GOUDSMIT MAGNETICS

OPERATING INSTRUCTIONS

GAUSSMETER HGM09S

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Table of Contents

1 Safety Instructions 5
1.1 Safety Instructions for the Device 5
1.2 Safety Instructions for the Measuring Probes 6
1.3 Safety Symbols 6
2 Brief Introduction 7
2.1 Preparing a Measurement 7
2.2 Running a Measurement 7
2.3 Measuring Unit 8
2.4 Selecting the Measuring Range 8
2.5 Display 9
2.6 Status Display 9
3 Gaussmeter Function 10
3.1 The Hall Effect 10
3.1.1 Linear Properties of the Hall Probe 10
3.1.2 Non-linear Properties of the Hall Probe 11
3.2 Measurement Details 13
3.2.1 Sample Measurement with an NdFeB Magnet 13
3.2.2 Remanence and Hall Gaussmeter Measurement 14
3.2.3 Accuracy Based on Positioning and Direction 15
3.2.4 External Static Magnetic Fields 16
4 Control Elements and Connections 17
4.1 Front Side Overview 17
4.2 Ports Overview 17
4.3 Power Supply 18
4.4 Batteries 18
4.4.1 Charging the Batteries 19
4.5 Probe Connection 20
4.6 USB Interface 20
5 Operation 21
5.1 Keyboard 21
5.2 Display 22
5.3 Status Display 22
5.4 Switching on/off 24
5.5 Null 24
5.6 Measuring Range 25
5.6.1 Overview Measuring Ranges 25
5.7 Measuring Unit 26
5.8 DC/AC Field Measurements 26
5.8.1 DC Field Measurements 27
5.8.2 AC Field Measurements 28
5.9 Peak Value Measurement 30
5.9.1 Normal Peak Value Recording 30
5.9.2 Fast Peak Value Recording 31
5.10 Probe Data 33
6 Setup Menu 34
6.1 Settings 35
6.1.1 Operating Mode of the USB Interface 35
6.1.2 Selecting the Display Units 35
6.1.3 Operating Mode of the Peak Value Recording 36
6.1.4 DC/AC Field Measurement 36
6.1.5 Range Selection 37
6.1.6 Polarity Display (North/South) 37
6.1.7 Switching off the Device 37
6.1.8 Charging the Batteries 38
6.1.9 Brightness of Display Illumination 38
6.1.10 Display Contrast Adjustment 38
6.1.11 Version Remarks 39
7 Serial Interface 40
7.1 Introduction 40
7.2 Connecting the Gaussmeter to a Computer 41
7.2.1 Connector Plug 41
7.3 Direct Operation on the Computer 41
7.3.1 Example Normal Measuring Mode in Excel® 42
7.3.2 Example Fast Peak Value Mode in Excel® 42
7.3.3 Example Slow Peak Value Mode in Excel® 42
7.4 Operation via Interface 43
7.4.1 Installation on the Computer 43
7.4.2 USB Interface Data Format 43
7.4.3 Character Set 43
7.4.4 Introduction to the SCPI Language 43
7.4.5 SCPI Data Types 45
7.4.6 The SCPI Status Model 48
7.5 Summary of SCPI Commands 51
7.5.1 Control Commands 51
7.5.2 Main Commands 51
7.5.3 Peak Value Functions 52
7.5.4 Probe Functions 52
7.5.5 Parameters 52
7.5.6 Device Functions 52
7.6 Explanation of the Individual SCPI Commands 53
7.6.1 Control Commands 53
7.6.2 Main Commands 57
7.6.3 Peak Value Function 61
7.6.4 Probe Functions 63
7.6.5 Parameters 64
7.6.6 Device Functions 69
8 Unit Conversion Table 70
9 Technical Data 71
10 Warranty and Copyright 73
11 Index 74

Table of Illustrations

Display	9	Ports	17
Basic Assembly of a Hall Probe	10	Battery Box	18
Flux Line Characteristics of NdFeB Induction Disks	13	Display	22
Field Strength Pattern of NdFeB Induction Disk	14	USB Connection	41
Front Side	17	SCPI Status Model	49

1 Safety Instructions

1.1 Safety Instructions for the Device

Use the measuring instrument only according to the user manual.

Do not replace any parts and do not make any modifications on the product without our explicit and written consent. Do not carry out any service measures at this device. For repair and maintenance please return the product to MAGSYS magnet systeme GmbH or to your supplier, in order to make sure that all safety features remain.

Handling malpractices may result in damage to the device and possibly in injury or death of persons.

The power supply is designed for a voltage range of 100 to 240VAC at 47 to 63Hz. Do not use the power supply on voltages beyond these areas.

Before use, check the power supply for cracks or missing plastic parts. Pay attention to the insulation. Do not use the power supply if it is damaged.

Do not dispose of the measuring device in normal household garbage. Please contact the manufacturer for the proper disposal of this instrument.

Only use magnetic field probes designed for this measuring device.

Observe the labeling of this measuring device before connecting a magnetic field probe to it.

Replace the rechargeable batteries only by batteries of the same type.

Make sure to insert the rechargeable batteries correctly into the measuring device and mind the correct polarity.

Do not dispose of the rechargeable batteries in the regular household garbage. Heed your national regulations for the disposal of old batteries.

Do not work in explosive environs or near inflammable gases or vapors with this device.

Environmental conditions
The device is designed for the use in rooms with low condensation. See technical data.

1.2 Safety Instructions for the Measuring Probes

The magnetic measurements should only be carried out in areas with a max. voltage of 60V DC, 30V AC RMS. The magnetic field probes are not electrically insulated. Please note that the probe holders and the housing might be electrically connected with the protective earth.

If you work in areas with voltages higher than 60V DC, 30V AC RMS or 42V peak values, act with particular caution because of electric shock hazard.

For measurements in high magnetic fields, please pay attention to the dangers that may arise by strong magnetic fields.

1.3 Safety Symbols

Safety symbols can be found on various spots on the device.

Before using this connection or function read the corresponding instructions in the manual.

This symbol refers to information and references in the instruction manual which the user has to follow in order to avoid injuries to persons or damage to the device, or to obtain correct measuring results.

2 Brief Introduction

Measurements with the Gaussmeter use the Hall effect as a measuring principle. A Hall probe is a symmetric semiconductor impressed by current. A magnetic field running vertically to this element generates an asymmetry on the chip and thereby creates an output voltage that, as a first approximation, is proportional to the product of magnetic field strength and the forced current. For higher magnetic field strengths this dependency is no more linear. This effect is automatically compensated in the device. The Gaussmeter thus measures the magnetic flux density locally. The sensor only captures the component of the magnetic flux density which runs perpendicularly through it.

