

MODEL RESISTIVITY AND IP SURVEY

Objective: To carry out a resistivity/IP mapping survey in which depth of exploration is controlled by electrode spacing.

Introduction:

An apparatus is provided with which a resistivity and IP survey can be carried out. It consists of a sand and water-filled tank in which some conductive and polarizable objects have been buried and a measuring apparatus which is a small, field-type of resistivity/IP meter system. The transmitter part of the system supplies a square waveform of current to the tank. The receiver part measures the average square wave voltage amplitude at the potential electrodes from which apparent resistivity is calculated) and also any systematic distortion of the voltage waveform (produced by induced polarization). Alternatively, IP can be sensed by comparing the apparent resistivity values measured at different frequency.

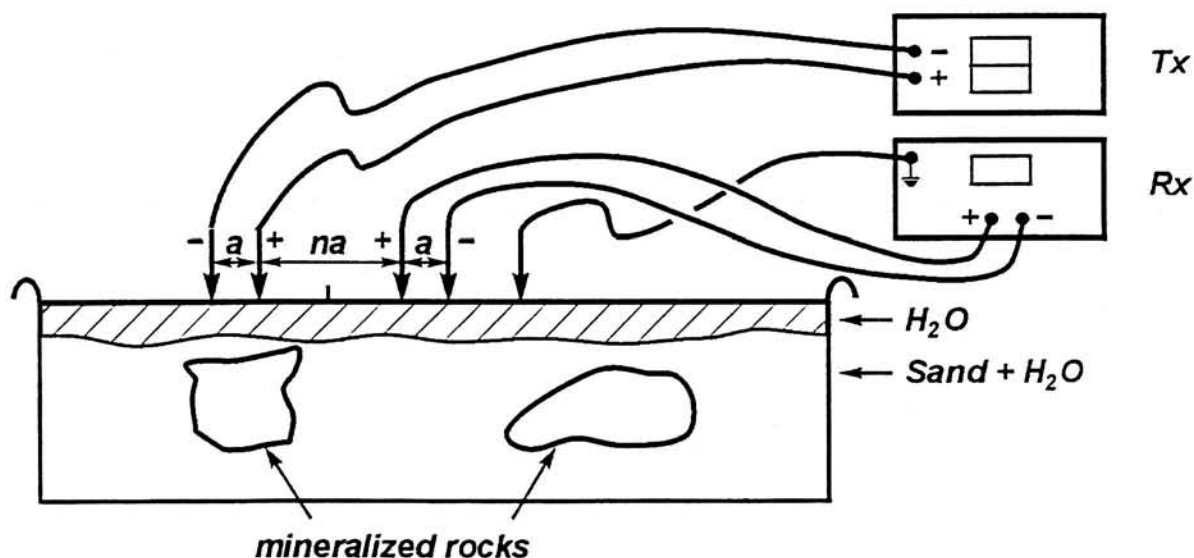


Figure 1:- The model, with a dipole-dipole array applied to its surface.

The Model:

The model is a simulation of ground conditions that might be met in practice. The water layer is more conductive than the sand-water substratum and is of variable depth. It models the conductive and somewhat irregular overburden often present in nature. The target bodies are low porosity rock specimens buried in the sand, some containing sulphide ore minerals. Relative to the wet sand host medium, the electronically conducting minerals are both better conductors and surface polarizable. Unmineralized low porosity rock is much more resistive. Minor contamination on the surfaces of the sand grains may produce a very small background polarizability.

The Survey:

The apparatus permits one to create a fixed separation, in-line, electrode array of any standard type and move it anywhere over the survey area. Typical arrays for this purpose are the *dipole-dipole* and *pole-dipole* electrode configurations. Choose the array dimensions with thought to the desired penetration and resolution. It is essential to survey at more than one electrode separation so that one can decide which are effects coming from targets buried in the sand and which are due to variations in the depth of the water layer. However, if time is limited, it may be wise to map the whole model area with a single spacing array (of large separation) and then to carry out one or more multiple separation profiles over interesting features. Pseudo-sections should be drawn up for the multi-spacing profiles.

Exercise:

Decide on the array to be used, and the survey grid. (Reference it to the tank coordinates marked on the tank frame). Check and, if necessary, adjust the water level to the top of the reference marker pin at the back of the tank. Also check that the electrodes just touch the water.

