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GEM 4-Sensor Helicopter System

GEM Advanced Magnetometers has developed a helicopter based magnetometer system using four optically pumped Potassium sensors. The installation is housed in a special "bird" with two fins at the tips of an imaginary tetrahedron to allow for measurement of the absolute magnetic field and gradients in three directions: vertical, along, and across-the-track.

The noise envelope is 6 pT/m for 20 readings per second. Signal processing algorithms also provide a measure of noise (fourth difference) for all channels, direct gradients between any pair of sensors.

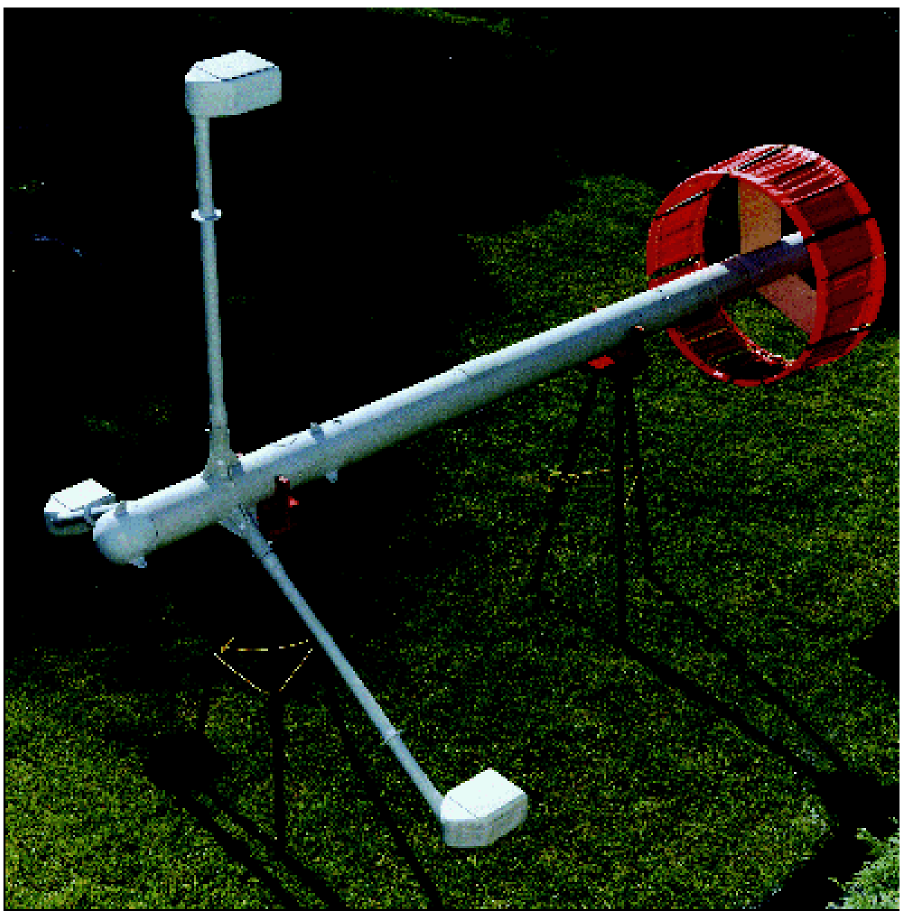

Photo of GEM 4-Sensor Helicopter System. 4 Potassium sensors are arranged in an imaginary tetrahedron for measurement of total field and three gradients.

Advancing Overhauser, Potassium and Proton Precession Magnetometer Technologies for More than 2 Decades - "Our World is Magnetic!"

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Optically Pumped Potassium "SuperSenser" Technology

GEM is unique as the only commercial supplier of Potassium magnetometers -- the highest sensitivity and absolute accuracy optically pumped systems available. The GSMP-30A system extends these characteristics to the next generation of even higher performance instruments.

Major benefits of the GSMP-30A include:

- Acquisition of very high resolution and accuracy data. Potassium systems are a minimum of 10 times more sensitive than cesium optically pumped systems.
- Proven reliability and predictability of results. The natural physics of Potassium narrow line spectra minimizes heading and orientation errors to negligible levels.
- Minimization of maintenance costs. Once a system is purchased, there is no need to return it for periodic optical alignment. This significantly reduces servicing and shipping costs over the lifetime of an instrument.
- Enhanced survey efficiency. The GSMP-30A minimizes operating requirements, such as warm up times, that slow surveys down.
- High bandwidth (Nyquist frequency of 10 Hz) for detailed spatial resolution of geologic features.
- Minimal power requirements of 5 to 6 watts.
- Interfacing to standard commercial data acquisition systems via serial RS-232 communications.
- Low noise. The following example shows data from a low-height flight acquired by SOREQ – the Israeli Nuclear Energy Agency.