2.1 Preparing a Measurement

- Make sure that the batteries are loaded.
- Connect the device to a personal computer via the USB cable if required. Or connect the included power supply via the USB socket.
- Connect a measuring probe.

  A suitable measuring probe can be plugged in via the Mini-DIN socket on the top of the device. Each measuring probe is calibrated individually. The calibration data are stored in the probe memory. On inserting or changing a measuring probe these parameters are read in automatically.
- Switch the device on and off by pressing the **I/O** button longer (approx. 2 sec).

2.2 Running a Measurement

After switching on the device, the current measuring value is shown continuously. The display additionally shows further information on the state of the device and the selected measuring range as well as the measuring mode.

- The measuring range can be changed by pressing the **RANGE** button. The characteristics of this button can be modified in the setup menu. By repeatedly pressing the **RANGE** button both the measuring range and the display unit or the DC/AC field measurement can be changed.

- Insert the measuring probe into the measuring field after adjusting the requested measuring range and the requested unit. Especially for inhomogeneous magnetic fields, such as they occur on the surface and edges of magnets, keep in mind that the measured magnetic flux density depends very largely on the distance and the position. Further pay attention that the magnetic field component is measured in one direction only, so that a tilting of the measuring probe may lead to an error.

2.3 Measuring Unit

The Gaussmeter shows measuring values in physical units of the SI-system as well as of the CGS system (Gauss system – particularly in use in North America).

The unit is either definitely preset in the setup menu or you can adjust it by pressing the **RANGE** button. Each time you press the button the next unit is selected.

Please note that the same button selects the measuring range and the DC/AC field measurement, if necessary.

2.4 Selecting the Measuring Range

By repeatedly pressing the RANGE button, you select the measuring range via four areas each. The maximum measuring value in this area is shown in the bottom left area of the display. You can also select an automatic range mode via the setup menu. In this operating mode, the measuring range is automatically aligned with the current measurement. Please note that no automatic range adjustment is possible in the peak mode.

If the measuring value exceeds the selected range limit, the display shows **-OL-** instead of the measuring value.

2.5 Display

A typical example display is demonstrated below.

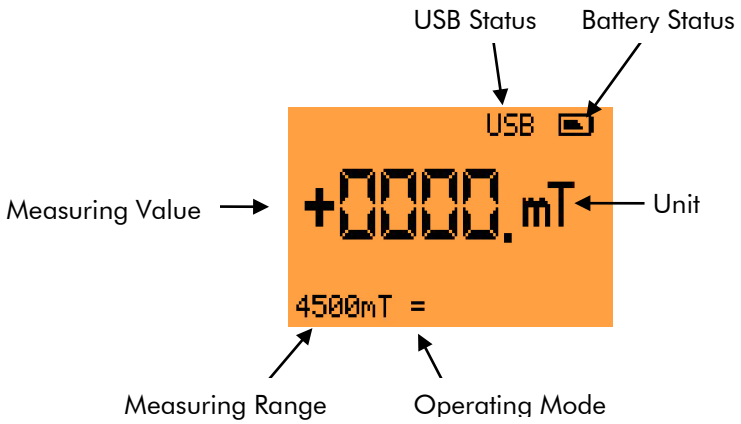


Figure 1 Display

2.6 Status Display

In addition to showing the current measuring value, the Gaussmeter display also shows the status information, a negative or positive peak value, if required, and the state of the USB interface as well as the charging status of the battery.

3 Gaussmeter Function

3.1 The Hall Effect

3.1.1 Linear Properties of the Hall Probe

The measurement is based on the deflection of charge carriers in a magnetic field inside a conductor. For this reason the Lorentz force is the basis for measuring a magnetic flux density. If you set a voltage between the beginning and the end of a flat electrical conductor, the carriers move with a speed of $\vec{v}_{Drift} = \mu_n \cdot \vec{E}_e$, whereby μ_n represents the carrier mobility in the conductor. Due to their high mobility, the carriers are always electrons. Perpendicular to the current direction, a voltage can be measured that is ideally proportional to the magnetic flux density. Only the part of the flux density is effective which runs perpendicularly through the flat side of the conductor.

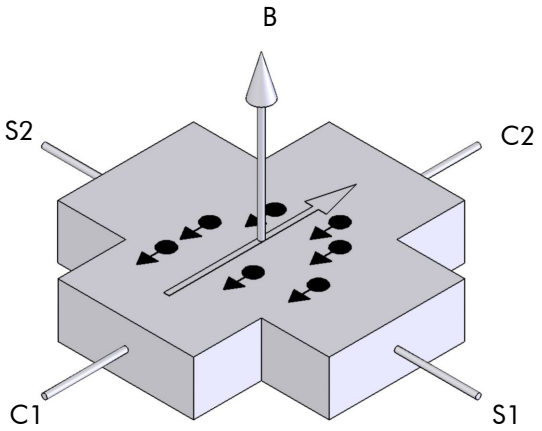


Figure 2 Basic Assembly of a Hall Probe

If you do not extract any current from the electrodes S1 and S2, but only measure the voltage, the following applies:

$$n_e \cdot e \cdot \frac{U_{Hall}}{w} = \frac{I}{w \cdot t} \cdot B$$

It follows that: $U_{Hall} = \frac{I}{n_e \cdot e} \cdot \frac{1}{t} \cdot B$

With
n_e Carrier
e Elementary charge of the electron (1.6022x10^{-19} As)
w Width of the path on which the electrons move
t Effective force of the Hall element
B Flux density in [Tesla]

This represents the idealized Hall effect.

In reality, the results deviate from this idealized effect.

Since there is a linear equation between the current and the measuring result, it follows that

$$R_{Hall} = \frac{1}{n_e \cdot e \cdot t} \cdot B = S_0 \cdot B$$

3.1.2 Non-linear Properties of the Hall Probe

Contrary to the idealized description you find a non-linear performance:

$$R_{Hall} = S_0 \cdot B \cdot \left(1 + \alpha_{HALL} \cdot B^2\right) + R_{offset}$$

For the used Hall probes the real description is true for flux densities of up to approx. 5000 mT.