Make a series of measurements of voltage (V_1) and waveform distortion (V_2) over the survey grid using a fixed electrode configuration (e.g., dipole-dipole, with fixed n) and a fixed Tx current and period (8 /30 s is good). It likely will be convenient to log the data in a spreadsheet program on an adjacent computer. Plot profiles of the apparent resistivity and the relative IP response (V_2/V_1). If you have enough parallel profiles, plot contour maps of both quantities. Conduct a multi-spacing survey along at least one appropriate survey line and plot a pseudo-section of your results.

At a fixed position over a polarizable zone and also a non-polarizable zone (and for only a single spacing and array position), measure apparent resistivity as a function of waveform period from 1/30 s (30 Hz) to as long a period as possible (about 1/4 Hz). Turn the transmitter current off while changing period and remember to change both the Rx and the Tx and adjust the averaging time to at least one period. It is not necessary to resynchronize after each change of frequency. Compare the two sets of spectral observations and explain all results as completely as possible.

The U. of T. Resistivity/IP System

The measuring system is a small, portable battery operated transmitter (Tx) and a mating receiver unit (Rx). The transmitter unit produces a low frequency alternating current with a precisely square waveform. The period of the square wave is selectable.

Electrodes:

For measurements on the laboratory model, four graphite electrodes are provided for the current and the potential probes. For field use, ski pole type rods are used for the current electrodes. For resistivity surveys, the potential electrodes may be of the same type. For resistivity /IP measurements, it is best if the potential electrodes are of the porous pot type. The receiver unit also needs its own ground reference. It may be placed anywhere near the potential electrodes and connects to the receiver case. In a field survey, the receiver case is usually grounded by a direct earth connection at the instrument, or by sitting the unit on the ground, or by contact through the operator. In the model, any connection to the water in the tank that is completely separate from either current electrode is satisfactory

Instrument Description:

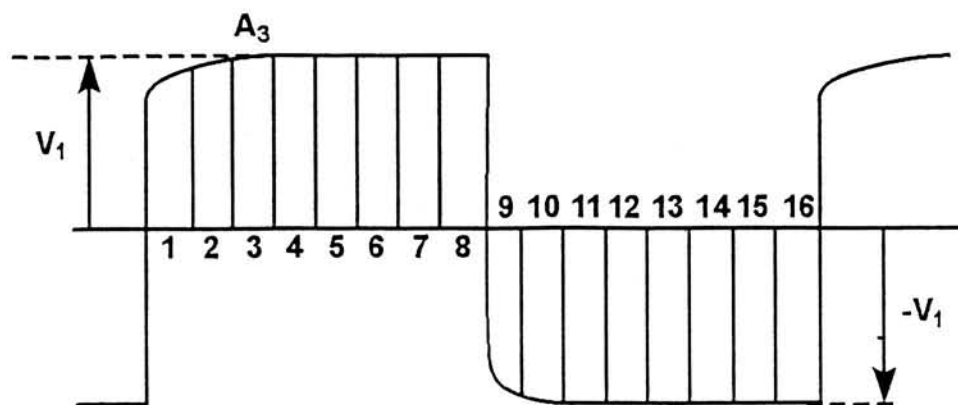
The transmitter supplies a square current waveform with period that is a selectable binary multiple of 1/30 second, i.e., from 0.033 s ($=1/30$ s) to 4.267 ($=128/30$) s in binary steps (i.e., frequencies in the range 30 - 0.235 Hz). (For countries with a 50 Hz power line frequency, the base period can be set internally to 1/25 s.) The amplitude of the square wave of current may be set anywhere from 0.1 mA to 3.0 A, the maximum depending on contact resistance of the current probes. It is unwise to use currents greater than 50 mA in the model tank.

The receiver unit is a noise-rejecting digital voltmeter that can measure several characteristics of the potential difference presented to its terminals. The measurements are made by synchronous rectification, a process which strongly rejects noise and interfering signals at all but the expected frequency components (fundamental and its odd harmonics) of the signal.

Synchronous rectification requires the receiver to have a synchronized replica of the transmitter waveform available to it. Thus, the transmitted waveform is controlled from a primary crystal oscillator in the transmitter and a similar crystal oscillator in the receiver generates precisely the same frequency (using separate oscillators allows the Rx and Tx to be operated apart).

