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Paper

Model Results for a Dipole-Dipole Transient Electromagnetic Technique

I. B. Ramaprasada Rao and Satyanarayana Kabra

Department of Geophysics
Osmania University
Hyderabad 500 007, India

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Abstract

Model results for a dipole-dipole transient electromagnetic technique applied over sheet conductors, indicate that sign changes in the response depend not only on target depth but also on target inclination for a given depth. Maximum response is obtained when the transmitter-receiver separation is chosen as 1.33 to 1.54 times the target depth.

Introduction

Several new configurations of transmitter-receiver combinations, for use in ground transient electromagnetic surveys, are at present being investigated in different parts of the world. Prominent among these configurations are (a) one-loop arrangement, (b) displaced loops arrangement, (c) in-loop arrangement, (d) dual-loop arrangement. (Spies 1975), and (e) two-loop arrangement.

Pioneering work in this subject is at present being carried out in Australia, at the Commonwealth Scientific and Industrial Research Organization (CSIRO), Macquarie University and the Bureau of Mineral Resources (B.M.R.)

A matching effort in analysing the responses observed with these transmitter-receiver combinations is very desirable. In recent years the authors have conducted model studies on conductive sheet bodies using a two-loop arrangement, which is referred to here as a 'dipole-dipole transient technique', as many of the above configurations use two loops in practice. This note presents some of the results of the model studies.

Model results

Two aircore loops, with sides 5 cm x 5 cm (100 turns of insulated wire on the transmitter and 800 turns on the receiver), separated by a distance of R = 15, 20, 25, 30, and 40 cm, were used as transmitter and receiver coils. An aluminum sheet of dimensions 50 cm x 50 cm x 8 mm, set at inclinations of 0°, 10°, 20°, 30°, 50°, 70°, and 90° from horizontal, served as the conductive sheet model.

In Fig. 1 are shown the model results over a vertical conductive sheet, for different h/R ratios, where h is the depth to the upper edge of the target. Figure 2 shows the effect of inclination for a chosen h/R value. The model results over a horizontal conductive sheet for different h/R values are shown in Fig. 3. When the sheet is horizontal, the sign of the response depends on the h/R value; the response being totally negative for h/R < 0.5. A similar conclusion was drawn by Spies (1980) for the results over the 'Elura model'. In the present studies it was observed that inclination also has a profound effect on the sign of the response. As the inclination changes from vertical to horizontal, the sign of the peak response changes from negative to positive (Fig. 2). Hence with a dipole-dipole (two-loop) system interpretation is complex, because the sign can change as a result of changing depth as well as inclination of the sheet conductor. The second peak observed in Fig. 2 for x/R = 2.15 is due to the lower edge of the sheet conductor.