3.1.2.1 Reasons for the Occurrence of R_{offset}

The largest deviation from the idealized Hall effect is the occurrence of an offset voltage without a magnetic field. This effect is mainly caused by geometrical asymmetries of the Hall element.

3.1.2.2 Reasons for the Field Dependence of the Sensitivity

There are several influences for the flux-density dependence of the sensitivity:

The carrier mobility depends on the flux density. This influence generally brings about a negative α_{Hall} and is irrelevant for the used Hall sensors.

More important is the geometry of the used Hall sensors. The lamellar structure creates a geometry-based field dependence of the sensitivity.

The non-homogeneous distribution of the current density in such a structure is the cause of this effect.

Already in field-free cases, the current distribution on the Hall element is complex. This entails a lowering of S_0 and has an influence on the field dependence of the sensitivity.

A complex real-time correction of the handheld Gaussmeter HGM09 compensates for the inherent non-linearities of the used Hall probes and guarantees a very stable zero point.

3.1.2.3 Field Dependence of the Cross Current Resistance

The complex current distribution is the cause of the resistance of a Hall probe. Current components which, just as the Hall voltage, run perpendicularly to the direction of the current feed, cause a diverted Hall effect. For the current source this effect results in a flux density modulated resistor.

The device must have a sufficiently high dynamic for the measurement with fast magnetic pulses, to be able to compensate this effect. The handheld Gaussmeter HGM09 is optimized for this operating case.

3.1.2.4 Temperature Dependence of the Sensitivity

Due to the large band gap of the used Hall sensors, the temperature dependence of the probe sensitivity is low, it is approx. -0.06%/ºC.

3.1.2.5 Temperature Dependence of the Cross Current Resistance

The temperature dependence of the cross current resistance ranges at approx. 0.3%/ºC and is compensated automatically by the device.

3.2 Measurement Details

The used Hall probes contain a very small active semiconductor area ranging at approx. 100μm. The local resolution of this measuring method is thus rather high. Also note that individual Hall probes measure one field component only.

3.2.1 Sample Measurement with an NdFeB Magnet

Due to the high local resolution, the near-surface measurement with magnets may lead to misinterpretations because of the large field-strength gradients.

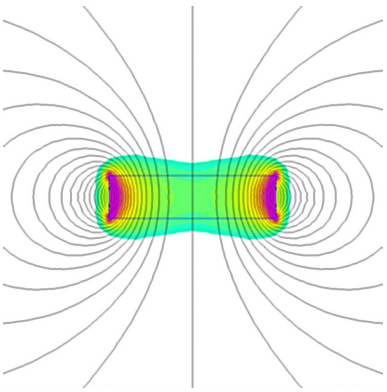


Figure 3 Flux Line Characteristics of NdFeB Induction Disks

Figure 3 shows an NdFeB magnet with a material remanence of 1400mT. In this example the magnetic disk has a thickness of 5mm with a diameter of 20mm. The magnet is supposed to be measured in 1mm distance from the surface.

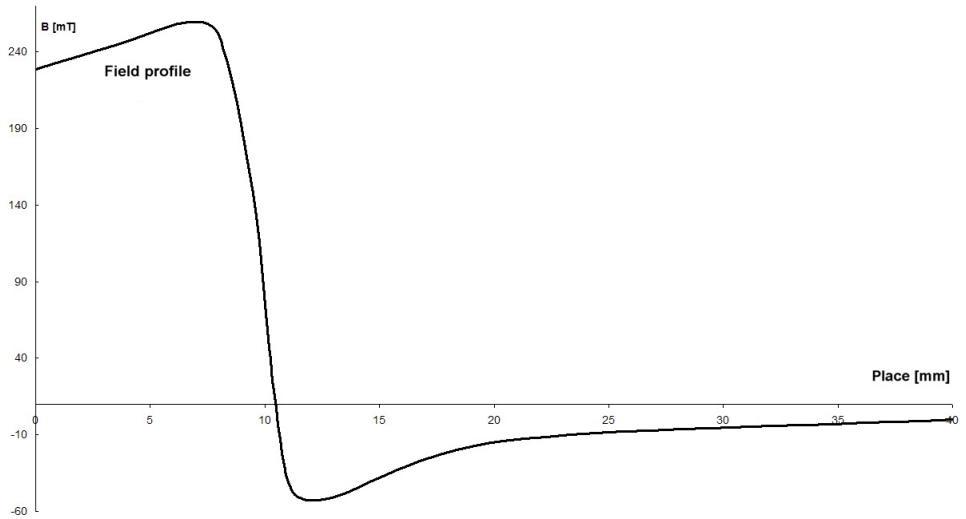


Figure 4 Field Strength Pattern of NdFeB Induction Disk

The diagram in Figure 4 represents the measurement with a Hall probe which is moved in parallel to the surface of the magnet with a distance of 1mm distance to the measuring surface.

A minimum of the flux density emerges in the center of the magnet. Here approx. 230mT are measured. Due to the locally changing working points on the radius of the magnet, the flux density increases toward the outside. In the center the magnet carries the highest magnetic load in air and therefore provides the lowest flux density.

3.2.2 Remanence and Hall Gaussmeter Measurement

The remanence B_r is a measure for the aligned magnetic dipoles in the center of the magnet. B_r is the theoretically maximal flux density that can be achieved if the magnet is in magnetic idle. If it works against a magnetic resistance, it is always $B < B_r$.

On the surface of an individual magnet $B < B_r/2$ applies even more.

Which value is actually measured in the pole center depends on the geometry of the magnet.

As B_r as well as B are measured in the unit Tesla, the magnetic field measured on the outside is often mixed up with the remanence.

Please note that **a magnet** without back iron only **shows a value clearly below the remanence** on the surface. Due to the local and geometry-dependent measurement, the remanence of the workpiece cannot be checked reliably with a Gaussmeter.

3.2.3 Accuracy Based on Positioning and Direction

Since the measuring value is dependent on the position, an accurate and repeatable measurement depends on the exact positioning of the probe during the measurement.

The measurement on the pole center of the magnet is most uncritical. When moving the probe on the pole surface of the magnet, the measuring value hardly changes at first. When changing the distance though, the measuring value varies considerably.

The smaller the magnet to be measured, the stronger even slight misalignments change the measuring value. For quality-related research it is essential to ensure the positioning accuracy.

Since a Hall probe only records one field strength vector, the correct alignment relative to the magnet is important.

Please be particularly careful when measuring at the zero point at pole transitions. By slightly tilting the probe, you measure additional lateral field shares that seem to displace the zero passage.

