



GSM-19 v7.0

Overhauser Magnetometer / Gradiometer / VLF

Introduction

The GSM-19 v7.0 Overhauser instrument is the total field magnetometer / gradiometer of choice in today's earth science environment -representing a unique blend of physics, data quality, operational efficiency, system design and options that clearly differentiate it from other quantum magnetometers.

With data quality exceeding standard proton precession and comparable to costlier optically pumped cesium units, the GSM-19 is a standard (or emerging standard) in many fields, including:

- * **Mineral exploration (ground and airborne base station)**
- * **Environmental and engineering**
- * **Pipeline mapping**
- * **Unexploded Ordnance Detention**
- * **Archeology**
- * **Magnetic observatory measurements**
- * **Volcanology and earthquake prediction**

Taking Advantage of the Overhauser Effect

Overhauser effect magnetometers are essentially proton precession devices except that they produce an order-of magnitude greater sensitivity. These "supercharged" quantum magnetometers also deliver high absolute accuracy, rapid cycling (up to 5 readings / second), and exceptionally low power consumption.

The Overhauser effect occurs when a special liquid (with unpaired electrons) is combined with hydrogen atoms and then exposed to secondary polarization from a radio frequency (RF) magnetic field.

The unpaired electrons transfer their stronger polarization to hydrogen atoms, thereby generating a strong precession signal-- that is ideal for very high-sensitivity total field measurement.

In comparison with proton precession methods, RF signal generation also keeps power consumption to an absolute minimum and reduces noise (i.e. generating RF frequencies are well out of the bandwidth of the precession signal).

In addition, polarization and signal measurement can occur simultaneously - which enables faster, sequential measurements. This, in turn, facilitates advanced statistical averaging over the sampling period and/or increased cycling rates (i.e. sampling speeds).

The unique Overhauser unit blends physics, data quality, operational efficiency, system design and options into an instrumentation package that ... exceeds proton precession and matches costlier optically



pumped cesium capabilities.

And the latest v7.0 technology up-grades provide even more value, including:

- **Data export in standard XYZ**
(i.e. line-oriented) format for easy use in standard commercial software programs
 - **Programmable export format** for full control over output
 - **GPS elevation values** provide input for geophysical modeling
 - **<1.5m standard GPS** for high-resolution surveying
 - **<1.0 OmniStar**
 - **<0.7m for Newly introduced CDGPS**
 - **Multi-sensor capability** for advanced surveys to resolve target geometry
 - **Picket marketing / annotation** for capturing related surveying information on the go.
- And all of these technologies come complete with the most attractive prices and warranty in the business!**

Maximizing Your Data Quality with the GSM-19

Data quality is a function of five key parameters that have been taken into consideration carefully in the design of the GSM-19. These include sensitivity, resolution, absolute accuracy, sampling rates and gradient tolerance.

Sensitivity is a measure of the signal-to noise ratio of the measuring device and reflects both the underlying physics and electronic design. The physics of the Overhauser effect improves sensitivity by an order of magnitude over conventional proton precession devices. Electronic enhancements, such as high-precision precession frequency counters enhance sensitivity by 25% over previous versions. The result is high quality data with sensitivities of 0.022 nT / vHz. This sensitivity is also the same order-of magnitude as costier optically pumped cesium systems.

Resolution is a measure of the smallest number that can be displayed on the instrument (or transmitted via the download process). The GSM-19 has unmatched resolution (0.01mT) This level of resolution translates into well-defined, characteristic anomalies; improved visual display; and enhanced numerical data for processing and modeling.

Absolute accuracy reflects the closeness to the "real value" of the magnetic field -- represented by repeatability of readings either at stations or between different sensors. With an absolute accuracy of +/- 0.1 nT, the GSM-19 delivers repeatable station-to-station results that are reflected in high quality total field results.

Similarly, the system is ideal for gradient installations (readings between different sensors do not differ by more than +/- 0.1 nT) -- maintaining the same high standard of repeatability. The GSM-19 gradiometer data are consistently low in noise and representative of the geologic environment under investigation.

