PMG2

Proton magnetometer and gradiometer

Operation manual

Contents

1. Introduction

The proton magnetometer PMG2 is a portable instrument which is powered by an internal battery. It is intended for ground measuring of the absolute value of the magnetic induction vector of the Earth´s magnetic field by measuring the frequency of the precession of protons in hydrogen nuclei. The magnetic induction vector is also called the magnetic field vector.

The magnetometer PMG2 allows the Earth´s magnetic field to be measured in three modes:

SINGLE mode is used in a profile magnetic survey with one sensor. It detects the absolute value of the magnetic field in the location of the sensor. The sensor is connected to the ‘Up sensor’ connector.

GRAD mode uses two sensors. The absolute values of the magnetic induction vector in the locations of both sensors are measured simultaneously. The horizontal or vertical gradient of the magnetic field between the two sensors is determined by subtraction: The value of the field measured in the location of the sensor connected to the ‘Up sensor’ connector minus the value of the field measured in the location of the sensor connected to the ‘Down sensor’ connector. The gradient measurement removes to some extent the undesirable influence of disturbing fields, compensates for the influence of the regional field and does not depend on diurnal variations in the Earth´s magnetic field.

AUTO mode allows repeated measurements with one sensor in set time intervals. Both the starting time and the length of the intervals can be set prior to the measurements. This mode is used for measuring diurnal variations in the Earth´s magnetic field.

The results of the measurements can be stored in an internal memory. The data can be transmitted to a computer through USB interface using the communication program which is supplied with the instrument. The program saves the data in a text file of the external computer.

The magnetometer PMG2 is delivered with a power supply, which is a built-in lead acid battery. The non-magnetic rechargeable battery does not contribute enough to the magnetic moment of the instrument to affect measured values. A battery charger is also supplied with the instrument.

All functions of the magnetometer PMG2 are controlled by an internal microprocessor. This internal microprocessor allows an operator to communicate with the instrument via a keyboard and LDC display, controls the measurement process and transmits the acquired data to an external computer through the USB interface.

The proton magnetometer automatically checks correctness of the measurement and of the activities of the operator. If a failure is detected, the operator is warned with an error message on the display.

2. Specifications

Measuring range	20 000 to 100 000 nT
Resolution	0.1 nT
Absolute accuracy	±1 nT
Maximum gradient value	1 000 nT/m
Measuring cycle	ca 2 s
Triggering	- manual
	- automatic in AUTO mode
Internal clock	day, month, year, hours, minutes and seconds,
	independent of battery condition
Data memory	24 500 readings
Universal Serial Bus (USB)	
Power supply	internal lead acid battery 12 V / 3.4 Ah,
Battery lifetime	5 000 readings on average in GRAD mode
Processing unit:	
Dimensions	230 x 80 x 170 mm
Weight	3.2 kg including battery
Sensor	
Dimensions	dia 80 x 200 mm
Weight	0.7 kg
Operating temperature range	- 10 to 60 °C
Storage temperature range	- 20 to 70 °C

3. Description

The proton magnetometer PMG2 consists of a processing unit, measuring sensors and a post.

3.1 Measuring sensor with accessories

The measuring sensor contains two coils properly arranged to suppress an external disturbing field. The coils are placed in a laminated cylinder container filled with a liquid rich in hydrocarbons.

North and south are marked on the container of the sensor. The ‘north’ mark should point to the geographical north. The orientation of the sensor does not affect the value of the measured magnetic field, but it does affects the intensity of the signal from the sensor and thus the size of error of the measurement.