In normal applications, a maximum flux density value is usually determined at a given position. The measuring probe is placed in position and varied in location and direction until the maximum is found. The device supports this measurement with the peak hold.

3.2.4 External Static Magnetic Fields

Particularly in sensitive measuring ranges, an external static magnetic field, as e.g. the Earth's field, can already become clearly noticeable. These external magnetic fields lead to a corruption of the measuring result.

To compensate external magnetic stray fields or asymmetries of the Hall probe, the device can be reset.

For this purpose please hold the measuring probe into a field-free area, e.g. a zero Gauss chamber, or orient the measuring probe in a free field in east-west direction and press the **NULL** button for approx. 3 seconds. The device then carries out a null balance automatically.

The values are stored so that this balancing has to be carried out only in seldom cases.

If the magnetic field is too high during the automatic balancing, the correction is stopped with an error message.

4 Control Elements and Connections

4.1 Front Side Overview

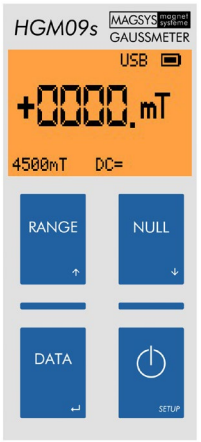


Figure 5 Front Side

1	Display	
2	**RANGE** button	Range selection
3	**NULL** button	Reset
4	**DATA** button	Data recording
5	**IO** button	On/Off

4.2 Ports Overview

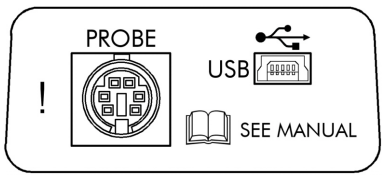


Figure 6 Ports

1	PROBE	Port for the probe
2	USB	Port for computer or power supply

4.3 Power Supply

The Gaussmeter can be operated with the included power supply. The power supply is connected via the USB port (type Mini-B) on the top of the device. The power supply is designed for a line voltage of 100 to 240V alternating current 50-60 hertz at a charging rate of max. 300mA. Use the power supply only when both the device itself and the connector cable obviously do not show any damages.

4.4 Batteries

The device is designed to operate with rechargeable batteries, type NiMH 2450mAh AA PK4. Alternatively the device can also operate with standard NiMH batteries of the same voltage and similar capacity. Only use the identical battery type if a change is necessary. Only change both batteries at the same time.

To insert or remove batteries, separate the device from the measuring probe and remove the cables from the USB plug. Switch off the device. Remove the protective cover and carefully open the battery box on the bottom side of the device. Mind the correct inserting position when exchanging the batteries. Mind the correct polarity. Normally old batteries must not be disposed of in the regular household garbage. Protect your environment and heed your national waste disposal regulations for old batteries.

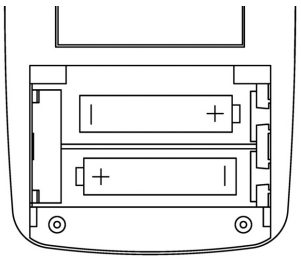


Figure 7 Battery Box

The normal operating time with fully loaded batteries is approx. 10 hours. You can prolong this time by selecting a darker backlight. You can adjust the brightness in the parameter menu. Moreover, you can activate the automatic switch-off. The device switches off automatically after 2 or 5 minutes, if no button is pressed and the measuring value does not change significantly.

4.4.1 Charging the Batteries

The battery is charged via the power supply during operation or when connected to a personal computer. The top right edge of the display shows the battery charge condition.

Please note that the batteries are only charged when the device is switched on or when it remains connected to the power supply or personal computer after switching off. The top right edge of the display shows the battery charging status.

Note	
	The device does not charge automatically when you feed it via the power supply and do not switch it on.

You can also avoid the charging by pressing the **IO** button in charging state once again and hereby finally switch off the device.

In the setup menu you can manually deactivate the battery charging. This might become necessary if your personal computer cannot provide the required charging current. The interconnection of an active USB hub might help if such a problem occurs. Please note that this hub must however possess its own power supply.

4.5 Probe Connection

The magnetic measuring probe is plugged into the probe port (DIN Mini-DIN-socket) on the top of the device.

Note	
	Only use measuring probes which are approved by the manufacturer to operate with this device.

Note	
	The probe plugs must not be connected to the electric potential, the protective conductor or the plug shell. If you measure near current conducting parts, make sure that there is sufficient distance and a sufficiently good insulation.

4.6 USB Interface

The transmission of the measuring values and the entire Gaussmeter control are possible via the installed standard USB interface.

The interface is specified according to the USB (Universal Serial Bus) 2.0. The interface is not insulated. Please note that the shielding of the measuring probes (e.g. the metallic handle) might be connected to the protective conductor of your personal computer via this USB interface.

The device supports two USB device classes. On the one hand the HID class. In this mode the data can be entered directly into any program. The Gaussmeter acts similar to the keyboard of a personal computer.

On the other hand, the device can be operated in the USB device class CDC and thereby emulates a virtual serial interface on the personal computer or another processor. In contrast to the HID mode, the installation of a driver on the processor becomes necessary here.

Via the virtual serial interface all functions and parameters of the device can be set using the SCPI command, and the measuring values can be read out automatically.

5 Operation

5.1 Keyboard

The required functions are selected and triggered via 4 buttons. The labeling of the button corresponds to the requested function, e.g. **RANGE** changes the range of the measuring value.

More complex parameter settings can be made via menu functions in the setup menu.

The button functions in detail:

	With this button you change the measuring range, the measuring unit and the measuring mode (DC or AC fields). The exact function of this button depends on the settings in the setup menu. Further explanations, see there.
	Via **NULL** the displayed peak value is set to zero in the peak value measuring mode. If you press the button for approx. 3 seconds, the magnetic offset values are compensated.
	In the USB operating mode HID (keyboard) the current measuring values are transmitted to the connected processor and can be entered into any program. This button has no function in the other operating modes. In the USB operating mode CDC (virtual interface), pressing this button can be read out via an SCPI command.
	To switch the device on and off, press the button for approx. 2 seconds. If you press the button longer when switching on, the setup menu is called up.

5.2 Display

A typical display example is shown below.