Sampling rates are defined as the fastest speed at which the system can acquire data. This is a particularly important parameter because high sampling rates ensure accurate spatial resolution of anomalies and increase survey efficiency.

The GSM-19 Overhauser system is configured for two "measurement modes" or maximum sampling rates -- "Standard" (3 seconds / reading), and "Walking" (0.2 seconds / reading) These sampling rates make the GSM-19 a truly versatile system for all ground applications (including vehicle-borne applications).



Gradient tolerance represents the ability to obtain reliable measurements in the presence of extreme magnetic field variations. GSM-19 gradient tolerance is maintained through internal signal counting algorithms, sensor design and Overhauser physics. For example, the Overhauser effect produces high amplitude, long-duration signals that facilitate measurement in high gradients.

The system's tolerance (10,000 nT / meter) makes it ideal for many challenging environments -- such as highly magnetic rocks in mineral exploration applications, or near cultural objects in environmental, UXO or archeological applications.

Total Field and Stationary Vertical Gradient showing the gradient largely unaffected by diurnal variation. Absolute accuracy is also shown to be very high (0.2 nT/meter).

Much like an airborne acquisition system, the GSM19 "Walking" magnetometer option delivers very highly-sampled, high sensitivity results that enable very accurate target location and / or earth science decision-making.

Increasing Your Operational Efficiency

Many organizations have standardized their magnetic geophysical acquisition on the GSM-19 based on high performance and operator preference. This preference reflects performance enhancements such as memory capacity; portability characteristics; GPS and navigation; and dumping and processing.

Memory capacity controls the efficient daily acquisition of data, acquisition of positioning results from GPS, and the ability to acquire high resolution results (particularly in GSM-19's "Walking" mode).

V7.0 upgrades have established the GSM19 as the commercial standard for memory with over 1,465,623 readings (based on a basic configuration of 32Mbytes of memory and a survey with time, coordinate, and field values).

Portability characteristics (ruggedness, light weight and power consumption) are essential for operator productivity in both normal and extreme field conditions.

GSM-19 Overhauser magnetometer is established globally as a robust scientific instrument capable of withstanding temperature, humidity and terrain extremes. It also has the reputation as the lightest and lowest power system available -- reflecting Overhauser effect and RF polarization advantages.

In comparison with proton precession and optically pumped cesium systems, the GSM-19 system is the choice of operators as an easy-to-use and robust system.

GPS and navigation options are increasingly critical considerations for earth science professionals.

GPS technologies are revolutionizing data acquisition -- enhancing productivity, increasing spatial resolution, and providing a new level of data quality for informed decision-making.

The GSM-19 is now available with real-time GPS and DGPS options in different survey resolutions. For more details, see the GPS and DGPS section.

The GSM-19 can also be used in a GPS Navigation option with real-time coordinate transformation to UTM, local X-Y coordinate rotations, automatic end of line flag, guidance to the next line, and survey "lane" guidance with cross-track display and audio indicator.



Other enhancements include way point pre-programming of up to 1000 points. Professionals can now define a complete survey before leaving for the field on their PC and download points to the magnetometer via RS-232 connection.

The operator then simply performs the survey using the way points as their survey guide. This capability decreases survey errors, improves efficiency, and ensures more rapid survey completion.

Dumping and processing effectiveness is also a critical consideration today. Historically, up to 60% of an operator's "free" time can be spent on low-return tasks, such as data dumping.

Data dumping times are now significantly reduced through GEM's implementation of high-speed, digital data links (up to 115 kBaud).

This functionality is facilitated through a new RISC processor as well as the new GSM-19 data acquisition / display software. This software serves as a bi-directional RS-232 terminal. It also has integrated processing functionality to streamline key processing steps, including diurnal data reduction. This software is provided free to all GSM19 customers and regular updates are available.

Adding Value through Options

When evaluating the GSM-19 as a solution for your geophysical application, we recommend considering the complete range of options described below. These options can be added at time of original purchase or later to expand capabilities as your needs change or grow.