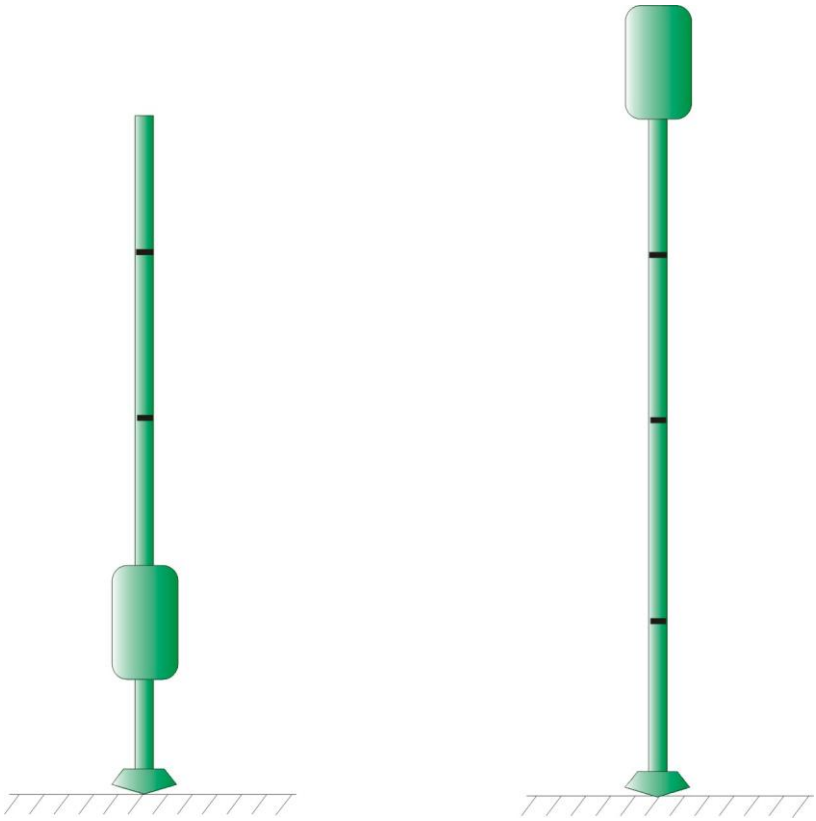


Fig. 1: Post assembly for line measurement

For measurements the sensor is mounted on a post which is assembled using up to five half meter long sticks joined with screw coupling. In this way the sensor can be set to

various heights above the ground - see Fig. 1. For gradient measurement an extension (gradient stick) is used to keep both sensors 0.5 or 1 m apart - see Fig. 2. The gradient stick allows the position of the sensors to be set so that the orientation of both sensors to the Earth´s magnetic field may be the same. For AUTO mode measurements (diurnal variations) an anchor ring with ropes and pins is supplied to hold the post in place.

The measuring sensors and the processing unit are connected via 2.5 m long cables.

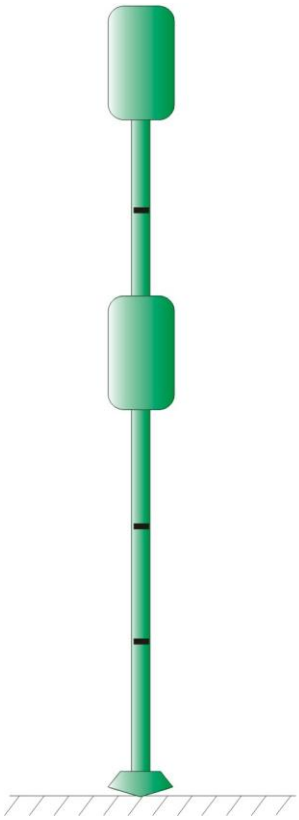


Fig. 2: Post assembly for gradient measurement

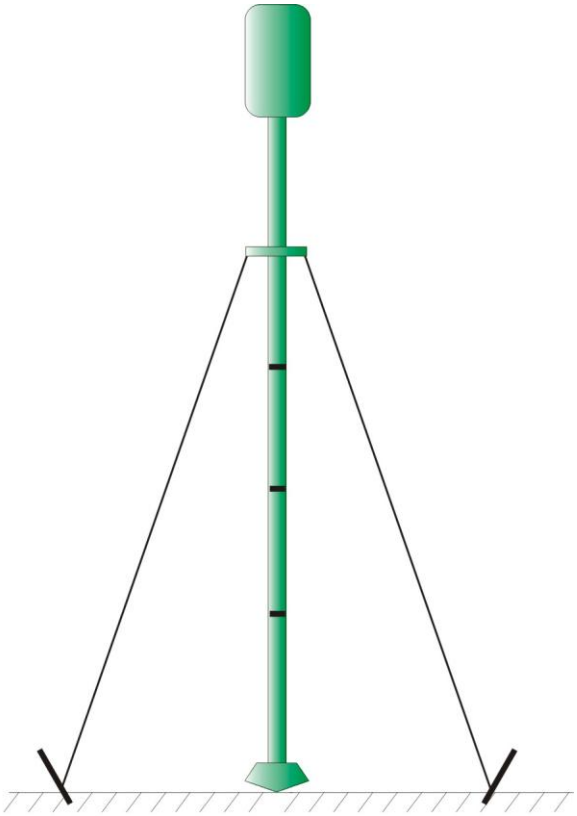


Fig. 3: Post assembly for magnetic variation measurement

3.2 Processing unit

The processing unit allows for communication with an operator via a keyboard and an eight row alphanumeric LCD display. It contains circuits for processing and analyzing the measured signal: tuning circuits, low-noise amplifier, filter and shaping amplifier.