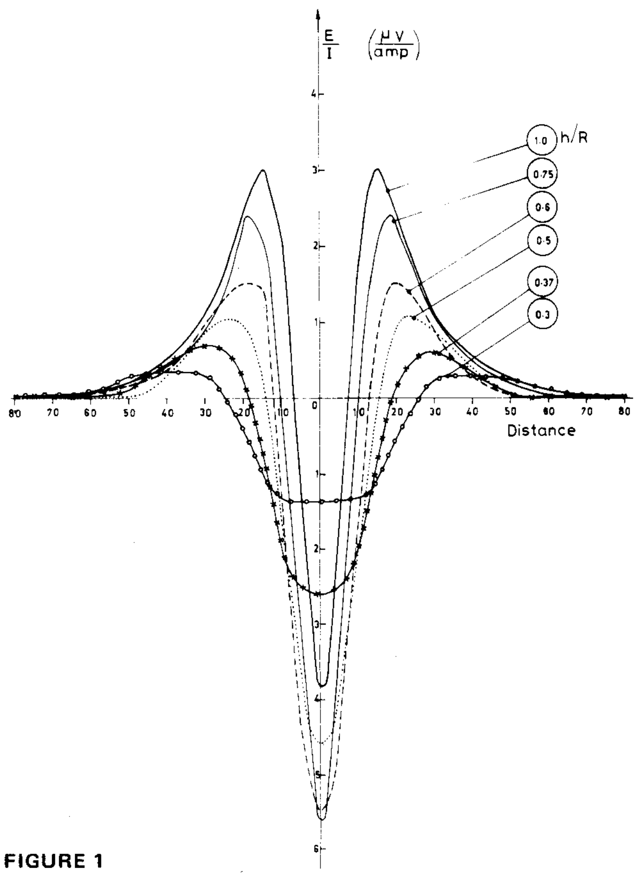

FIGURE 1
Dipole-dipole transient response due to a vertical conductive sheet: t = 2 ms; distance in centimetres.

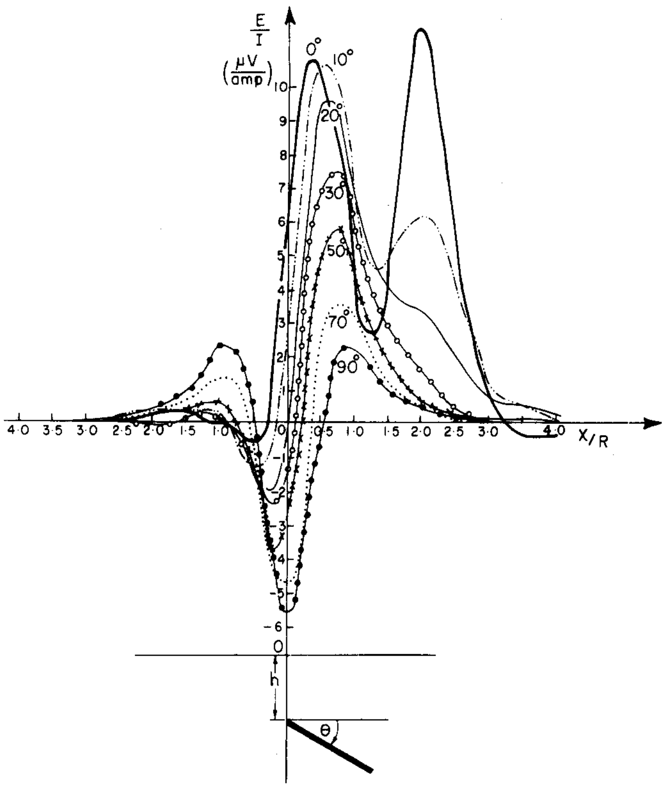

FIGURE 2

Dipole-dipole transient response due to an inclined conductive sheet: t = 2 ms; L/R = 0.75.

