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Algorithmic Maintenance and Testing Sounding the Possibilities of Equipment Radial Frequency Sounding

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SUMMARY

The paper presents the results of the implementation and optimization of the algorithm for calculating the direct problem and transformation data of radial frequency sounding. Also shown are the results of its application to different horizontal models in order to obtain the parameters of the equipment produce.

Introduction

The Trofimuk Institute of Petroleum Geology and Geophysics SB RAS about 10 years ago, equipment was developed frequency sounding and profiling Nemfis (sounding parameter frequency). Its main feature is the presence of two receiver coils with opposite momenta. Moments are selected so that the summation signal of both coils, the direct field generator in the air, exceeding the medium response at zero order becoming [Manstein et al, 2008; Manstein et al., 2003]. Thus increasing the quality of information, but there is a need for strict adherence to the geometry of the device.
Become actual problem of finding an alternative method of suppression direct field. As a result of studies, it was found the presence of a surface on which the vertical component of the magnetic field from the source passes through zero. The equation of this surface is easily obtained from the expression for the calculation of the magnetic field in a homogeneous space:

$$H_z^t = -\frac{I_t M_t}{4\pi R^3}\left(\frac{3r^2}{R^2} + \frac{3kr^2}{R} + k^2 r^2 - 2 - 2kR\right)e^{-kR},$$

where $k^2 = i\omega\mu_0\sigma$, r and R – cylindrical, and spherical radii, I_t and M_t – current and moment of the generator coils, σ - electrical conductivity of the medium. Where, for small kr, direct compensation condition fields:

$$r \approx \sqrt{2}z.$$

This gave the basis to create the device, in which a set of receiving coils located on this surface and at different distances from the generator. The described method of compensating direct sensing field and was patented [Patent number 2502092]. In this case, the sounding parameter is not only the frequency but also the distance between source and receives coils.

The emergence of a new device resulted in a need to modify the existing algorithms for the calculation of the direct problem and the creation of software for the transformation of data in order to assess the applicability of the equipment.

Solution of the problem

Expression to calculate the vertical component of the magnetic field is as follows [Balkov et al., 2004]:

$$H_z = \frac{M_t}{2\pi}\int_0^\infty \lambda^3 J_0(\lambda r) X d\lambda, \text{ where}$$

$$X = \frac{p_1 \cdot ch(p_1 \cdot h) + p_2 \cdot sh(p_1 \cdot h)}{(p_0 \cdot p_1 + p_1 \cdot p_2)\cdot ch(p_1 \cdot h) + (p_1^2 + p_0 \cdot p_2)\cdot sh(p_1 \cdot h)}, \text{ and}$$

$$p_j^2 = \lambda^2 + k_j^2,\; k_j^2 = i\omega\mu_0\sigma_j,\; j = 0..2.$$

This integral is calculated numerically and by using a large amount of data at many coils this process is excessively long. To avoid this integration parameters were studied. For example, such as the upper bound of the integration interval after which the contribution to the total amount will not be significant. As well as the sampling step and the use of various methods of integration. The optimum parameters for the conservation acceptable margin of error at maximum speed were obtained.
Another important point is that in the final equipment Nemfis EMF can be analytically expressed in terms of conductivity of the medium. In the case of RFS everything looks a little more complicated. Analytically, it can not be expressed but still has ambiguity. I.e. one value may correspond to a pair of EMF resistance. To overcome these difficulties it is necessary to determine the uniqueness of the area, and this find extrema or points of intersection of the derivative to zero. Initially, derivatives are

calculated numerically. But the speed and accuracy of this algorithm does not add. Successful attempt was made to make the calculation of the derivative under the integral sign and take it analytically.

