Fast 3-Component Variometer Based On A Cesium Sensor

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New compact and fast three-component variometer measuring the total terrestrial magnetic field intensity in 20÷65μT range and two transverse components in ±1μT range is presented. The reproducibility of the field components measurements is 0.15nT, the noise-limited sensitivity is 0.01nT r.m.s. or 0.25" at 0.1 sec sample rate.

The variometer constitutes a scalar Cesium sensor placed into the center of 3D coil system aligned along terrestrial field H_0. The coil system produces DC magnetic field H_{ZC} compensating ~95% of H_0, magnetic field H_{XY} rotating at 160÷640Hz in the plane perpendicular to H_0, and DC magnetic fields H_{XC} and H_{YC} compensating variations of transverse Earth field components. The scalar sensor measures the total magnetic field H which is the vector sum of the fields listed above. If H_0 deviates from Z oscillating components appear in H; these components are used as signals for the X-Y feedback systems.

Partial compensation of Z-field down to 3÷5μT allowed us to decrease transverse rotating field amplitude, increasing at the same time X-Y channels sensitivity. A Cesium optically pumped sensor was chosen as the most appropriate for low magnetic field range scalar device.

A quartz cubic frame with 21.5cm side was designed for holding the windings.

For generating of AC and DC currents feeding the coil system, we use processor-controlled DACs; radio-field resonant to the Cs magnetic transition is produced by frequency synthesizer referenced to the stable quartz oscillator. The detection of X-Y error signals is realized on micro-processor level, allowing to reduce X-Y feedback response time down to one field rotation period (6 ms) with full suppression of the second harmonic.

Long-term stability of the device is mostly determined by the coil system; the procedures of calibration of X,Y,Z coil constants and their cross-coefficients are also implemented on micro-processor level, and they do not require any external magnetometric equipment.