GSM-19 v6.0 Overhauser Archaeological Gradiometer

Introduction

The GEM Systems GSM-19 v6.0 is an Overhauser gradiometer system that provides improved sensitivity for detecting and mapping **near surface** magnetic objects. The v6.0 can be equipped with a Global Positioning System (GPS).

The GPS positioning option can be used for standard positioning and timing, timing only, UTM conversion and grid navigation. Used with a base station, results can be post processed to yield sub-meter acurracies.

Showing the GSM-19 with backpack mounted Gradiometer

The GSM-19 v6.0 has the internal capacity to store a large amount of data and to rapidly transfer that data from field instruments to a computer making more time available for the data reduction tasks.

Magnetism and the Importance of Sensitivity and Gradient Measurement

Magnetic archaeological targets, in general, exhibit varying degrees of remanent and induced magnetization. Both $\mathbf{I}_r$ and $\mathbf{I}_i$ components are combined vectorially to produce the net magnetization of the target, and in the case of steel objects, the $\mathbf{I}_r$ component can be an order of magnetude greater than the induced component.

Iron and steel objects will rust in oxidizing environments. This has the net effect of reducing the intensity of their magnetization. As well, the combination of intensity and orientation of the remanent component can either decrease or add to the induced magnetic anomaly.

It is therefore important to choose a magnetometer with superior sensitivity to changes in magnetic field intensity and a method of measurement that optimizes the spacial resolution of near surface objects. Both of these factors have been incorporated into the design of the GSM-19 v6.0 gradiometer.

GSM-19 v6.0 Advantages.

- **sensitivity** - based on a new signal processing algorithm, the sensitivity of the measurements has been improved by 25 percent from previous versions. This advantage will increase resilience against background noise, producing better data and faster operation.
- **resolution and absolute accuracy** - an order of magnitude improvement in the resolution of precession frequency (from 0.01 to 0.001 nT) improves the quality and repeatability of the measurements. As well, the improved absolute accuracy (a variance of only ± 0.1 nT between any GSM-19 V6.0 sensors) makes this model an ideal choice for gradiometer installations.
- **increased memory capacity** - the internal storage capacity of the GSM-19 v6.0 with minimum memory (4 Mbytes) using a standard magnetometer configuration recording time, X&Y and field value, is approximately 262,000 readings. With optional increments, the storage capacity can be increased to over 2 million readings (32 Mbytes).
- **high resolution, stable gradient measurements** - precise gradient measurements from a vertical, two sensor array (sensitivities 0.015 nT) with a separation of 172.1 cm yields a gradient sensitivity of 0.0087 nT/m. One kilogram of iron buried at a depth of 6 m yields an anomaly of approximately 0.2 nT (or 0.1 nT/m). This anomaly can be resolved with 11.5 divisions of sensitivity (0.1 nT/m/ 0.0087 nT/m). A noise envelope of 0.02 nT/m (RMS of two sensors, each with 0.015 nT sensitivity), sets a practical limit of 5 divisions of sensitivity for this target.

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Backpack Walking Magnetometer/ Gradiometer Support & Option

The GSM-19 v6.0 "walking magnetometer" and "walking gradiometer" are supplied with an optional backpack supported sensor configuration that is uniquely constructed, permitting the measurement of the total field (one sensor) or vertical magnetic gradient (two sensors) while having both hands free to maintain balance or to operate the console during traverses.

GEM Systems pioneered the innovative "Walking" option that enables acquisition of nearly continuous data on survey lines. The "Walking" option is a popular feature of the GSM-19 v6.0.

Similar to an airborne survey in principle, data is recorded at discrete time intervals (up to 5 readings per second) as the instrument is carried along the line. At each survey picket (fiducial), the operator touches a designated key. The Walking Magnetometer automatically assigns a picket coordinate to the last reading and linearly interpolates coordinates of all intervening readings during post processing.

A main benefit of the Walking option is that the high sample density improves definition of near surface targets. Because the operator can record data on a near-continuous basis, the Walking Magnetometer increases survey efficiency and minimizes field expenditures -- especially for highly detailed ground-based surveys.

GSM-19 v6.0 Specifications

Sensitivity: 0.015 nT/$\sqrt{}$Hz

Absolute accuracy: ± 0.1 nT

Dynamic Range: 10,000 to 120,000 nT

Gradient Tolerance: Over 10,000 nT/meter

Maximum Sample Rate: 1 reading per 3 seconds, (Standard)
2 readings/sec, Walk option
5 readings/sec, Fast option

Console Weight: 2.1 kg

Console Dimensions: 223 x 69 x 240 mm

Environmental:
Storage Temperature: -70°C to 60°C.
Operating Temperature: -40°C to 60°C.
Humidity: 0 to 100%, splashproof.

Power Requirements:
12 V 2.2 Ah battery will operate continuously for 45 hours on standby.

Power Consumption:
2 watt-seconds per reading typical in Standard mode at 20°C. In Walk and Fast modes, 2 watts continuous.

Integrated GPS Option

The integrated GPS option consists of a 12 channel Marconi Allstar OEM board with Standard Positioning Service (SPS). By using a base station magnetometer equipped with the GPS board, DGPS corrections can be computed using licenced software.

When carrying out DGPS corrections, the GPS determined position of a base station is computed and compared to its surveyed geodetic position. The differential information from the base station is merged with the GPS measurements from the roving GPS receiver, and is used to remove the systematic (correctable) error factors. The receiver uses the WGS-84 geographic reference.

Using WayPoint software for postprocessing the results, the corrected DGPS positions can be determined to submeter accuracies if the Dilution of Precision factors for time, horizontal and vertical measurements are not greater than 0.8, 1.5 and 2.0 respectively.

Archaeological Mapping

Buried man made objects or voids such as subterrainian tombs often displace natural magnetic field paterns existing prior to cultural activity and therefore result in anomalies outlining their lateral extent. Objects such as buried walls, kiln baked pottery, bricks and tiles, buried roads and pathways have been mapped using magnetic methods.

In some circumstances, models of magnetic targets can be computed and therefore yield close approximations of amplitudes and spacial extent of anomalies expected. This approach is very helpful in determining the survey grid dimensions required to resolve the target effectively.

Both horizontal and vertical gradients are useful in the search for near surface objects. Computing the vector solution (magnetude and direction) can be helpful in determining if the target is monopolar or dipolar and the convergence of vectors yields a depth approximation. A second derivative computed from the gradient measurements is effective at mapping the horizontal extent of magnetic targets (i.e. the zero crossover of the 2nd derivative convienently maps the inflection point or approximate edge of the target).

About GEM Systems

GEM Systems is the leading world manufacturer of Overhauser, proton and optically pumped potassium magnetometers for land, sea, air and space applications.

GEM Systems has provided its clients with quality instrumentation for magnetic measurements since 1980. A commitment to superior performance, small size, and low power consumption has been GEM Systems' philosophy since the introduction of its first magnetic instrument.

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