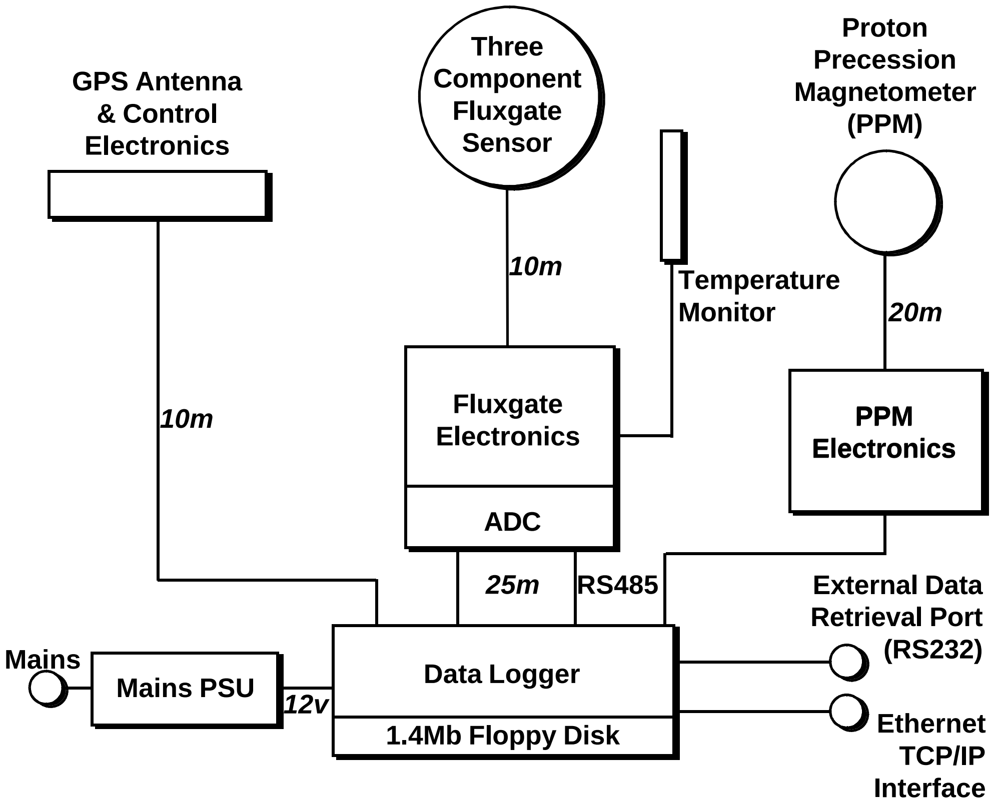
GEOMAGNETIC DATA ACQUISITION SYSTEM

G-DAS
Geomagnetic Data Acquisition System



G-DAS® includes a 3 component fluxgate magnetometer, a proton magnetometer, a GPS receiver and an embedded PC-based data logger with all electronics built into an integrated package. Daily files of minute-mean data are logged to disk together with accurate timing information, obtained from the GPS receiver.

- **Magnetic field variations monitored in the Horizontal (H) Declination (D) and Vertical (Z) components**
- **Absolute Total Field intensity (F) from the proton magnetometer**
- **Accurate temperature monitoring**
- **Minute-mean values of all components written to DOS compatible floppy disk with data storage capacity of 1 month**
- **Timing control synchronised to GPS**
- **Operates from mains or a single 12V DC supply**
- **Logged data may be retrieved through a modem or the Internet**
- **Embedded PC-based data logger**
- **Automatic software start-up**
- **16 bit ADC, dynamic range from ±1000 to ±64,000 nT**
- **Data analysis software included**
- **Hard disk data storage capacity, up to 1 year**

• *For further details, please contact:*
• Earthquake, Forensic Seismology & Geomagnetism Programme • British Geological Survey • Murchison House • West Mains Road • Edinburgh EH9 3LA • UK •

The *G-DAS* Magnetic Observatory Systems

1. System Overview

G-DAS (Geomagnetic Data Acquisition System) has been developed by the British Geological Survey (BGS) for use in magnetic observatories. It is an automatic system which runs with a minimum of operator intervention.

