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Optimizing the acquisition time for time domain spectral IP by measuring during the on-time

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Combined direct current resistivity and time domain induced polarisation (DCIP) measurements are traditionally carried out with a current injection sequence using half of the time for transmission of current and the rest without transmission. With this sequence the resistivity is determined during the on-time and the IP from the potential decay during the off-time. However, if only resistivity is measured some commercial instruments use a square wave current injection, without any off-time between the positive and negative phases of current injection, and are thus able to reduce the time needed for these measurements.

In this paper we show that this approach could be implemented for DCIP measurements by also measuring the IP during the on-time. DCIP measurement using a square wave current injection signal, and measuring the IP response during current transmission, has been modelled numerically and tested in the field against a traditional IP measuring cycle with fifty percent current-on and fifty percent current-off.

The numerical modelling was conducted using superposition of step responses following (Fiandaca et al. 2012, 2013), but with a square waveform (Fig. 1). Sensitivity analysis was carried out in the software AarhusInv (version 6.20) on synthetic models with the square-waveform and the classical waveform. The comparison shows that with the square-waveform approach the IP parameters are resolved at least as well as with the classical approach.

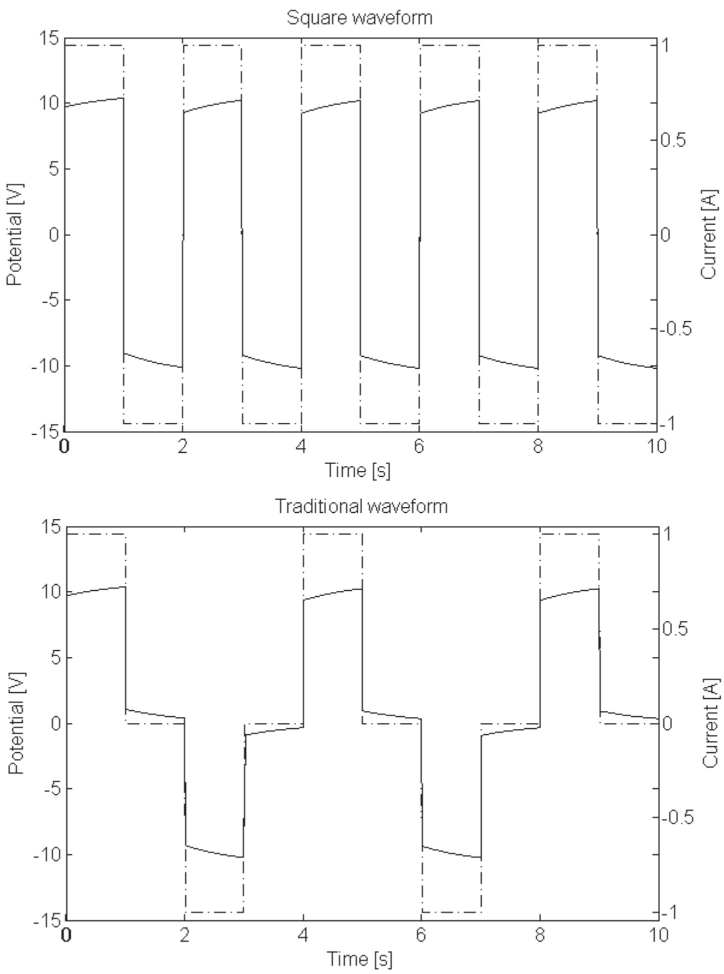

Fig. 1: Modelled waveforms using superposition of step response. The step response is calculated for a homogeneous half space (ρ = 50 Ωm, m_0 = 100 mV V^{-1}, τ = 1.0 s and C = 1.0). The upper diagram shows the square waveform without off-time and the lower diagram shows the traditional waveform. Potential is drawn as solid and current as dash-dotted line.

The field test was done in an environment with Quaternary clayey till overlaying Silurian shale. A dolerite dyke in the shale creates an IP anomaly suited for the experiment. The DCIP profile (202.5 meters, electrode spacing of 2.5 meters) was centred on top of the known IP anomaly and retrieved using a multiple gradient array (Dahlin and Zhou 2006) and the ABEM Terrameter LS instrument. To improve the IP data quality and reduce capacitive coupling separated cables were used for transmitting current and measuring potentials (Dahlin and Leroux 2012). The positions of all electrodes were determined using a differential GNSS system (Topcon GR3 and SWEPOS network-RTK).

Full waveform recordings from the field test for one of the electrode quadruples can be seen in Fig 2. The field test data show a clear IP effect during the current on time, but at the time of writing a complete processing and evaluation of the results is still ongoing.

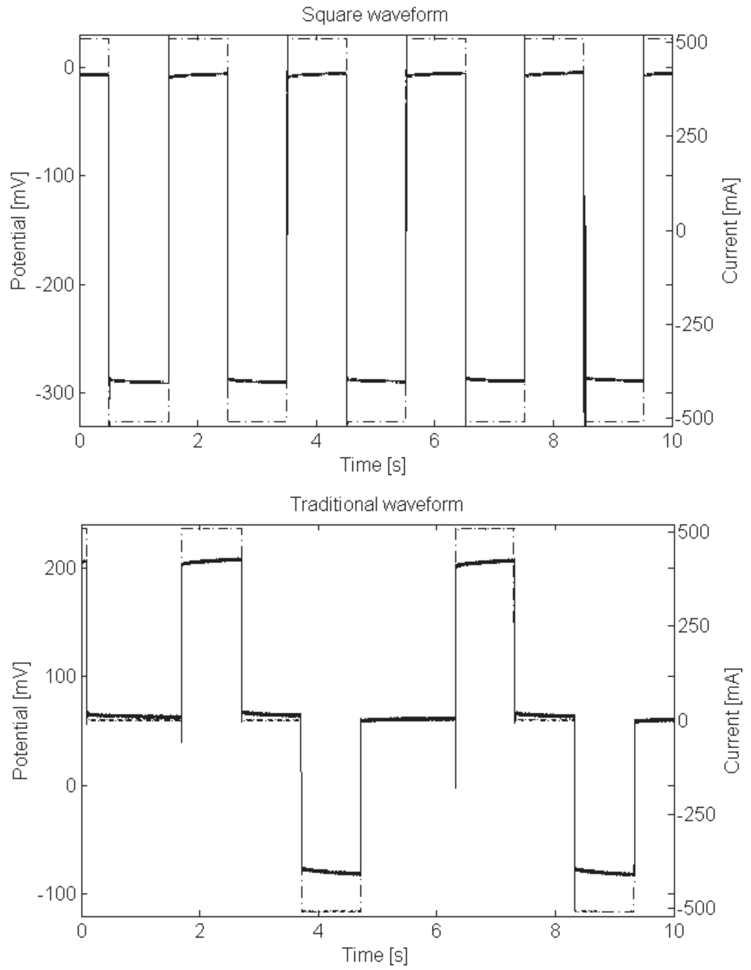

Fig. 2: Full waveform recordings from the field measurements for the same quadruple but with different current injection waveforms. Note that additional current pulses can be transmitted for the same measurement time when using the square waveform compared to the traditional. Potential is drawn as solid and current as dash-dotted line.

Our results support that the approach of using a square wave current injection signal is practically applicable and can reduce the measuring time substantially by measuring the IP-response during the current-on time.

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