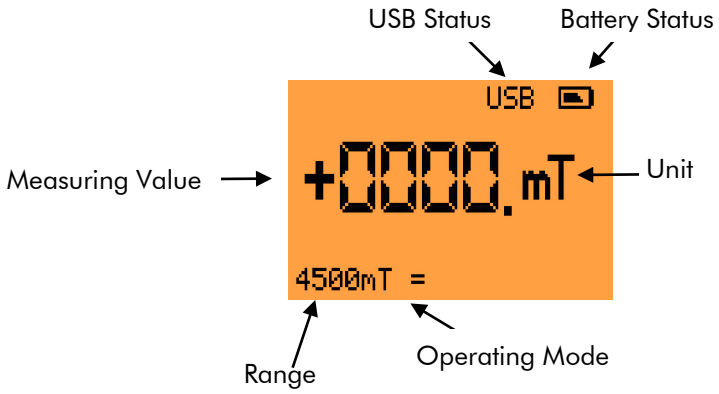
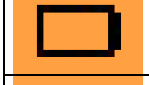


Figure 8 Display

5.3 Status Display

Apart from the measuring value the display shows some status information.

The top right area displays the battery charging status.		Battery fully charged.
		Residual capacity approx. 75%
		Residual capacity approx. 50%
		Residual capacity approx. 25%
		Battery almost empty. Immediate charging required.
		Battery status is determined.
		Battery defective.
		Battery charging.

Interface	USB	The device is connected to the computer via a virtual interface.
	KEYB	The device is connected to the computer as a keyboard simulation. In this mode, the Gaussmeter acts like a keyboard. Pressing the **DATA** button causes the transmission of the current measuring values to the selected program.
	ERR	An internal error has occurred. Detailed error notes are given on quitting the setup menu.
Measuring Range	4500mT =	The bottom left area of the display shows the currently selected measuring range with the currently selected unit.
Operating Mode	=	The equals sign to the right stands for DC field measurements.
	~	The shift sign to the right stands for AC field measurements.
	PEAK	*Peak* in the bottom part shows the operating mode Fast-Peak-Registration, thus the fast recording of the maximum values of DC fields.

The display *Peak* with two measuring values in the penultimate line shows the two maximum and minimum measuring values determined during the slow peak value registration.

The current measuring value is 109.5mT,
the smallest peak value was -112.2mT,
the highest peak value was +109.5mT.

5.4 Switching on/off

The device is switched on and off with the right bottom **IO** button. In each case the button must be pressed for approx. 1 second. This avoids an accidental switching on and off.

If the batteries are not yet fully charged during switch off, the charging continues also after switching off. You can see this in the top right battery display. By pressing the **ON** and **OFF** button once again, the device is finally switched off.

During activated automatic switch-off, the device is turned off after 2 or 5 minutes without any activity.

5.5 Null

During the peak value measurement the stored minimum and maximum values are reset by briefly pressing the **NULL** button.

To compensate external magnetic fields, press the **NULL** button for approx. 3 seconds. The device then carries out an automatic null balance. During the null balance the text NULL SET is displayed. The null balance roughly takes 4 seconds. To avoid fatal errors, this process is interrupted by the error message OVERFLOW, if the adjacent external field is larger than 10% of the respective measuring range.

Note	
	Only carry out the null balance in a preferably field-free area.

Operation via the external interface:

`:PEAK:NULL`	Reset peak values
`:NULL`	Carry out null balance

5.6 Measuring Range

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The Gaussmeter has 4 measuring ranges. The range limit value is shown at the bottom left of the display. The range limit values depend on the ranges themselves and on the selected measuring unit. The ranges can be switched manually or automatically. Regarding the manual switch, the measuring range is selected by multiple pressing of the **RANGE** button. The automatic range selection mode is set via the setup menu, followed by the parameter *Range off manually*.

With automatic range selection activated, the device switches to an insensitive range if the measuring value has exceeded 90% of the actual measuring range. A sensitive range is selected when the measuring value falls below 10% of the actual measuring range.

Operation via the external interface:

`:RANG:SET {0|1|2|3}`	Manual setting; 0 = most sensitive area
`:RANG:AUTO`	Automatic setting

5.6.1 Overview Measuring Ranges

		DC Field Measurement		AC Field Measurement		Fast Pulse Measurement	
Unit	Range	Range Limit	Resolution	Range Limit	Resolution	Range Limit	Resolution
Tesla T	1	10 mT	1 µT	10 mT	10 µT	10 mT	10 µT
	2	100 mT	10 µT	100 mT	100 µT	100 mT	100 µT
	3	1000 mT	100 µT	1000 mT	1 mT	1000 mT	1 mT
	4	4500 mT	1 mT	3000 mT	10 mT	4500 mT	10 mT
Ampere/m A/m	1	10 kA/m	1 A/m	10 kA/m	10 A/m	10 kA/m	10 A/m
	2	100 kA/m	10 A/m	100 kA/m	100 A/m	100 kA/m	100 A/m
	3	1000 kA/m	100 A/m	1000 kA/m	1 kA/m	1000 kA/m	1 kA/m
	4	3800 kA/m	1 kA/m	2500 kA/m	10 kA/m	3800 kA/m	10 kA/m
Gauss G	1	100 G	10 mG	100 G	100 mG	100 G	100 mG
	2	1000 G	100 mG	1000 G	1 G	1000 G	1 G
	3	10 kG	1 G	10 kG	10 G	10 kG	10 G
	4	45 kG	10 G	30 kG	100 G	45 kG	100 G
Oersted Oe	1	100 Oe	10 mOe	100 Oe	100 mOe	100 Oe	100 mOe
	2	1000 Oe	100 mOe	1000 Oe	1 Oe	1000 Oe	1 Oe
	3	10 kOe	1 Oe	10 kOe	10 Oe	10 kOe	10 Oe
	4	45 kOe	10 Oe	30 kOe	100 Oe	45 kOe	100 Oe

5.7 Measuring Unit

You select the requested measuring unit by pressing the **RANGE** button. The function of the **RANGE** button depends on the setting of the setup menu under *Units*.

The measurement is carried out either in the unit Tesla, Gauss, kA/m or in Oersted. The display shows the selected measuring unit. The respective range limit value changes according to the selected measuring unit. This is shown in the bottom left display area.

Also see the measuring ranges overview.

Operation via the external interface:
`:UNIT {TESL|APM|GAUS|OE}`

5.8 DC/AC Field Measurements

With the Gaussmeter you can carry out both DC field measurements (typical for permanent magnets) and AC field measurements (typical for transformers and similar components). You can moreover record fast single impulses.