G-DAS is designed to continuously monitor and record variations in magnetic declination (D), horizontal intensity (H), vertical intensity (Z). The system is equipped with a fluxgate magnetometer with a suspended sensor. Absolute total field (F) is measured using an Overhauser effect proton precession magnetometer. All timing is derived from a GPS synchronised clock.

G-DAS provides the same functionality as FLARE *Plus* and now includes software allowing it to be interfaced directly through a suitable IP port to the INTERNET.

Features of G-DAS

- Remote unattended operation
- One-second samples of H, D, Z and temperature from the fluxgate magnetometer
- One-minute values of H, D, Z and temperature calculated from the fluxgate magnetometer data logged to DOS-compatible disk
- Ten-second samples of total field (F) from Overhauser proton magnetometer.
- One-minute values of proton magnetometer data logged to disk.
- Fluxgate magnetometer resolution: 0.2nT
- Proton magnetometer resolution: 0.1nT
- Battery operation
- Sensor temperature monitoring
- Operation from mains or a single 12 V DC supply
- The equipment can be customised to suit local site requirements
- 1 second timing accuracy (UT) maintained using a GPS satellite receiver
- Display of data on a standard TFT screen
- Data analysis and verification software
- Ethernet 10/100 Base-T (TCP/IP) Interface
- Internal data buffer capable of storing 1 year of 1 second fluxgate data
- Automatic data retrieval by direct connection, modem, radio or using IP protocols.

2. Detailed Equipment Specifications

i) Triaxial Fluxgate Magnetometer (Instrument data sheet attached)

Resolution: 0.2 nT
Dynamic range: ±64,000 nT to ±1000 nT in each component (resistor selectable)
Frequency response: DC - 1 Hz
Temperature Coefficient: < 0.3nT/°C
Operating temperature range: 0 - 50°C
Power supply +15V DC
Power requirements: 2 W

The magnetometer is of the suspended type, designed to eliminate errors due to pier tilt. It is recommended that the fluxgate sensors and fluxgate control electronics are kept in the same temperature environment.

ii) Proton Magnetometer Overhauser type

Resolution: 0.01 nT
Absolute accuracy: 0.2 nT
Long term stability: 0.05 nT/year
Dynamic range: 20,000 to 120,000 nT
Power supply: 12 V DC
Operating temperature: - 40°C to +60°C
Power requirements 1.5 W

iii) Analog to Digital Converter (ADC)

2 x 16 bit ADC's, resolution 0.01 mV
Up to 4 analog inputs
Maximum analog input ±10 V
Maximum sampling rate 4 channels/second
Operates from a single 12 V supply
Power consumption 50mW

The ADC communicates with the ***G-DAS*** data logger through a two-wire, RS485 interface. This interface can drive signals up to 1 km but in practice, to avoid damage due to lightning, the separation between the ADC and the ***G-DAS*** logger should be kept as short as possible, 25 m is recommended.

iv) Data Control and Logging PC

200 MHz Pentium-Class embedded PC with “Unix type” operating system
64Mb internal memory
4 serial RS232 compatible ports
IBM/PC compatible bi-directional parallel I/O port
1.44Mb floppy disk
20 Gb hard disk
TFT (VGA) data display
Unix type operating system
Single 12 V power supply
Power consumption: 7 W
IP interface

v) GPS Time Receiver

12 channel receiver
May be operated independently from the logger
Positional accuracy 10m, approximately
6 m antenna cable
Active antenna module
Absolute timing accuracy ±100 ns
Single 12 V supply
Power consumption 1.8 W

vi) Operating software

The resident code in the PC controls all data capture and logging operations, and the optional transmission of data through a serial link to a modem. The data are transmitted from the PC as a binary RS232-compatible data stream or may be retrieved through the Internet using ftp protocols.