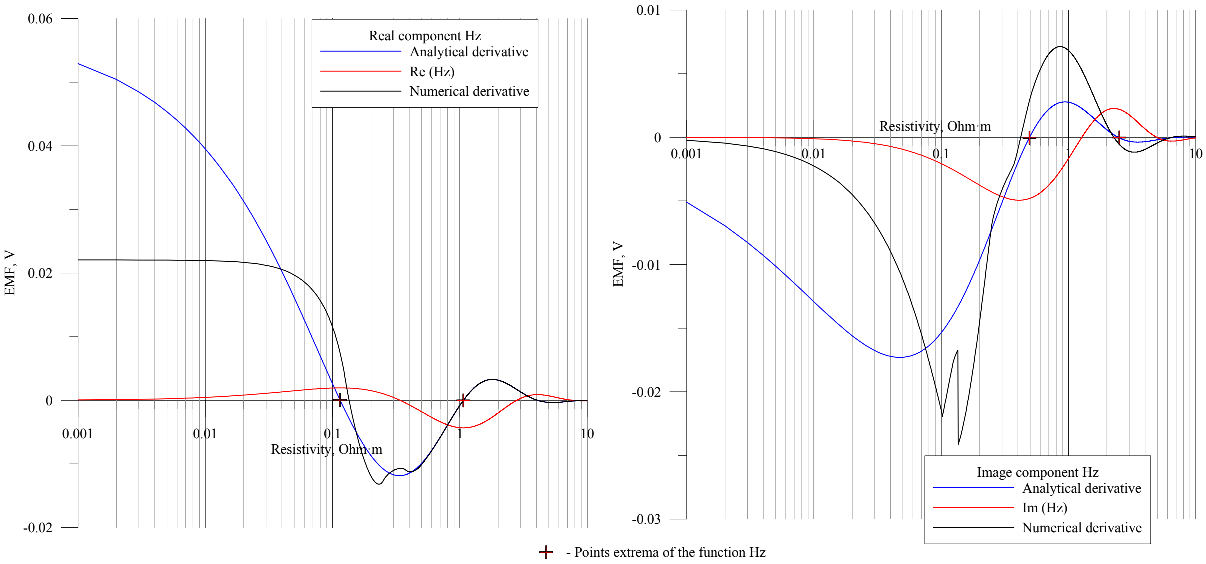

Figure 1 *Functions of the real and imaginary components of the magnetic field derived from their environmental resistance.*

The figure 1 shows the different components of the graphics functions, as well as their numerical and analytical derivatives . Plus sign marked extremum points. We can see that the analytical derivative more accurately defines extreme. Besides its calculation takes much less time.

Modeling signals

In order to determine sounding capabilities of equipment was simulated at different horizontally layered media.

Figure 2 shows a comparison of the frequency sounding curves and angular frequency soundings. Left overlying layer has electric resistivity of 100 Ohm·m subjacent 10 Ohm·m, the right way around.

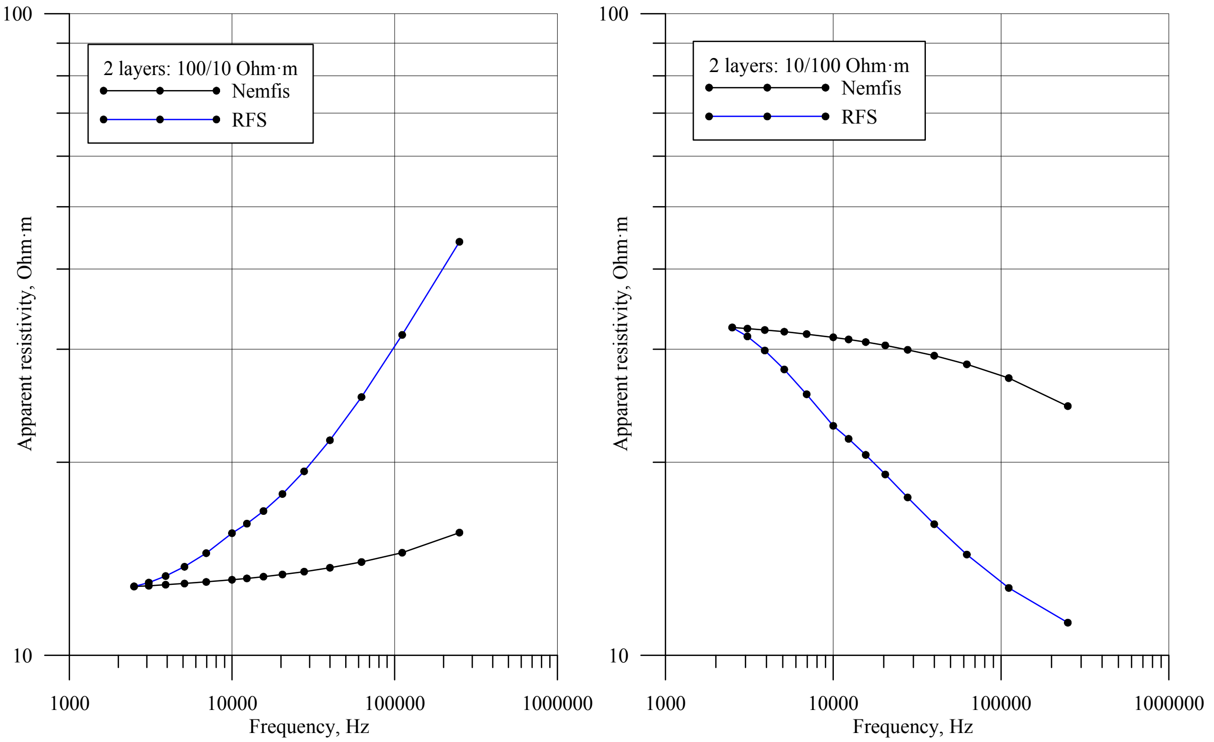

Figure 2 *Comparison of the frequency sensing capabilities (Nemfis) and radial frequency (RFS).*