The processing unit is placed in a duralumin box. Two bayonet watertight connectors for connecting the sensors are located on the left side of the box. In SINGLE and AUTO modes only the upper left connector is used, ‘Up sensor’. In GRAD mode, the

connector is used for the upper sensor. The gradient is determined by subtraction: The value of the field measured in the location of the sensor connected to the ‘Up sensor’ connector minus the value of the field measured in the location of the sensor connected to the ‘Down sensor’ connector.

There are two connectors on the right side of the box. The upper one serves for connecting to the computer through USB. The connector for charging of the internal battery is located in the lower part of the instrument. The connector can also be used for an external power supply after removing the internal battery.

The lead acid battery is placed in the bottom part of the unit and is accessible by unscrewing the four bolts in the bottom cover. The battery compartment is hermetically separated from the electronics.

The display and the keyboard are located on the top side of the unit. The keyboard contains 16 watertight membrane push-buttons.

The instrument is delivered with a harness to fasten it on the chest of an operator.

3.3 Functions

The measurement of the magnetic field is conducted in two steps. In the first measuring step the polarization current feeds the sensor and causes uniform orientation of magnetic moments of hydrogen nuclei contained in the liquid in the sensor. The time of polarization is automatically increased according to the decreasing source voltage so that the precession signal gained from the sensor may remain constant. During the polarization cycle the sensor and the low-noise amplifier are disconnected. The first step of the measuring sequention is terminated by switching the polarization current off.

In the second step due to an interruption of the polarization current in the sensor the transient field is dumped and then the low-noise amplifier is connected to the sensor. The signal induced in the sensor is amplified, filtered and shaped to suit the processing in numeric circuits. In the sampling circuit of the microprocessor the frequency of attenuated oscillations of the precession motion of the hydrogen nuclei is evaluated. The frequency is directly proportional to the measured magnetic field.

The entire measuring cycle is controlled by a microprocessor which computes the measured magnetic field and statistical error of the measurement from the value of the frequency of the precession. Both values are displayed and optionally stored in the data memory.

During the second step, the amplitude of the precession signal and the time constant of the decay are determined. The supplementary values are also stored in the data memory.

3.4 Operating controls

[ON / OFF]	switching on and off
[ENTER]	start of measurement or other selected procedures, setting validity of modified parameters or data, storing measured data in the memory
[ESC]	termination of any going-on procedure without storing data
[NEXT]	next item
[0] to [9]	loading digits
[v]	scanning series of consecutive data towards higher ordinal numbers
[^]	scanning series of consecutive data towards lower ordinal numbers

3.5 Display

A display is used in the processing unit allowing display of eight rows. A backlight can be used to make the display readable in worse conditions, but the power consumption is higher. Therefore the option should be used for the shortest time possible. The backlight can be set in the Setup menu.

4. Operation

4.1 Power supply

The instrument is delivered with a built-in hermetically closed lead acid battery 12V / 3.4Ah. The battery compartment is accessible from the bottom part of the box by unscrewing the four bolts fastening the bottom cover of the instrument.

The internal battery can be charged directly in the instrument with the charger supplied with the instrument.

4.2 Switch on/off

The first check of the instrument function can be performed with the processing unit without connecting the sensor. The instrument is switched on by pressing [ON / OFF].
A notice appears on the display giving the type of the instrument and Free memory, which is a number of readings that can still be saved in the memory.

In the case of a faulty power supply an error message is displayed.

If the battery is deeply discharged, the instrument automatically switches off.

Also, the instrument automatically switches off if the time interval AutoPowerOff elapses and there are no activities of the operator on the keyboard or through the USB interface. The interval can be set in the Setup menu, item Time.