Samples are taken from 4 ADC inputs as 16 bit numbers every second. The data collected, logged and transmitted by the PC are:

Time and date
Fluxgate magnetometer: H, D and Z, one second samples and INTERMAGNET compatible minute mean values.
Fluxgate temperature
Proton precession magnetometer: Total Field (F), 6 samples/minute.

vii) Power Supply Module

The system power module provides the operating voltages required by the following system components:

Fluxgate magnetometer
Proton magnetometer
PC
Analog to Digital Converter
GPS receiver

The power supply module operates from either a 110 V or 220 V, 50/60 Hz mains supply generating a 12 Volt supply for the PC and all sensors. A 12 Volt, 24 AH battery will support operations for up to 10 hours in the event of a mains failure.

The total system power consumption is:

G-DAS 1200 mA @ 12 V

All data capture, reduction, storage, communication and display functions are controlled by the PC. The following list indicates the functions the PC code can perform:

Capture and digitisation of all data from the fluxgate and proton magnetometers
Calculation of one-minute values from the fluxgate magnetometer H, D, Z data
Calculation of one-minute values of F from the proton magnetometer data
Storage of one-minute values on floppy disk (40 day capacity)
Storage of one-second values of fluxgate data on hard disk (1 year)
Storage of one minute values of fluxgate and proton data on hard disk (1 year)
Display of H D Z, and temperature every second
Display of all proton magnetometer samples
Display of all one-minute values calculated from the proton magnetometer, fluxgate magnetometer data and temperature.
Display of GPS derived date, time and position information and satellite availability

The one-minute values from the fluxgate magnetometer data are produced using a 21-point Gaussian filter to reduce aliasing.

The system timing and sampling control is derived from GPS signals and is maintained to an accuracy of 1 second.

3. Cost of the Standard *G-DAS* System

The cost of the ***G-DAS*** system as specified in this document is available on request. The basic price includes the costs of freight but ***not*** the installation of the equipment by BGS staff. It ***does not*** include any applicable UK or local taxes or duties, which must be paid by the customer.

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4. Notes

i) The fluxgate magnetometer specified is a suspended type, constructed by the Danish Meteorological Institute. This instrument has been adopted as an observatory standard by many countries and is currently operational in Denmark, Greenland, Finland, Germany, Japan and the UK.

ii) The recomended maximum separation between fluxgate sensors and the ***G-DAS*** data logger is 25m. A separation greater than this is technically feasible, but with long cabling there is a considerable risk of damage to equipment due to lightning strikes.

iii) The maximum separation between the proton magnetometer sensor and the control electronics is 20m with a further recommended maximum 25m separation between the proton magnetometer control electronics and the PC, which can share the same accommodation. The 25m separation between the proton magnetometer electronics and the PC may be extended using a fibre optic link (at extra cost) but it is desirable to keep the separation between proton magnetometer sensor and its control electronics to a minimum to reduce the risk of lightning damage.

iv) It is appreciated that instrument accommodation varies considerably from one observatory to another and ***G-DAS*** has been designed to be flexible so that it can operate successfully in a wide range of conditions. To identify any potential problems at an early stage we would encourage the customer to communicate with us to discuss the accommodation available and its suitability. The location and construction of the plinth on which the fluxgate are mounted is particularly important.

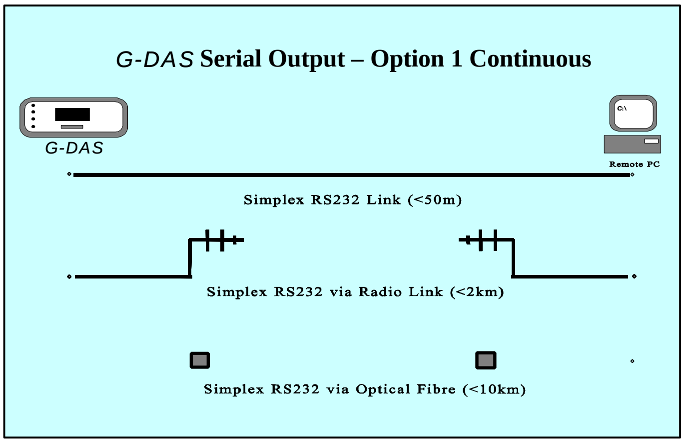
v) Prior to an installation by BGS staff all site preparation, accommodation and plinth construction must be complete and suitable cable ducting must be in place.