Select the measuring mode via **RANGE** or via the corresponding entry in the setup menu.

Operation via the external interface:
`:MODE {DC|AC}`

5.8.1 DC Field Measurements

When measuring DC fields, the gathered measuring values are integrated via a time interval of 100 milliseconds. Influences of AC magnetic fields are thereby suppressed. This applies especially for interspersions of the AC network with a net frequency of 50 to 60 hertz.

The measuring values are emitted with positive or negative signs respectively.

Alternatively, the magnetic field polarity can also be displayed to (north/south). You can choose this by selecting the item POLE DISPLAY in the setup menu.

Operation via the external interface:

```
:MODE DC
```

5.8.1.1 DC Field Measurement Characteristics

Field Strength	Accuracy (1σ)
≤ 1.5 T	±0.5 %
> 1.5 T	±1.0 %

5.8.2 AC Field Measurements

In the operating mode AC field measurement the effective value (RMS) is calculated from the determined AC field shares. DC field shares are automatically suppressed in this type of measurement.

Note	Please note that superimposed DC field shares must not be so large that they exceed the measuring range. A small AC field together with a DC field may result in a display *overflow*.

Operation via the external interface:
`:MODE AC`

The accuracy of the AC field measurement depends on the AC field's frequency and wave shape.

5.8.2.1 AC Field Measurement Characteristics

Maximum ratings for sinusoidal signal

Frequency	B_{eff}	Accuracy (1σ)
≤2 kHz	≤1 T	≤±1.0 %
≤5 kHz	≤2 T	≤±2.0 %

The error of the AC field measurement is composed of the error of the DC field measurement and the error of frequency and shape factors.

Error DC Field Measurement (1σ)	
B ≤1.5 T	≤±0.5 %
B ≥1.5T	≤±1.0 %

Frequency Response Factor (Sinusoidal Field Pattern)

Frequency	Factor
2 kHz	1.00
5 kHz	0.98
7 kHz	0.95
10 kHz	0.90

Shape Factor (Sinusoidal Field Pattern)

Field Strength B_{eff}	Factor
700 mT	1.00
1000 mT	1.01
1500 mT	1.02
2000 mT	1.03

The frequency response factor and shape factor are multiplied with the basic accuracy in dependence of the respective measuring parameters, and then added to the basic accuracy.

Example:

Measuring B_{eff} = 1000 mT at a frequency of 5 kHz.

The basic accuracy is 0.5%. The frequency response factor is 0.9%. The shape factor is 1.02.

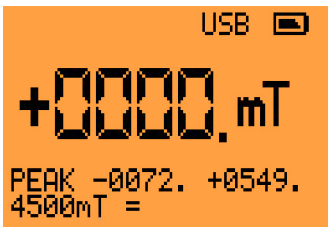
The error from of these factors is 0.95 * 1.02 = 0.97 = -3%

For the measurement you have to calculate a total error of -3%±0.5%.

5.9 Peak Value Measurement

The device has 2 different operating modes for measuring peak values. They differ in speed, evaluation and resolution.

5.9.1 Normal Peak Value Recording



For the normal peak value recording of minimum and maximum values the displayed measuring value is analyzed continuously and the lowest or respectively highest value are determined from it.

In this operating mode approx. 10 measurements per second are carried out in high resolution. This enables recordings of slowly changing field sizes. A typical application is the determination of a maximum field strength value of a permanent magnet by manual positioning of the measuring probe on the surface.

Reset the value via the **NULL** button.

The automatic range selection cannot be used in this operating mode.

The accuracy corresponds to the DC field measurement.

Operation via the external interface:

```
:PEAK:MODE SLOW
```

5.9.2 Fast Peak Value Recording

The fast recording of the maximum values of DC fields is required for short magnetic impulses, as they are generated in e.g. magnetizing systems.

In this operating mode you record peak values of the magnetic field starting from a duration of 10µs. The display shows the absolute highest amount.

Reset the value via the **NULL** button.

The automatic range selection cannot be used in this operating mode.

Note	Please note that in sensitive measuring ranges magnetic AC fields caused by e.g. transformers or electric lines might lead to a measuring value. Normally, these values would not be noticed during normal operation, because disturbances with a net frequency of 50 or 60 hertz are filtered out.

Operation via the external interface:
`:PEAK:MODE FAST`

5.9.2.1 Fast Peak Value Measurement Characteristics

Maximum ratings for the fast peak value measurement

Range	≤±1.0 %	≤±2.0 %
10 mT	≤70 Hz	≤100 Hz
100 mT	≤100 Hz	≤150 Hz
1 T	≤300 Hz	≤500 Hz
4.5 T	≤500 Hz (B <1.5T)	≤700 Hz

The error of the fast peak value measurement consists of the error of the DC field measurement and of a frequency factor that depends on the measuring range.

Error DC Field Measurement (1σ)	
B ≤1.5 T	≤±0.5 %
B ≥1.5T	≤±1.0 %

Range-Depending Frequency Response Factor (Sinusoidal Field Pattern)

Measuring Range	4500 mT	1000 mT	100 mT	10 mT
Frequency	1.00	1.00	1.00	1.00
50 Hz	1.00	1.00	1.00	0.99
70 Hz	1.00	1.00	0.99	0.98
100 Hz	1.00	1.00	0.98	0.93
200 Hz	1.00	1.00	---	---
500 Hz	0.99	0.99	---	---
700 Hz	0.99	0.98	---	---
1000 Hz	0.98	0.98	---	---
2000 Hz	0.92	---	---	---

The range-depending frequency response factor is multiplied by the basic accuracy, depending on the respective signal frequencies and then added to the basic accuracy.

Example:

Measurement in the range of 1000mT with a frequency of 1kHz.

The basic accuracy lies at 0.5%. The frequency response factor is 0.98 = -2%.

During this measurement, you have to calculate a total error of -2%±0.5%.

The frequency response factor as well as the shape factor are multiplied by the basic accuracy depending on the respective measuring parameters and then added to the basic accuracy.

5.10 Probe Data

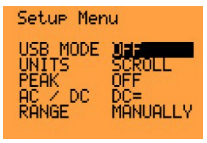
For a correct measurement the Gaussmeter must always know the necessary probe data. The connected probes contain a parameter memory which stores the probe parameters, the serial number and the labeling. After changing the probe or switching on the device these data are read in automatically.