If the instrument does not display the above mentioned information even after repeatedly pressing [ON /OFF], it means there is an instrument failure. It is recommended to contact the distributor or the manufacturer.

4.3 Battery condition check

The battery condition check is performed automatically each second after the instrument is switched on. The voltage levels for error messages about the battery discharge were set from the discharge characteristics according to the power consumption at the time of the check. If an error message about the battery discharge is displayed, it is necessary to charge the battery or to replace it with a charged one. The software does not allow operation of the instrument if the battery is deeply discharged and switches it off automatically. Thus erroneous operation and damage of the battery are prevented.

If the instrument is not used for a long time, the battery should be checked and charged at least twice a year.

The battery in the instrument is used to power the data memory even after the instrument is switched off. If the error message about low voltage of the battery is displayed, an immediate transmission of measured data to a computer is recommended, otherwise the data may be lost. The measured data are lost when the battery is removed.

The battery voltage is checked by a built-in digital voltmeter and displayed.

5. Basic setting

All functions of the instrument are controlled by a microcomputer that retains the current setting of parameters after the instrument is switched off. After the instrument is switched on or after the termination of a selected procedure the control switches to a status in which further commands from the keyboard are awaited. They are accepted in a system of menu. [ESC] terminates any procedure and transfers control to the previous menu.

After the instrument is switched on, the name of the instrument and the information of free data memory is displayed, it is the number of readings that can be stored in the data memory (the remaining capacity of the data memory). After two or three seconds the main manu is displayed.

```
Single      Bat:10.8V
MEASURE
POSITION
MEMORY
SETUP
Line:+1026 Pos:-0980
08.06.2012  15:38:44
```

Voltage of the power supply can be checked – in the upper right corner of the display. Date and time are displayed at the bottom.

In the main menu:

- measurement can be started
- position of the measurement can be set (The current line and position are displayed under the menu.)
- contents of the data memory can be examined
- setting parameters can be set in the setup menu. They are:
  - measurement mode
  - tuning of input circuits of the magnetometer
  - time and date of the internal clock
  - time interval to switch off
  - backlight of the display

The modified parameters are retained in the memory even after the instrument is switched off until next modification. Only if the battery is low, are the set parameters lost and replaced by default values.

5.1 Setting the internal clock - TIME

Time and date can be modified in the setup menu, item TIME. A cursor indicates the place to be modified by numeric push-buttons. The cursor is moved by pressing [v] and [^]. The push-button [NEXT] moves the cursor to the date that can be modified similarly.

To store the modified data in the memory it is necessary to press [ENTER] after the modification. The procedure can be terminated without changing data by pressing [ESC]. The control returns to the setup menu.

5.2 Tuning of the magnetometer - TUNE

Considering the character of the signal processed by the analog part of the instrument it is necessary to tune input circuits at least approximately to the measured magnetic field. To display the current tuning interval select TUNE item in the setup menu. For the SINGLE mode the display shows for example:

```
SETUP->TUNE:
Sensor: UP
41600 – 43800nT
43500 – 45800nT
45500 – 48000nT

Auto tune: ON
```

The word On/Off indicates if the function of the automatic tuning of input circuits is on or off. The automatic tuning can be switched on or off by pressing [v] and [^]. [NEXT] moves to the next item.The interval of the magnetic field can be selected by pressing [v] and [^] according to the awaited value.

The tuning intervals are:

1. 20 000 - 21 000 nT
2. 20 900 - 22 000 nT
3. 21 900 - 23 000 nT
4. 22 900 - 24 100 nT
18. 43 500 - 45 800 nT
19. 45 500 - 48 000 nT
20. 47 700 - 50 200 nT
21. 49 900 - 52 600 nT

5. 24 000 - 25 200 nT
6. 25 100 - 26 400 nT
7. 26 300 - 27 700 nT
8. 27 500 - 29 000 nT
9. 28 800 - 30 400 nT
10. 30 200 - 31 800 nT
11. 31 600 - 33 300 nT
12. 33 100 - 34 800 nT
13. 34 600 - 36 400 nT
14. 36 200 - 38 200 nT
15. 38 000 - 40 000 nT
16. 39 700 - 41 800 nT
17. 41 600 - 43 800 nT
22. 52 300 - 55 100 nT
23. 54 800 - 57 700 nT
24. 57 400 - 60 400 nT
25. 60 100 - 63 200 nT
26. 62 900 - 66 200 nT
27. 65 900 - 69 300 nT
28. 69 000 - 72 600 nT
29. 72 300 - 76 000 nT
30. 75 700 - 79 600 nT
31. 79 300 - 83 300 nT
32. 82 900 - 87 300 nT
33. 86 800 - 91 400 nT
34. 90 900 - 95 700 nT
35. 95 300 - 99 999 nT