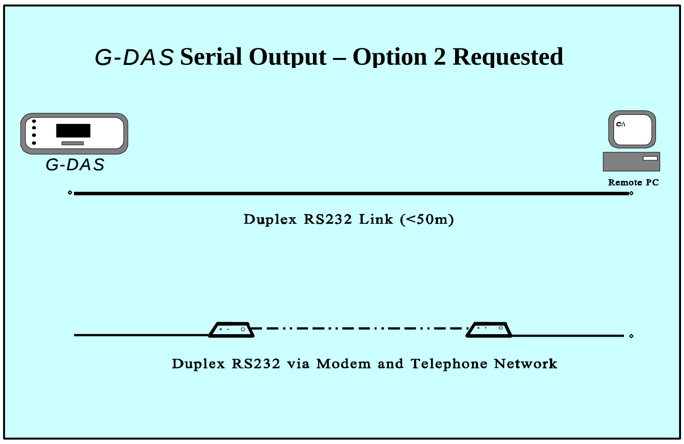
vi) As ***G-DAS*** is a specialised piece of equipment it is recommended that BGS staff install it at the customer's site and train the local operators in the calibration and maintenance of the equipment. A data analysis package is available and if required, customers are given training in its use during the installation visit. A complete installation and training program would normally take 5 days.

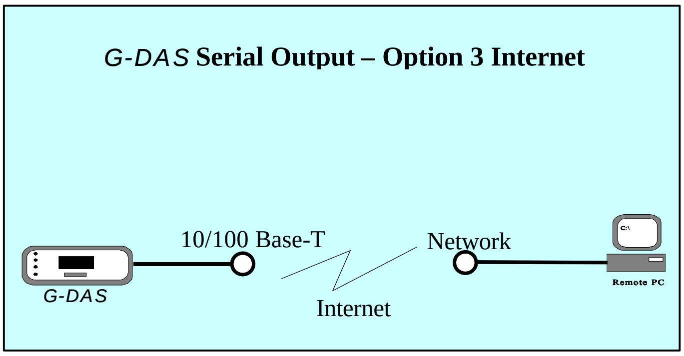
Figures

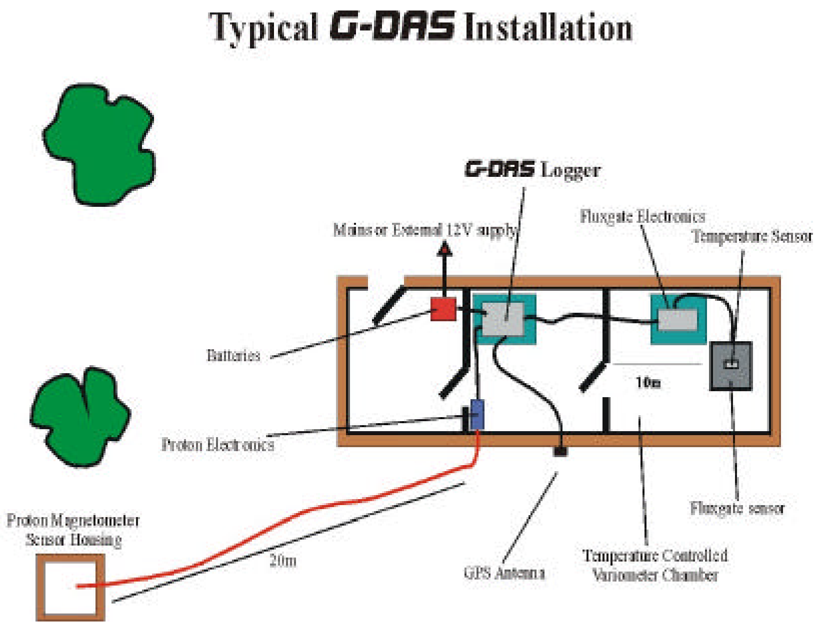
The figures illustrate various possible methods of transmitting data from a ***G-DAS*** system to a local or remote site.

A diagram illustrating the possible layout of ***G-DAS*** equipment in a magnetic observatory is also given.



