.0 | 142.56 | 143.33 | 0.77 |
| 10 | 2.5 | 138.44 | 138.43 | 0.01 |
| 15 | 2.5 | 132.45 | 132.33 | 0.12 |

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Fig.3 Plot of Constructed Terrameter

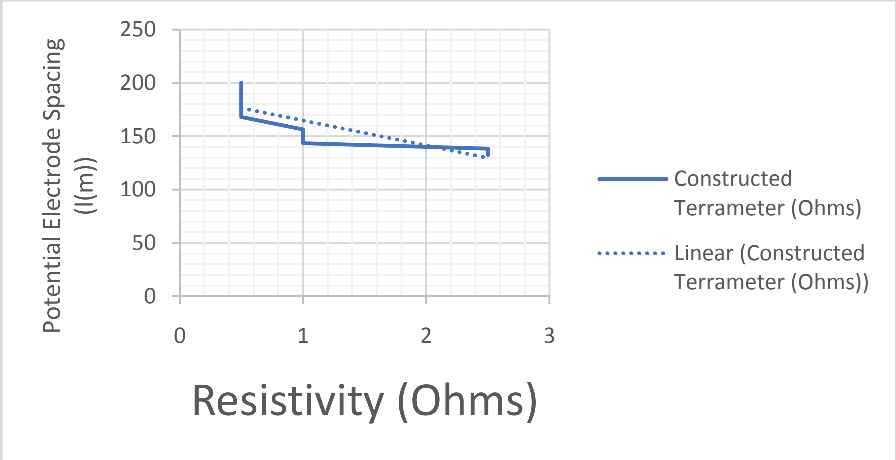
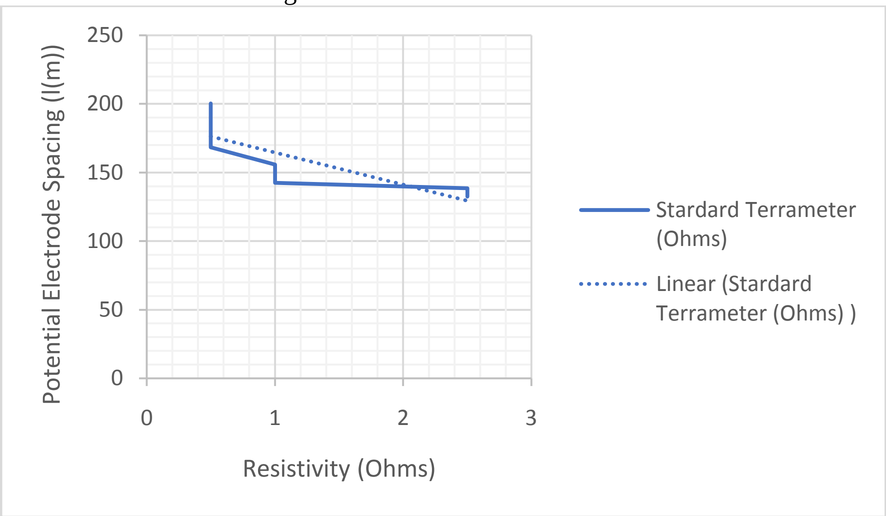



Fig.4 Plot of Standard Terrameter.




## IV. CONCLUSION

The measurement of ground electrical conductivity is important to many branches of engineering, communication, geophysics, hydrological and mineral exploration. Electrical installations, earthling of transformers in the electric power networks, the detection of different types of minerals and rocks present in the earth's crust are some of the uses to which we put the measurement of ground electrical conductivity.

Since it has been shown that the readings of this new resistivity meter are only reliable up to a spread of AB/2 = 100, its uses would be limited to shallow investigations where the depth of interest is not more than 50m, e.g geotechnical studies and groundwater exploration in basement environments. Efforts are being made to improve on the performance of this system.

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