# 02-04 FOUR FREQUENCY AEM SYSTEM EM-4H

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## Introduction

AEM systems in Russia have their own history, and it is quit long. David Fountain in his brilliant work dedicated to the AEM development have mentioned the first system in the USSR which was introduced in 1950s (Fountain, 1998). Airborne survey in our country was always accompanied by such problems as large areas, short season, far distance from base airport etc. Surely, all these factors had an influence on the AEM development.

During the last several years many AEM complexes of various type were used on Russian territories. Nevertheless, for today the most popular AEM system is the frequency domain one called EM-4H. This system was developed by GeoTechnologies and every season is used by AeroGeophysica. EM-4H allows high quality conductivity mapping of 1:25000 scale. One of the advantages is high flight speed – up to 220 km/h. The first fixed-wing version was introduced in 2000. Since 2006, after it was modified for installation on a helicopter, it is called EM-4H.

*Figure 1. EM-4H installed on the An-3*

## EM-4H technical description

The EM-4H transmitter is a multi-turn loop mounted in horizontal plane on the fuselage of an aircraft (the vertical magnetic dipole). The aircrafts which was actually used are the An-2, An-3 (both fixed-wing) and Mi-8 (helicopter). The loop in fixed-wing version has the triangular form with apexes on the tail and on the ends of wings. It's square is about 40 $m^2$. In the helicopter version for the loop montage the special carriage is used (Figure 2). The loop square is greater, about 60 $m^2$.

The EM-4H measures signals on four fixed frequencies: 130, 520, 2080 and 8320 Hz. The current in the transmitter loop is the sum of four sines. The approximate values of the dipole moments are 20000, 10000, 4000 and 2000 $Am^2$ correspondingly.

*Figure 2. EM-4H installed on the Mi-8*

All signals are measured by the receiver towed in a small bird by the 70 meters cable. It measures three orthogonal components in single point. It's sensitivity comes to several μA/m.

The EM-4H installation geometry has the well-known problem – the transmitter field induces currents in the fuselage and as a result we need to compensate their influence. To solve this problem there are two additional loops mounted in different vertical planes. Each loop is a transmitter working on it's own frequency. Their frequencies are 670 and 830 Hz. The measurements of these signals by the same receiver allow determination of the geometry parameters. As a result we can precisely calibrate the transmitter dipole moments and compensate the primary field.

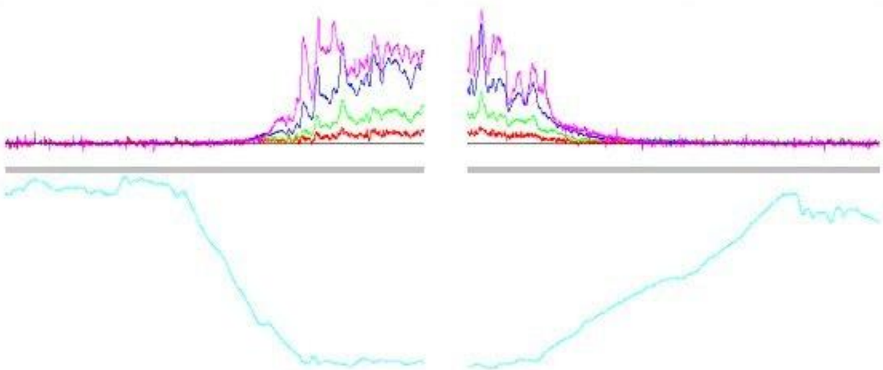

*Figure 3. Compensation zones. Quadrature components (up) and Altitude (down)*

EM-4H system stability allows calibrating only twice per more then 5 hour long flight – in the beginning and in the end. Calibration is performed on the 500 meters altitude and takes only 2-3 minutes because the Data Acquisition System calculates all parameters automatically. Compensation results are shown on the Figure 3. The mean value of the quadrature components in compensation zones is $3 \cdot 10^{-5}$- $5 \cdot 10^{-5}$ of the primary field, standard deviation – $2 \cdot 10^{-4}$- $5 \cdot 10^{-4}$. It is a quite high precision because, for example, recalculation of these parameters to the 6,5 m transmitter-receiver separation gives 0,1- 0,4 ppm accuracy.

## EM-4H measurements

Main measured parameters of the EM-4H are the vectors of the quadrature and in-phase components for four working frequencies 130, 520, 2080 and 8320 Hz. Precise phase measurements automatically give the quadrature vectors of the pure secondary field. AeroGeophysica uses special algorithms to calculate the in-phase vector. In addition, EM-4H calculates traditional phase invariants: the polarization ellipse semi-axes ratios, big semi-axes values, big semi-axes orientations.