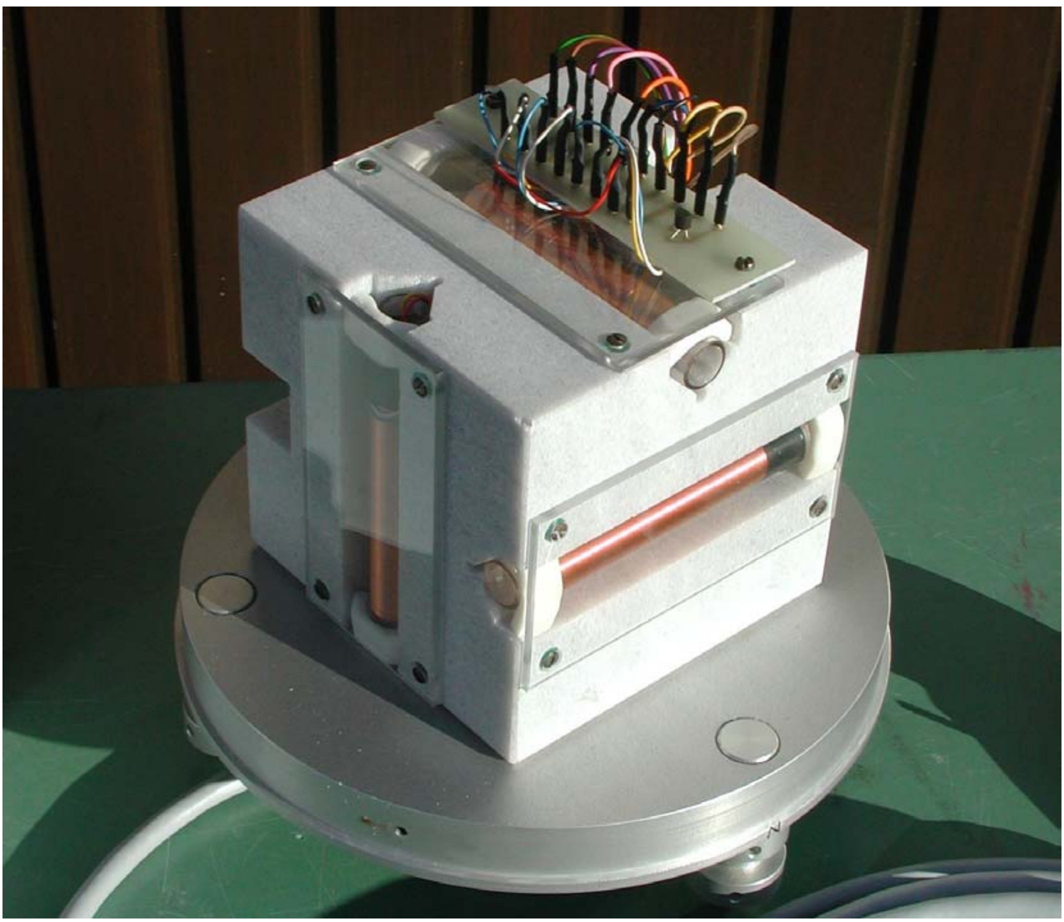






Fluxgate

Magnetometer FGE



Fluxgate Magnetometer FGE

Since the 1920th DMI has been involved in the development and production of instruments for use at magnetic observatories and the La Cour instruments such as the QHM and the BMZ well as the La Cour variometers have been used and are still being used world wide in more than 60 different countries.
In recent years DMI has developed and started to produce highly stable fluxgate magnetometer type FGE, which is suitable for digital recording of the magnetic field at observatories and in the field.
The main idea behind this effort has been to construct a reliable and very stable instrument, which does not suffer from annoying drift with time and temperature.
The FGE magnetometer has analog outputs enabling use to adapt the instrument to their own data logging systems. An optional build-in AD-converter is also available.

In order to avoid drift due to tilt of the instrument pier, which is often the main cause of baseline drift, a special version of the magnetometer is available in which the sensors are suspended by two crossed bronze bands to compensate the tilt.

Features

3 linear core sensors mounted on a marble cube for good mechanical stability.
Compensation coils on quartz base for highest temperature stability.
Highly stable digitally controlled compensation of main field.
Very good long time stability.
Nonmagnetic electronics which may be placed close to the sensor head in a thermostatically controlled room to avoid any temperature drift.
2 built-in temperature sensors.