Preliminary approximate setting of the tuning point is performed on the basis of a magnetic field map - see Fig. 4 in dependence on the geographic coordinates of the point of measurement. An error message indicates if the measured value of the magnetic field is not within the tuning interval. If the automatic tuning is on, the input circuits will be automatically tuned at the next measurement.

The modified tuning interval is stored in the memory after pressing [ENTER]. By pressing [ESC] the tuning procedure is terminated without changing the interval.

For the GRAD mode the tuning should be repeated twice, for each sensor (both UP and DOWN) separately. The automatic tuning (On/Off) is the same for both sensors.

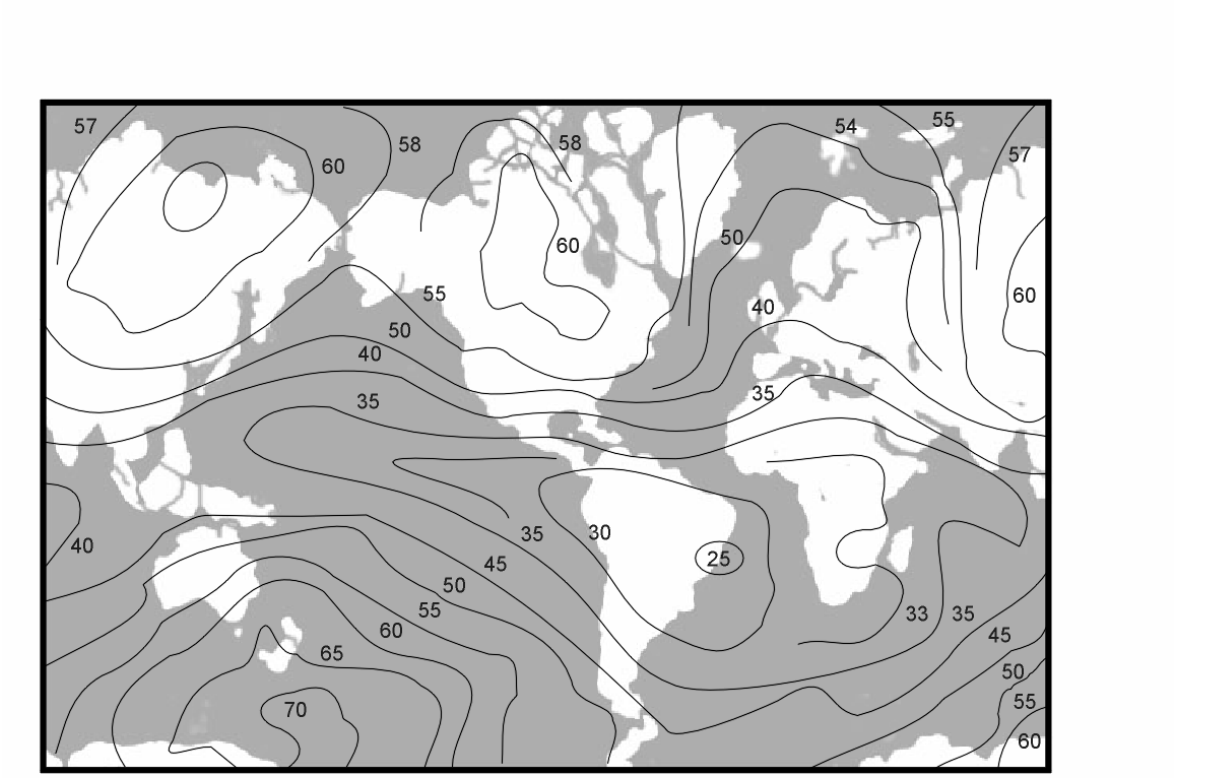


Fig. 4: Earth's magnetic field

5.3 Setting the backlight - BACKLIGHT

The backlight is switched on or off by selecting the radio button in the setup menu, item backlight. It can be modified by [v] and [^]. Power consumption is relatively high when using backlight, it is recommended to set the time to the minimum value.