Our approach with options is to provide you with an expandable set of building blocks:

- * **Gradiometer**
- ** **Walking- Fast Magnetometer / Gradiometer VLF (3 channel)**
- * **GPS (built-in and external)**

GSM-19G Gradiometer Option

The GSM-19 gradiometer is a versatile, entry level system that can be upgraded to a full-featured "Walking" unit (model GSM-19WG) in future.

The GSM-19G configuration comprises two sensors and a "Standard" console that reads data to a maximum of 1 reading every three seconds.

An important GSM-19 design feature is that its gradiometer sensors measure the two magnetic fields concurrently to avoid any temporal variations that could distort gradiometer readings. Other features, such as single-button data recording, are included for operator ease-of-use.

GSM-19W / WG "Walking" Magnetometer / Gradiometer Option

The GSM-19 was the first magnetometer to incorporate the innovative "Walking" option which enables the acquisition of nearly continuous data on survey lines. Since its introduction, the GSM-19W / GSM-19WG



have become one of the most popular magnetic instruments in the world.

Similar to an airborne survey in principle, the system records data 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 system automatically assigns a picket coordinate to the reading and linearly interpolates the coordinates of all intervening readings (following survey completion during post-processing).

A main benefit is that the high sample density improves definition of geologic structures and other targets (UXO, archeological relics, drums, etc.).

It also increases survey efficiency because the operator can record data almost continuously. Another productivity feature is the instantaneous recording of data at pickets. This is a basic difference between the "Walking" version and the GSM-19 / GSM-19G (the "Standard" mode version which requires 3 seconds to obtain a reading each time the measurement key is pressed). **GSM-19 "Hands-Free"**

Backpack Option The "Walking" Magnetometer and Gradiometer can be configured with an optional backpack-supported sensor. The backpack is uniquely constructed -permitting measurement of total field or gradient with both hands free. This option provides greater versatility and flexibility, which is particularly valuable for high-productivity surveys or in rough terrain.

GSM-19GV "VLF" Option

With its omnidirectional VLF option, up to 3 stations of VLF data can be acquired without orienting. Moreover, the operator is able to record both magnetic and VLF data with a single stroke on the keypad.

3rd Party Software - A One-Stop Solution for Your Potential Field Needs

As part of its complete solution approach, Terraplus offers a selection of proven software packages. These packages let you take data from the field and quality control stage right through to final map preparation and modeling.

Choose from the following packages:

- * **Contouring and 3D Surface Mapping**
- * **Geophysical Data Processing & Analysis**
- * **Semi-Automated Magnetic Modeling**
- * **Visualization and Modeling / Inversion**

Geophysical Data Processing and Analysis from Geosoft Inc.

GSM-19 with internal GPS board. Small receiver attaches above sensor

Version 7 -- New Milestones in Magnetometer Technology



The recent release of v7.0 of the GSM-19 system provides many examples of the ways in which we continue to advance magnetics technologies for our customers.

Enhanced data quality:

- * 25% improvement in sensitivity (new frequency counting algorithm)
- * new intelligent spike-free algorithms (in comparison with other manufacturers, the GSM-19 does not apply smoothing or filtering to achieve high data quality)

Improved operational efficiency:

- * Enhanced positioning (GPS engine with optional integrated / external GPS and real-time navigation)
- * 16 times increase in memory to 32 Mbytes
- * 1000 times improvement in processing and display speed (RISC microprocessor with 32-bit data bus) 2 times faster digital data link (115 kBaud through RS-232)

Innovative technologies:

- * Battery conservation and survey flexibility (base station scheduling option with 3 modes - daily, flexible and immediate start)
- * Survey pre-planning (up to 1000 programmable waypoints that can be entered directly or downloaded from PC for greater efficiency)
- * Efficient GPS synchronization of field and base units to Universal Time (UTC)
- * Cost saving with firmware up grades that deliver new capabilities via Internet

More About the Overhauser System

In a **standard Proton magnetometer**, current is passed through a coil wound around a sensor containing a hydrogenrich fluid. The auxiliary field created by the coil (>100 Gauss) polarizes the protons in the liquid to a higher thermal equilibrium.