GEM Systems
ADVANCED MAGNETOMETERS

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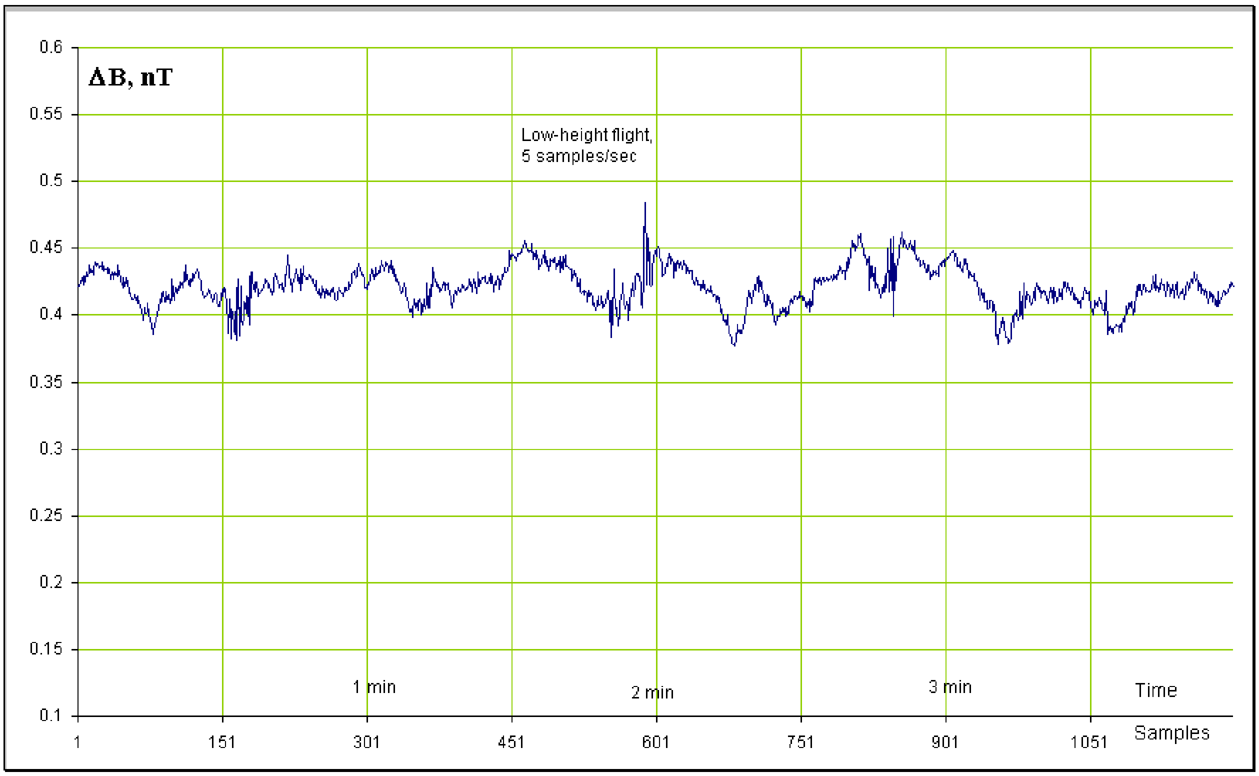

Sample Airborne Data from Soreq. Peak-to-Peak noise is between 5 and 10 pT.

Gradiometer Configuration

Four optically pumped Potassium sensors are used in a special configuration to measure tri-directional gradients. The sensors are placed in the back end of the bird shell and the tips of three fins, 3 to 4 m apart from each other. Average periods in the four Potassium frequencies are measured by a special computerized frequency counter and converted into magnetic field units. The differences in readings are taken and divided by the sensor spacings.

Horizontal across track gradient is measured directly from the readings of the two lower (horizontal) sensors. The vertical is determined from the average field measured by horizontal sensor and the sensor in the vertical fin. Horizontal along-the-track gradient is based on the average field from the three sensors placed in the fins and the bird-end sensor. Fourth differences are calculated for all three gradients as well as four absolute values of the magnetic field.

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Bird Design

Traditional criteria for EM birds were observed when the bird was designed. Requirements for rigidity are very much relaxed in comparison with EM birds. It is sufficient to measure gradients with 0.1% accuracy (up to 5 to 10 pT / m and beyond).

The bird's shell was therefore designed with sufficient diameter and wall thickness to accept the magnetometer sensor and support weight of sensors, fins, skirt, and its own weight with <0.1% change of relative sensor positions due to shell flexing.

The fins are spaced at 120 degrees to allow for simple calculation of gradients in all three directions; the average magnetic field of all three sensors falls in the centre of the bird shell to allow for simple determination of along-track gradient.

All three fins are 2.0m long to achieve a spacing for the vertical gradiometer equal to 3.0m. Horizontal across and along-the-track gradients are based on a sensor spacing of 3.45 and 3.76m, respectively, although the sensor in the bird shell can be moved along the shell to suit any potential requirements for different along-track configurations.

The bird skirt is designed to improve the distribution of weight along the bird shell; the fins are placed in front to overweight the skirt and to make the front end somewhat heavier in a stationary state. This ensures a downward pressure on the skirt when flying, and stable towing of the bird. Pick-up points are selected close to Euler minimum flexing points, although rigidity is not crucial.

Signal Processing

The Potassium magnetometer supplies frequency information at up to 20 times per second for precise measurement and conversion into magnetic field units.

Signals are processed through GEM's Potassium console, or the system can be interfaced to a data acquisition unit for later conversion in to magnetic field units using a formula supplied by GEM Advanced Magnetometers.

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Bird Specifications

Bird	5m	82 kg
3 Arms	2m	32 kg
Skirt	5m (diameter)	6 kg

Potassium 70 mm SuperSenser Specifications

Sensitivity:	0.001 nT @ 20 readings / second
Resolution:	0.0001 nT
Absolute Accuracy:	0.2 nT
Dynamic Range:	20,000 to 120,000 nT
Gradient Tolerance:	Over 2,500 nT/m
Sampling Rate:	1 to 20 readings / sec
Operating Temperature:	-20C to +55C
Console:	223 x 69 x 240mm
Sensor:	152 x 89mm (external dia.) cylinder
Electronics Box:	310 x 75 x 90mm