5.4 Selection of the measurement mode - MODE

The item MODE in the setup menu allows the selection of one of the measurement modes: SINGLE, GRAD, AUTO. The currently selected mode is marked with the radio button. It can be changed by [v] and [^].

After pressing [ENTER] the mode can be changed by repeatedly pressing [NEXT]. The pressing of the push-button [ENTER] asserts the selection, [ESC] terminates the procedure without changing the mode.

5.5 Setting the time interval to switch off - TIME

To protect the power supply, the lead acid battery, the instrument is automatically switched off after elapsing the set time interval after the last activities of the operator on the keyboard. Thus the deep discharge and the damage of the battery are prevented even if the operator forgets to switch off the instrument. The default value is 20 min.

In the setup menu, item TIME the time is displayed. After elapsing of the time the instrument is automatically switched off. The format is hh:mm, where hh stands for hours, mm for minutes.

After pressing [NEXT] the time can be modified. The cursor is moved by pressing [v] and [^], the digits are changed by numeric push-buttons. [ENTER] asserts the new value, [ESC] terminates the function without saving the changes.

5.6 Setting the position - POSITION

The item POSITION in the main menu sets the position of the next measurement that will be conducted. The information is stored in the data memory together with the measured value. The position consists of the profile number ‘Line’, the position on the profile ‘Pos.’ and the spacing ‘Step’, which is the increment or decrement of the next position ‘Pos.’. If the ‘Step’ is positive, the value of the next ‘Pos.’ stored with the measurement in the data memory is increased by the value of the ‘Step’, if the ‘Step’ is negative, the value of the next ‘Pos’ is decreased. This allows the operator to move to the end of the profile, to higher positions, and also back to the lower positions.

By selecting the item POSITION in the main menu, ‘Line’, ‘Pos.’ and ‘Step’ can be edited. The current values are displayed, for example:

POSITION

Line: +1026
Pos.: -0980
Step: +10

A cursor appears at the place of the digit to be modified and can be moved by [v] and [^]. The value ‘Line’ can be set from -9999 to 9999. By pressing [NEXT] the second item, the current position on the profile ‘Pos.’ can be modified.

The value of ‘Pos.’ can be also set from -9999 to 9999 the same way as with the profile. Another pressing of [NEXT] allows ‘Step’ to be edited.

The value of the ‘Step’ can be set from -99 to 99 the same way as above. By [v] and [^] the digit to be modified is selected and by numeric push-buttons [0] to [9] it is changed.

The sign + and – is changed by pressing [0] when the cursor is placed at the sign.

[NEXT] is used for switching among the items ‘Line’, ‘Pos’ and ‘Step’. The modified data are stored in the memory by pressing [ENTER]. Pressing [ESC] terminates the function without storing the changes.

5.7 Recalling stored data - MEMORY

The item LIST in the memory menu is used to display the data stored in the data memory.

After entering it, the last measurement is displayed. By pressing [v] or [^] the following or the previous measurement is displayed.

```
MEMORY->LIST
Line:+1026 Pos:-0980
Single:
     45123.4 +02.3nT

Amp:5 D:0.5s
08.06.2012  15:38:44
```

In the SINGLE mode profile number and position number, value of the magnetic field, error of the measurement, signal intensity, time constant of the decay of the signal are displayed. In the GRAD mode and AUTO mode appropriate values are displayed.

6. Measurement

The instrument and its accessories are transported in a case. It must be assembled before operation.

The measured value of the magnetic field depends very much on the presence of metal objects near the sensor. The operator should remove all the metal objects prior to measuring.

6.1 Instrument setup

Screw together the sensor and the sticks of the post to the desirable length - see Fig. 1. The processing unit can be attached to the harness and carried on the chest.

Connect the sensor to the processing unit by using the appropriate connectors. In the SINGLE and AUTO modes the connector ‘Up sensor’ is used. In the GRAD mode both sensors are used. The upper sensor should be connected to the ‘Up sensor’ connector, otherwise the sign of the gradient value is changed.

It is recommended to keep the sensor as far as possible from the processing unit to limit the influence of the magnetic moment of the instrument.