When the current, and hence the field, is terminated, polarized protons precess in the Earth's field and decay exponentially until they return to steady state. This process generates precession signals that can be measured as described below.

Overhauser magnetometers use a more efficient method that combines electronproton coupling and an electron-rich liquid (containing unbound electrons in a solvent containing a free radical). An RF magnetic field -- that corresponds to a specific energy level transition -- stimulates the unbound electrons.

Instead of releasing this energy as emitted radiation, the unbound electrons transfer it to the protons in the solvent. The resulting polarization is much larger, leading to stronger precession signals.

Both Overhauser and proton precession, measure the scalar value of the magnetic field based on the proportionality of precession frequency and magnetic flux density (which is linear and known to a high degree of accuracy). Measurement quality is also calculated using signal amplitude and its decay characteristics. Values are averaged over the sampling period and recorded.

With minor modifications (i.e. addition of a small auxiliary magnetic flux density while polarizing), it can also be adapted for high sensitivity readings in low magnetic fields. (ex. for equatorial work)

GPS - Positioning You for Effective Decision Making



Key System Components

Key components that differentiate the GSM-19 from other systems on the market include the sensor and data acquisition console. Specifications for components are provided on the right side of this page.

Sensor Technology

Overhauser sensors represent a proprietary innovation that combines advances in electronics design and quantum magnetometer chemistry.

Electronically, the detection assembly includes dual pick-up coils connected in series opposition to suppress far-source electrical interference, such as atmospheric noise. Chemically, the sensor head houses a proprietary hydrogen-rich liquid solvent with free electrons (free radicals) added to increase the signal intensity under RF polarization.

From a physical perspective, the sensor is a small size, light-weight assembly that houses the Overhauser detection system and fluid. A rugged plastic housing protects the internal components during operation and transport.

All sensor components are designed from carefully screened non-magnetic materials to assist in maximization of signal-to-noise. Heading errors are also minimized by ensuring that there are no magnetic inclusions or other defects that could result in variable readings for different orientations of the sensor.

Optional omni-directional sensors are

Performance

available for operating in regions where the magnetic field is near-horizontal (i.e. $0.022 \text{ nT / vHz@1Hz}$ equatorial regions). These sensors maximize signal strength regardless of

Absolute Accuracy: $\pm 0.1 \text{ nT}$

Dynamic Range: 15,000

to 120,000 nT

Data Acquisition

Tolerance: $> 10,000 \text{ nT/m}$ Console Technology Sampling Rate: 60+, 3, 2, 1, 0.5, 0.2 sec

Console technology comprises an external keypad / display interface with internal firmware for frequency counting, system control and data storage / retrieval. For operator convenience, the Manual: display provides both monochrome text Coordinates, time, date and reading as well as real-time profile data with an stored automatically at minimum 3 easy to use interactive menu for per-second interval. forming all survey functions.

Base Station:

Time, date and reading stored at 3 to The firmware provides the convenience 60 second intervals.

of upgrades over the Internet via its software. The benefit is that instrumen-Optional remote control using RS-232

tation can be enhanced with the latest

interface.

technology without returning the system to us -- resulting in both timely implementation of updates and



RS-232 or analog (optional) output using 6-pin weatherproof connector
reduced shipping / servicing costs.

Storage - 32Mbytes (# of Readings)

Mobile:	1,465,623
Base Station:	5,373,951
Gradiometer:	1,240,142
Walking Magnetometer:	2,686,975

Dimensions

Console:	223 x 69 x 240 mm
Sensor:	175 x 75mm diameter cylinder

Weights

Console:	2.1 kg
Sensor and Staff Assembly:	1.0 kg

Standard Components

GSM-19 console, GEMLinkW software, batteries, harness, charger, sensor with cable, RS-232/USB cable, staff, instruction manual and shipping case.

Optional VLF

Frequency Range:

Up to 3 stations between 15 to 30.0 kHz

Parameters:

Vertical in-phase and out-of phase components as % of total field. 2 components of the horizontal field amplitude and total field strength in pT

Resolution:

0.1% of total field