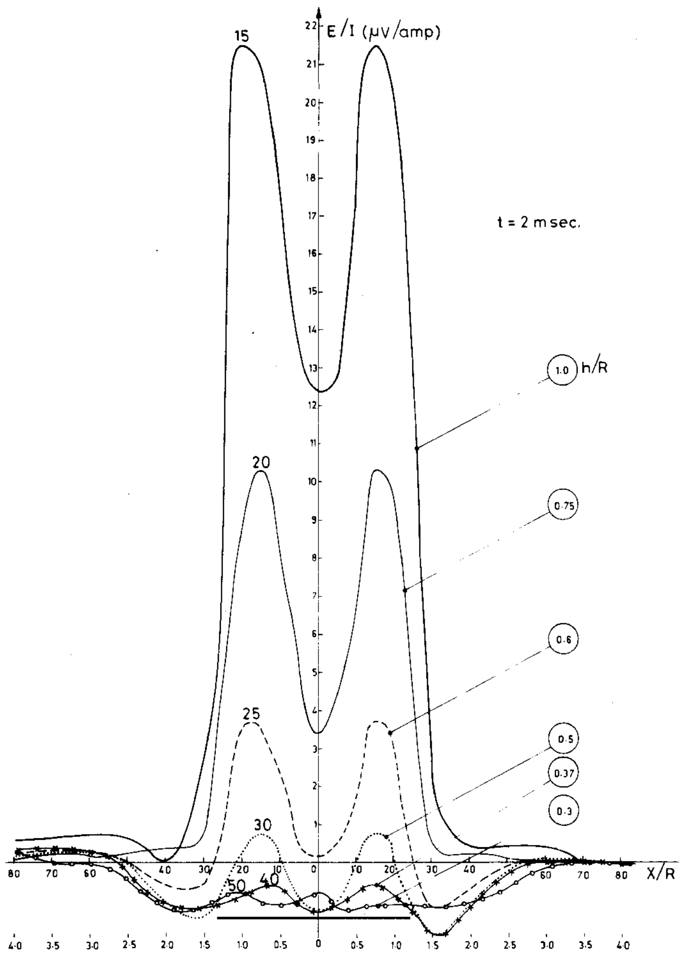

FIGURE 3

Dipole-dipole transient response due to a conductive horizontal sheet.

Figure 4 shows the normalised peak response (normalised with respect to the peak response obtained from h/R = 0.75) for a vertical sheet conductor as a function of h/R. From this figure we can note that the maximum peak response occurs for h/R = 0.65 to 0.75. The response versus the depth curve for the Elura model with the two-loop system (Fig. 24 of Spies 1980) using R = 77 m and time t = 1.9 ms shows a maximum response for a depth of 58 m, i.e. the maximum occurs at an h/R ratio of 0.75 in this case, also. In the present investigations an aluminium sheet of thickness 8 mm was used as the model. Hence, the time used (t = 2 x 10^{-3} s) is approximately equal to the product of $\delta \mu l^2$ ($\cong 3.2 \times 10^{-3}$), where δ is the conductivity of aluminium (taken as 4×10^7 mho/m), μ is the magnetic permeability ($4\pi \times 10^{-7}$ H/m) and l is the thickness of the target (8 mm). Further in the modelling investigations carried out by us, $l/R \cong 0.05$, i.e. $l \ll R$.

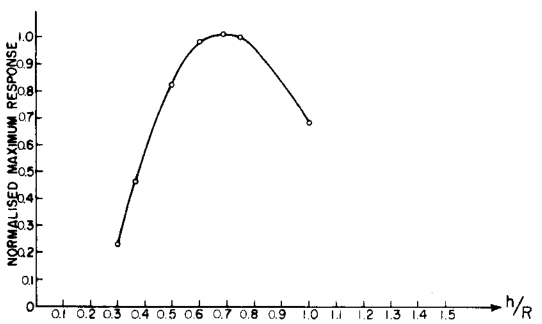

FIGURE 4

Response variation as a function of h/R for a vertical sheet conductor in the dipole-dipole transient method.

On the other hand for the Elura model the time t (= 1.9 ms) is much smaller than the product of $\delta \mu l^2$ ($\cong 86.9 \times 10^{-3}$), assuming the conductivity to be 4.8 mho/m and the width 120 m. In the case referred to, the result of Spies (1980), l/R is approximately equal to 1.55; that is, $l > R$. Thus while the model used by the authors can be treated as 'thin', the Elura model is relatively 'thick'. The curve shown in Fig. 4 has a practical significance in choosing the separation of transmitter and receiver in the dipole-dipole transient technique. The technique is evidently less sensitive to target thickness.

Conclusions

The modelling results over the sheet target reveal that the change of sign can occur in the dipole-dipole transient technique depending on the depth to the body as well as its inclination.

While prospecting for sheet conductors in a resistive environment, it is recommended that the transmitter-receiver separation R can be chosen as h/(0.70±0.05); that is 1.33 to 1.54 times the target depth expected. In such a case the maximum signal from the target should be obtained.

Acknowledgment

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