For the same reason it is recommended to keep the direction of the advance along the profile during the measurement on one area.

6.2 Sensor orientation

The measured value of the magnetic field does not depend on the sensor orientation. But with the changing orientation of the sensor towards the Earth’s magnetic field the signal from the sensor is changed and the statistical error of the measurement increases. To achieve the maximum signal the sensor must be oriented in the north - south direction, that is the ‘north’ mark on the sensor must point to the geographical north.

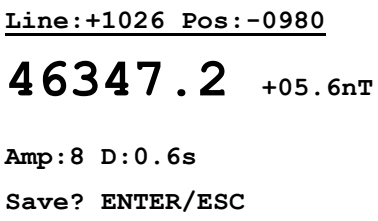
6.3 Tuning

Before measuring in a new area it is necessary to set or check the preliminary tuning of the instrument according to the map of the Earth’s magnetic field, see Fig. 4. If the measurement is conducted with inaccurately tuned circuits, an error message is displayed. If the automatic tuning function is on, the tuning will occur automatically with regard to the measured value. The automatic tuning is not performed in the case of an enormous

difference in which the value of the magnetic field is measured with a big statistical error. The tuning procedure is described in the chapter 5.

6.4 Measuring in SINGLE mode

SINGLE mode is selected in the setup menu, item MODE. The selection is asserted by [ENTER]. The instrument is prepared to measure the absolute value of the magnetic field vector. If the data memory should be used, the position of the first measurement must be set, which means setting the items ‘Line’, ‘Pos’ and ‘Step’ in the POSITION item of the main menu. This is described in detail in the chapter 5. The measurement is started by pressing [ENTER]. After about 2 seconds the measured value of the magnetic field with the statistical error is displayed, as well as the position of the measurement point ‘Line’ and ‘Pos’ and other information.



The value Amp means the signal intensity and the value D expresses a time constant of the decay of the precession signal. The question at the bottom indicates the option to store the reading in the data memory.

By pressing [ENTER] the reading is stored in the data memory and the next position is displayed. By pressing [ESC] the measured data is erased and the current position is displayed.

6.5 Measuring in GRAD mode

The instrument measures the value of the magnetic field in both locations of the sensors simultaneously. The displayed value of the gradient is determined by subtracting of the value of the magnetic field of the sensor connected to the ‘Down sensor’ connector from the value of the magnetic field of the sensor connected to the ‘Up sensor’ connector. The procedure of measuring and storing data is identical to the SINGLE mode. The measurement is started by pressing [ENTER]. After about 2 seconds the measured value of the gradient with the statistical error is displayed as well as additional information.

By pressing [ENTER] the reading is stored in the data memory and the next position is displayed. By pressing [ESC] the measured data is erased and the current position is displayed.

6.6 Measuring in AUTO mode

If the AUTO mode is selected, the instrument is prepared to serve as a base station and measure diurnal variations. When measurement is started, two items are displayed:
‘Start time’ sets the time of the first measurement of the base station.
‘Interval’ sets the time interval between measurements.

The results of the measurement in the AUTO mode are stored automatically in the data memory.

The measurement in the AUTO mode is terminated by switching the instrument off.

7. Data memory

The instrument is equipped with a large memory where all readings and identifiers can be recorded. The capacity of the data memory is about 24 500 readings. The readings obtained in various modes can be stored sequentially. The stored data can be displayed or transmitted to an external computer through the USB interface.

It is useful before the beginning of the measuring in a new area to transmit data stored in the data memory to the external computer and to erase the data memory. Thus the data memory is set to maximum capacity.

7.1 Erasing and checking of the data memory - ERASE

The stored data will be erased during the procedure, therefore it is necessary to transmit the data to an external computer prior to the procedure.

The erasing procedure starts by selecting the item ERASE in the memory menu. To prevent occasional erasing of the memory, the operator is repeatedly asked to confirm the operation. Only after pressing [NEXT] the data memory will be erased.

7.2 Data storage in the data memory

After a measurement the result is displayed as well as the profile number and the position on the profile of the measurement point and other information. To store the data, the operator presses [ENTER], otherwise [ESC] (canceling the measured value), and the measurement on the point can be repeated. The position of the next measurement is displayed in both cases. The position can be changed in the item POSITION.