The geometry parameters obtained using compensation moments allows their usage in data post processing. For example, they used for apparent conductivities calculation and for positioning of the magnetometer measurements while it is installed in the same bird. Figure 4 shows the apparent conductivities which are obtained as the inverse solution for the homogeneous half-space for each frequency (Fraser, 1978). The warm color stands for high conductivity and cool color for low conductivity.

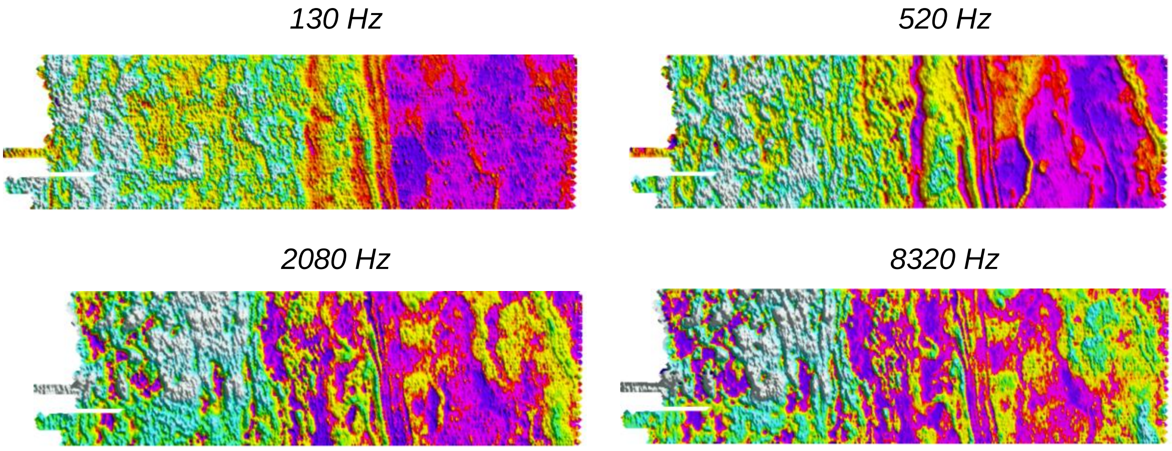


*Figure 4. Apparent Resistivity mapping*

Multi-frequency measurements allow the conductivity-depth analysis (Figure 5) using well known algorithm based on centroid depth calculation (Sengpiel, 1988) and apparent conductivity of the pseudo-layer half-space model (Fraser, 1978).

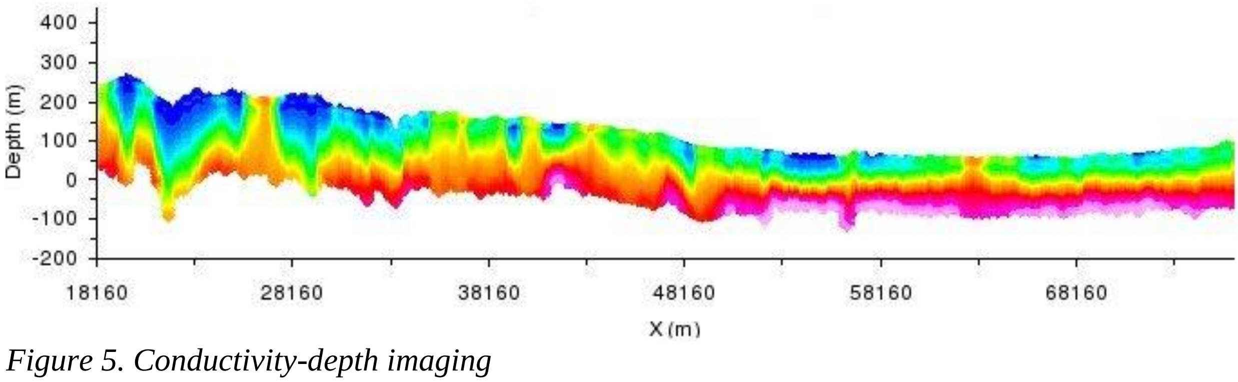


*Figure 5. Conductivity-depth imaging*

## Conclusion

The EM-4H installed in a STOL airplane or in a helicopter is a cost effective conductivity mapping system well suited for regional mineral exploration, groundwater resource evaluation, geological mapping. Every year more and more areas are covered with EM-4H survey. In 2008 AeroGeophysica starts four EM-4H systems, two of them are helicopter-borne.

There are several more companies in Russia having their own EM-4H systems. These systems was used successfully for different targets on Ural, in Norilsk region, in Yakutia, in Far East and in many other regions of Russian Federation.

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## References

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