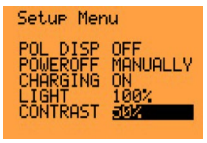
6 Setup Menu

You can change the device setup via the setup menu and hence adapt the device to the measurement task in an optimal way. By holding the **IO** button after switching on, the setup menu appears on the display.

During operation you can also activate the setup menu by holding the **RANGE** button for approx. 3 seconds.

The setup menu displays the selected menu item inversely. The individual menu item can be selected by the **NULL** ↓ and **RANGE** ↑ buttons. On reaching the bottom or first line the menu entries are scrolled further down or up respectively.



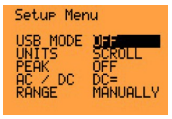


You can change the selected menu item by pressing the **DATA** ↵ button. The individual possibilities are displayed one after the other. Quit the setup menu by clicking the **IO** SETUP button.

6.1 Settings

The following setup possibilities can be adapted individually in order to be able to use the device for each application in an optimal way:

6.1.1 Operating Mode of the USB Interface

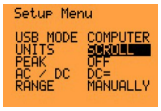


OFF	Switched off	The data connection is cut off. The device can however still be supplied with voltage via the USB connector.
COMPUTER	HMI interface	This mode is used for internal service at MAGSYS.
KEYBOARD	Keyboard emulation	The device acts similar to a keyboard of a connected computer. The data are transmitted after pressing the **DATA** button.
SERIAL	Virtual serial connection	The interface is activated and the computer can operate the device and read out the measuring values via the SCPI protocol.

Operation via the external interface:

`:PAR:USB {OFF|KEYB|COMP|SERL}`

6.1.2 Selecting the Display Units

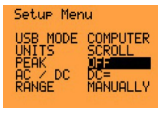


GAUSS	Display unit Gauss
KA/M	Display unit kA/m
TESLA	Display unit Tesla
OERSTED	Display unit Oersted
SCROLL	All units can be selected by multiple pressing of the **RANGE** button.

Operation via the external interface:

`:PAR:UNIT {ALL|TESL|GAUS|OE|APM}`

6.1.3 Operating Mode of the Peak Value Recording

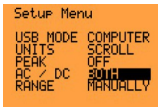


OFF	Switched off	The peak value recording is switched off.
FAST	Fast recording of max. values	The absolute higher peak value of the measuring value is recorded all 20µms. An automatic range switch is not possible. Only for DC field measurements.
SLOW	Slow recording of min. and max. values	The peak measuring values are recorded and displayed all 100ms. An automatic range switch is not possible. Only for DC field measurements.

Operation via the external interface

`:PAR:PEAK {OFF|SLOW|FAST}`

6.1.4 DC/AC Field Measurement

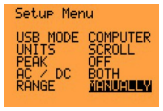


BOTH	Manual selection via the **RANGE** Button	
AC~	AC field measurements	Measuring the AC field.
DC=	DC field measurements	Measuring the DC field. The peak value measurement is only possible for DC field measurements.

Operation via the external interface

`:PAR:ACDC {BOTH|DC|AC}`

6.1.5 Range Selection

	**MANUALLY**	Manual range selection via the **RANGE** button	
	AUTO	Automatic range switch at the range limits	The switch is made at > 90% and < 10% of the measuring range. For peak value measurements the automatic range switch is not possible.

Operation via the external interface

`:PAR:RANG {MANU|AUTO}`

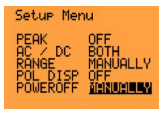
6.1.6 Polarity Display (North/South)

	**OFF**	Switched off	Only the sign is displayed.
	ON	Display of the north and south pole with the sign of the measuring value	For the exact definition of north and south pole, please consult the documentation of the used measuring probe. Only for DC field measurements.

Operation via the external interface:

`:PAR:POLD {OFF|ON}`

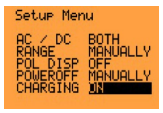
6.1.7 Switching off the Device

	**MANUALLY**	Manual switch off via the IO button	
	2 MIN	Automatic switch off after 2 minutes without Activity	The device is switched off when the buttons have not been pressed and the measuring value has not changed significantly.
	5 MIN	Automatic switch off after 5 minutes without activity	

Operation via the external interface:

`:PAR:POFF {MANU|2MIN|5MIN}`

6.1.8 Charging the Batteries

	**ON**	The batteries are charged via the power supply or the computer in operation	Charging is only possible when the device is switched on.
	OFF	The batteries are not charged	The charging is blocked.

Operation via the external interface:

`:PAR:CHAR {OFF|ON}`

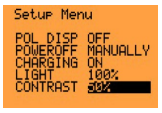
6.1.9 Brightness of Display Illumination

	**25%..100%**	Adjustment of the brightness of the display illumination	A minor brightness entails a longer battery lifetime.
	OFF	Switching off the display illumination	

Operation via the external interface:

`:PAR:LIGH {100|75|50|25|OFF}`

6.1.10 Display Contrast Adjustment

	**0%..100%**	Adjustment of the display contrast in 5% steps	Adjust the contrast corresponding to your lighting conditions.

Operation via the external interface:

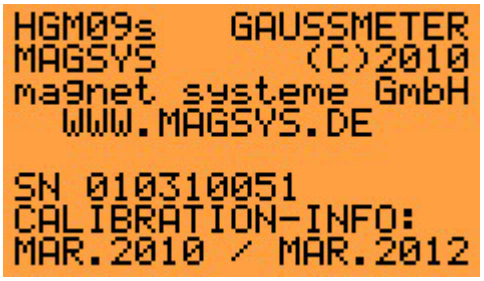
`:PAR:CON <0..20>`

6.1.11 Version Remarks

After quitting the setup menu, two display pages emit some information regarding the device. If you want to look at the display longer, keep the **IO** button pressed.

The first page displays:

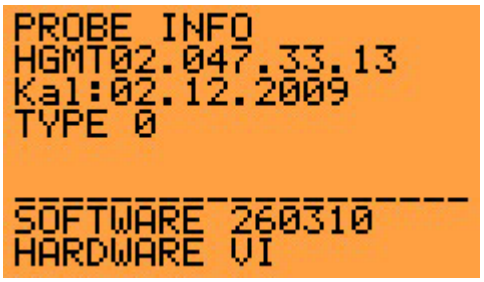
- Information regarding the manufacturer
- Name of the device
- Installed option
- Serial number
- Calibration information



The calibration information consists of the calibration date and the recommended date of the next recalibration.