As you can see equipment angular frequency sounding gives a much more pronounced than the curves sensing device Nemfis demonstrate that the prospects of the application of such realization sensing. Figure 3 shows the simulation results for a medium left Conductor - Insulator - Conductor, and right layers for resistance increases with depth.

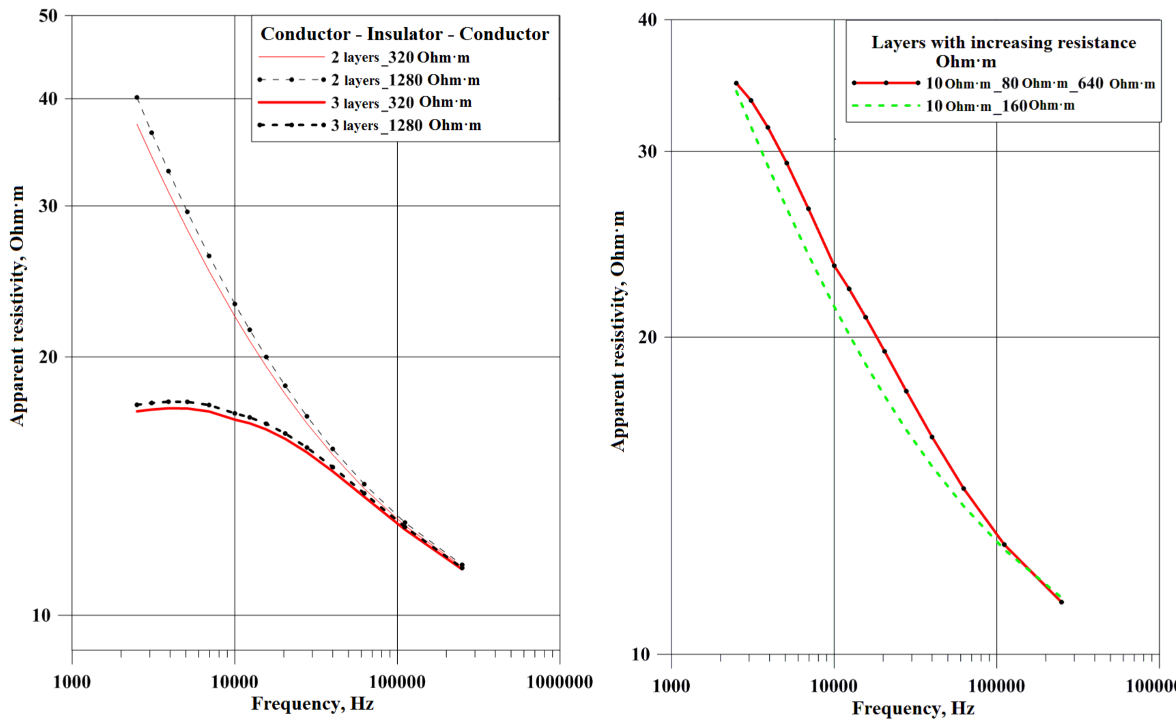

Figure 3 *Simulation results of signals from different models for equipment RFS. The left graph: 2- and 3-layer model, the last of the endless layers, have previous thickness 1m; conductor resistance 10 Ohm·m, insulators indicated in the legend. The right graph: same as the thickness of the left; resistance layers are indicated in the legend.*

After analyzing the results shown in the left graph can draw several conclusions. First, sounding curves for the two - and three-layer models quite well visible even in a small range of frequencies. Second, even with respect to the resistance layer is more than 3 times sounding curves are close to each other.

From the right graph shows that the sounding curves corresponding to the transition layer model are quite different from the model without it, although using a small number of frequencies (e.g., three high and one low frequency) as we see the model with the lower layer with resistivity of 160 Ohm·m and 640 Ohm·m is impossible to distinguish visually.

Conclusion

Has been implemented and optimized algorithm for solving the direct problem Angular frequency sounding. Speed and accuracy of his work give prospects for a fast algorithm for inversion. The simulation signals suggests the effectiveness of the implementation of sensing and marked the limits of applicability of the equipment produced.

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