Synchronization is achieved by connecting the units together for a short time (> 8 sec) before measurement starts. The oscillators are precise enough that the transmitted and reference waveforms then will remain accurately in-phase with each other for the following few hours. (The frequency of the receiver oscillator can be adjusted slightly to best match with the Tx oscillator, but this is not necessary when using the instruments in the lab).

The manner in which the signal waveform is measured is illustrated in Figure 2 and described in the text that follows:-



$$V_1 = \frac{1}{12} \left(\sum_2^7 A_i - \sum_9^{15} A_i \right)$$

$$V_2 = \frac{1}{12} \left(\sum_2^4 A_i - \sum_5^7 A_i - \sum_9^{11} A_i + \sum_{11}^{16} A_i \right)$$

$$V_3 = \frac{1}{8} (A_2 + A_3) - (A_5 + A_7) - (A_9 + A_{10}) + (A_{14} + A_{15})$$

} Negative on an increasing wave form.

Figure 2: Sampling of the voltage waveform

Receiver measurements:

The meaning of the function switch settings is given below.

- SP* Spontaneous potential - The constant (dc) component of potential across the terminals (with or without a superimposed ac component).
- SET* No input to meter - Sets the input circuit to cancel the steady SP and checks meter zero.
- V_1 Average amplitude of the square wave, measured over the middle 3/4 of each half cycle of the wave-form. (The ends are not used to prevent electromagnetic transients or small phase drifts from affecting the readings).
- V_2, V_3 Readings of waveform distortion, wherein any systematic growth or decay in amplitude of the potential waveform is detected. The received voltage at a late part of each half cycle is subtracted from the voltage at an early part. If the received waveform is perfectly square, the difference readings will be zero. (See Figure 2 for details). The IP effect usually causes a slight rise in potential from early to later time (negative V_2, V_3 if V_1 is positive.)

Operating sequence:

1. Turn on the Tx and Rx time bases. Connect and position the current and potential probes and the Rx ground wire.
2. Synchronize the Tx and Rx by connecting them together for at least 15 seconds with appropriate switch settings to *SYNC* (2 on Rx, 1 on Tx). Select the desired waveform

- period on Tx and Rx. In the lab, you may leave the sync cable connected, just return the switches to normal settings.
3. Don't bother with frequency adjustment (ω).
 4. Select the averaging time of the Rx. It must be the same as, or greater than the signal period.
 5. Set the voltage range to 1 V initially. You may change it later to 100 mV if signals are small. Don't use the 10 mV setting in the laboratory.
 6. With the Tx off, turn on the Rx and measure SP , check SET , and read V_I . A zero or near zero reading should be obtained, since there is no signal. ∴
 7. Select a transmitter current on the Tx and turn the meter function switch to CURRENT CHECK. Turn on the current for a moment and see if the meter rises from zero. If it does not, the Tx is able to supply the requested current. If it cannot (for instance, if an electrode is out of the water), the meter will swing positive. (Electrode resistance may limit the maximum current that can be selected.)
 8. To begin observations, turn the transmitter current on and observe the signal voltage on V_I (adjusting the Rx voltage range and possibly the Tx current for an appropriate signal level (5-500 mV). Watch the overload indicator on the Rx. The voltage range must be kept high enough that it never indicates NG (no good).
 9. To make IP measurements, read V_2 and/or V_3 in addition to V_I . Alternatively, turn off the Tx and change the Tx, Rx period settings and re-read V_I . V_2 , V_3 readings will be small compared to the V_I reading and usually of opposite sign. You must not change the range setting for this measurement.
 10. Move the electrode array and take more readings. Before each V reading, or at least every few minutes, briefly turn the Rx meter switch to SET . This re-zero's the meter and is particularly important on sensitive voltage ranges (≤ 100 mV). Always monitor the overload indicator on the Rx and the current check meter on the Tx during readings.
 11. **WARNING** The transmitter can generate up to 300 V. To protect both yourself and the instruments, TURN OFF the Tx before adjusting the electrodes or making any change of current or period, or when synchronizing. Also turn off both units whenever there is a pause in taking readings. This will conserve battery charge. However, always LEAVE THE TIME BASES ON UNTIL THE SURVEY IS COMPLETED. Otherwise you will have to resynchronize.