Optional features

Suspended sensors for optimal baseline stability.
Battery operation.
Build-in 16 bit AD-converter (Adam module)

Specifications

Analog output:	±1OV
Dynamic range:	User specified
Resolution:	0.1 nT
Compensation field range:	+-64 000 nT
Compensation field steps:	150 nT
Misalignment of sensor axis:	< 2 mrad
Long time drift:	< 3 nT/year
Temp. coeff. of sensor:	< 0.2 nT/°C
Temp. coeff. of electronics:	< 0.1 nT/°C
Resolution of temperature:	0.1 °C
Band pass:	DC to 1 Hz

Spec. of optional suspension

Range of compensation: ± 0.5°
Factor of compensation: > 200

General information

Size of sensor:	190 x 190 x 190 mm 9.5 kg
Size of suspended sensor:	250 x 250 x 550 mm 20 kg
Size of electronics:	160x90x360 mm 3.0 kg
Power requirements:	230 VAC, 3W
Operating temperature:	0 to 60°C Optional
Optional power supply:	10-18 VDC, 3 W

Optional digital output:

8 ch /16 bit ADAM AD-converter

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ADVANCED MAGNETOMETERS

GSM-90 v6.0

EUROMAG Observatory / Volcanology Magnetometer

The industry-standard v6.0 EUROMAG system is the latest innovation in Overhauser design - with many new technologies that deliver significant benefits for long-term monitoring applications.

Key technologies include:

Integrated GPS (time reception) option ... the only system with fully built-in GPS

25% increase in sensitivity over GEM's v5.0 system

Choice of sampling rates from 3 seconds, 1 second and 0.2 seconds ... with variable sampling intervals to 3600 seconds

Weather-proof housing for harsh environments

Overhauser sensor with enhanced robustness

Rapid data transfer at speeds up to 115 kilobytes (using GEM's proprietary GEMLinkW software)

Internet-based upgrades (from the office or field)

And all of these technologies come complete with the most attractive prices and warranty in the business!

GSM-90 Overhauser Magnetometer console with new sensor for enhanced robustness and signal quality.

The GSM-90 EUROMAG is a scalar magnetometer of high absolute accuracy (0.2nT) and low long term drift (0.05nT / year). It is optimized for use in magnetic observatories, long term monitoring arrays in volcanology, etc. where the following are essential:

* long term stability and high accuracy

* high resolution and low noise (0.02nT)

The EUROMAG is deployed in many installations, notably in observatories and on Mt. Etna, where dedicated scientists from the Instituto Nazionale di Geofisica e Vulcanologia (INGV) are using the system as a cornerstone of their research into the periodic eruptions of Europe's most active volcano.

Operating Principles

The EUROMAG is based on GEM's Overhauser Effect technology. the EUROMAG sensor has a free radical added ... in contrast to standard proton magnetometer sensors which only use a proton-rich liquid to produce precession signals. The free radical contributes free, un-bound electrons that couple with protons producing a two-spin system.

A strong RF magnetic field is used to disturb the electron-proton coupling. By saturating free electron resonance (ESR) lines, the polarization of protons in the sensor liquid is strongly increased.

Therefore, the Overhauser Effect offers a superior method of proton polarization -- delivering stronger signals from smaller sensors and with less power (i.e. 2Ws per reading or about 0.5W average power consumption for 1 reading per 5 seconds).

GSM-90 electronics are packaged in a thick, waterproof aluminum box specially designed to operate reliably in harsh environments. It is also microprocessor-based with full remote control capability. Results are made available in serial form (RS-232C interface) for collection by data acquisition systems.

Specifications

Resolution:	0.01 nT (gamma)
Absolute Accuracy:	0.2 nT
Dynamic range:	20,000 - 120,000 nT
Long term stability:	<0.05 nT/year
Sampling rate, minimum interval:	3 sec
Sensor size:	70mm dia. X 150mm
Power:	12V 200mA maximum, 40mA average
RS232C parameters:	programmable

* For the ultimate in low power operation, consider our GSM-90L requiring only 100mW for 1 reading in 5 seconds or 300mW for 1 reading per second.