7.3 Display of data stored in memory

The data stored in the data memory can be displayed or transmitted through the USB interface to a computer.

The data is displayed in the item LIST of the memory menu. After entering the item, the last stored data is displayed. Pressing [v] or [^] displays the following or the previous reading. Continually pressing [v] or [^] increases the speed of the scanning. A notice is displayed if the data memory is empty and when there is a beginning of the data memory.

7.5 Transmission of the stored data to a computer

Before transmission of the stored data to an external computer it is necessary to connect the instrument and the computer with the USB cable.

On the computer it is necessary to run the program which allows the data to be transmitted from the magnetometer to the computer and stored in a text file.

The format of the data is different for various measurement modes.

Format of the transmitted data

```
M Date       Time      Line  Pos   Field    Err  A D    Grad    Note
S 25.07.1995 09:32:16  0001  0000  48248.2  00.1 7 1.2          none
S 25.07.1995 09:32:30  0001  0002  48255.8  00.1 7 1.3
G 25.07.1995 09:32:58  0001  0004  48262.1  00.3 6 1.3 -00000.6
G 25.07.1995 09:33:10  0001  0006  48272.2  00.3 6 1.2  00002.3
G 25.07.1995 09:33:24  0001  0008  48277.1  00.1 7 1.1  00002.5
G 25.07.1995 09:33:36  0001  0010  48280.4  00.1 7 1.2  00002.0
G 25.07.1995 09:33:46  0001  0012  48283.1  00.0 6 1.4  00000.9
A 25.07.1995 09:34:01  0001  1111  48287.3  00.1 6 1.2
A 25.07.1995 09:34:21  0001  1111  48287.4  00.1 7 1.3
A 25.07.1995 09:34:41  0001  1111  48285.5  00.1 6 1.2
```

M is the measurement mode. The letter S stands for the SINGLE mode, G for the GRAD mode and A for the AUTO mode.

Date is the date of the measurement.

Time is the time of the start of the measurement.

Line is the profile number.

Pos is the position on the profile.

Field is the magnetic field value of the sensor connected to the ‘Up sensor’ connector.

Err is the statistical error of the measurement.

A is the signal intensity.

D is the time constant of the decay of the precession signal.

Grad is the value of the gradient.

Note is a comment about measurement.

In the AUTO mode the values of date, line and position are not valid because they are not used, they are not stored in the data memory with each individual reading.

9. Supplementary information

9.1 USB interface

The magnetometer PMG1 can be directly connected with a computer through the USB cable supplied by the manufacturer.

The program supplied with the instrument transmits data from the magnetometer to the external computer.

9.2 Charger

The charger is delivered with the instrument, allowing careful and optimum charging of the built-in lead acid battery 12 V / 3.4 Ah, so as to use its full capacity and lifetime. The product is double insulated.

The charger automatically sets the optimum charging mode according to the condition of the battery. There is no danger to damage of the battery from overcharging.

Operation:

1. Plug the connector of the charger cable in the connector on the lower right part of the instrument.
2. Switch on the charger by plugging it in.
3. The battery is charged when the pilot light turns off.

9.3 Maintenance and repair work

Under normal operating conditions the magnetometer requires no special maintenance. Only the built-in lead acid battery needs care. If the voltage drops under a certain level the battery might be damaged or the magnetometer might not operate correctly, so the instrument is switched off automatically. When the instrument is not used for a long time, it is still discharging and must be charged at least once a half-year.

Because of the complexity of the instrument it is strongly recommended not to make any interference into electronics.

In the case of a failure of the magnetometer the customer should contact the distributor or the manufacturer. The service will be performed as soon as possible.

9.4 Storage and transportation

The packed instrument can be stored and transported in the range of temperatures -20° to 70°C and at the relative humidity of up to 90%.

The built-in lead acid battery should be checked and charged with the supplied charger at least once a half-year.

9.5 Warranty

The manufacturer provides a one year warranty after the purchase of the proton magnetometer PMG2. Other information relating to the warranty is given in the warranty certificate.

9.6 Accessories

1 processing unit
2 sensors
1 charger
1 diskette with the communication program
1 USB cable for the connection to a computer
1 harness
1 bottom stick
4 middle sticks
1 gradient stick
1 anchor ring with ropes
3 pins
1 transportation case
1 manual