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# New sensor for study of ULF magnetic activity

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Ultra low frequency (ULF) variations (0.001-3 Hz) of natural magnetic field are very important for ground study of magnetospheric and ionospheric magnetohydrodynamic waves and solar-terrestrial interaction. Besides it a lithospheric ULF magnetic activity is recently considered as very promising candidate for application to short-time earthquake (EQ) forecasting. Present progress in spectral analysis methods and data processing instrumentation allows studying of signal fine structure almost in real-time operation condition, which is of great importance, particularly, for short-time prediction problem. Usually the lithospheric ULF EQ magnetic precursors are much weaker than magnetospheric signals and their frequency ranges are completely overlapped.

At present for measurement of ULF magnetic field variations the magnetometers with fluxgate and induction sensors are used. Fluxgate sensors are very compact (pencil-shaped form at length $\sim$ 3 cm) with SND in ULF band about 10-500 pT/Hz$^{0.5}$ (here and further a maximum SND value relates to a lower part of frequency range).

ULF induction (or search-coil) sensors usually have comparatively large dimensions (length 0.8-1.2 m, diameter 10-15 cm) and weight (few kilograms) but essentially lower SND (about 0.1-200 pT/Hz$^{0.5}$). At 3-component magnetic field measurement it is necessary to provide spacing between them about 1-2 m for avoiding mutual influence. This requirement creates problems caused by non-rigidity of 3-sensors construction and their space instability relatively ground surface (or horizontal plane). In addition, for such a long sensor a ratio of length/diameter is big enough, what leads to increased sensor sensitivity to variety mechanical deformations of sensor body.

These factors cause additional noise appearance due to induction effect in the Earth's magnetic field what creates heavily recognized artefacts at signal processing. Simple calculations show that sensitivity to changing of sensor axis direction can achieve a level about 250 pT for one second of arc. It means that for realization of SND low limit 0.1 pT/Hz$^{0.5}$ it is necessary to provide a directional stability of sensor axes approximately at level 2 ppb (parts per billion). Listed problems are aggravated at field works.

Therefore, the influence of mechanical instabilities on 3-component sensor construction, and consequently on efficient noise density (mainly in frequency range below 0.1 Hz) has to be significantly decreased. The way out from these difficulties can be found at development of fluxgate magnetic sensor of increased length and improved SND.

The fluxgate magnetic field sensor with 10 cm length has been developed. This device has SND in ULF band about 1-30 pT/Hz$^{0.5}$ and moderate consumed power. Its additional merit is extremely low noise density – about 3-30 pT/Hz$^{0.5}$ in the most prospective EQ magnetic precursor frequency range (0.001-0.03 Hz), which is less than SND for the best recent search-coil sensors.

A ULF magnetometer with such a compact solid sensor unit at partial compensation of the Earth's magnetic field in the sensors volume allows drastic decreasing the mechanical artefacts influence and facilitates the constructing of measuring sites for field works in remote areas. For geophysical observatory a combination of proposed sensor unit with a laser real-time measurement of angular axes deviation gives possibility for additional decreasing of a sensitivity threshold in ULF band at the cost of correction factors calculation during data processing.

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