The second page displays:

- Information regarding the used measuring probe
  - Type name
  - Calibration date
- Software status of the device
- Hardware status of the device



In the event of a device failure, please see the third page for more detailed explanations.

7

7 Serial Interface

7.1 Introduction

Via the installed serial interface all functions of the Gaussmeter can be piloted by a controller (e.g. a personal computer). The interface can be used in two completely different ways.

On the one hand the Gaussmeter can write the data directly into any PC application. In this KEYBOARD mode, the Gaussmeter acts similar to a keyboard that is connected to a personal computer. The measuring data are transmitted automatically on pressing the **DATA** button. A special installation of drivers is not necessary. This operating mode works for computers based on Windows[①] as well as for Linux[①] operating systems or for Apple[①] computers. The only requirement for the computer is that it has a connection for keyboards based on USB 2.0. This operating mode is e.g. suitable for filling out Excel[①] sheets easily.

If you want to control the Gaussmeter automatically and the connected computer is supposed to actively carry out the data exchange, a connection via a virtual serial interface is possible. In this operating mode a USB compliant CDC connection is established. The Gaussmeter acts like an additional serial interface for a user program. However, in this case you must install a driver. For the standard Windows[①] operating systems the driver is included in the delivery.

The data transmission itself, i.e. the protocol, is defined in close connection to the widely-used SCPI programming language for measuring devices.

[①] Trademark of the respective trademark owner

7.2 Connecting the Gaussmeter to a Computer

7.2.1 Connector Plug

The USB port on the top of the Gaussmeter is a Mini-B USB 2.0 socket.

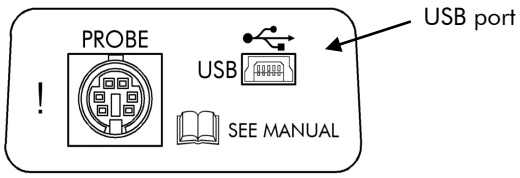


Figure 9 USB Connection

The Gaussmeter is connected to the computer via the supplied USB cable.

7.3 Direct Operation on the Computer

The Gaussmeter is connected to the computer via the USB interface. The device setting USB MODE is adjusted to KEYBOARD. The top right area of the display shows KEYB.

The installation of a driver depending on the operating system is generally not required. The operating system solely has to support the HID (Human Interface Device) device class according to USB 2.0. This is the case for standard computers under Windows[①], Linux[①] or Mac OS[①].

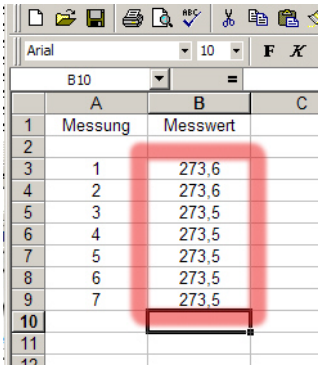
After starting a suitable program, e.g. Microsoft[①] Excel[①], the measuring data can be transmitted to the respective data fields by simply pressing the **DATA** button. The decimal separator is selected automatically in dependence of the country version of the computer.

The transmitted number of digits corresponds to the number that is monitored on the device display. For normal measurements and fast peak value measurements a measuring value and a carriage return are transmitted. For slow peak value measurements the current value and both peak values are emitted separately by the tab character. These three values are then normally placed side by side.

[①] Trademark of the respective trademark owner

7.3.1 Example Normal Measuring Mode in Excel[①]

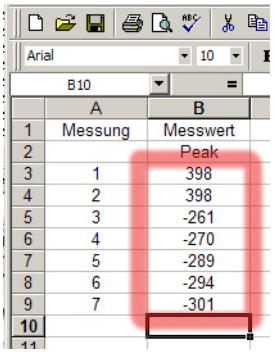
The marked values were transmitted by the Gaussmeter. Placement starting in cell B3.



	A	B	C
1	Messung	Messwert	
2			
3	1	273,6	
4	2	273,6	
5	3	273,5	
6	4	273,5	
7	5	273,5	
8	6	273,5	
9	7	273,5	
10			
11			

7.3.2 Example Fast Peak Value Mode in Excel[①]

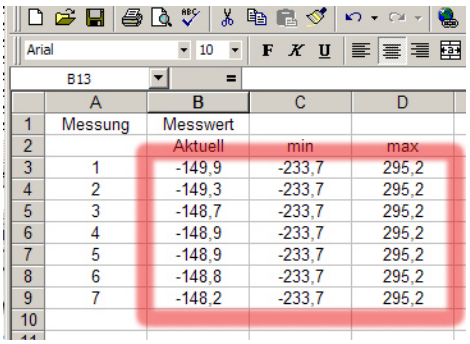
The marked values were transmitted by the Gaussmeter. Placement starting in cell B3.



	A	B
1	Messung	Messwert
2		Peak
3	1	398
4	2	398
5	3	-261
6	4	-270
7	5	-289
8	6	-294
9	7	-301
10		

7.3.3 Example Slow Peak Value Mode in Excel[①]

The marked values were transmitted by the Gaussmeter. Placement starting in cell B3.



	A	B	C	D
1	Messung	Messwert		
2		Aktuell	min	max
3	1	-149,9	-233,7	295,2
4	2	-149,3	-233,7	295,2
5	3	-148,7	-233,7	295,2
6	4	-148,9	-233,7	295,2
7	5	-148,9	-233,7	295,2
8	6	-148,8	-233,7	295,2
9	7	-148,2	-233,7	295,2
10				

[①] Trademark of the respective trademark owner

7.4 Operation via Interface

7.4.1 Installation on the Computer

For the comprehensive operation on an external computer use the CDC device class (Communication Device Class) of the USB specification. This communication class defines a virtual serial interface on the connected computer. For the user program, the Gaussmeter turns out to be an additional serial interface. The operation can be tested by simple terminal programs, as Hyperterm under Windows[①]. Depending on the operating system, the installation of a driver on the computer might become necessary. You find more detailed notes on this in the driver installation documents.

7.4.2 USB Interface Data Format

The data format of the virtual interface is predefined.

A possible adjustment or change of the parameters, as the transfer rate etc., has no effect. The data flow is stored in the USB protocol. The data are always transmitted with the maximum possible speed.

7.4.3 Character Set

The ASCII character set is used. The following control characters are used:

Character	Octal	Decimal	Hex	Function
<LF>	12	10	0A	End of command line
<CR>	15	13	0D	Feed
<ETX>	3	3	03	Abort

Other control characters can be used to achieve a clear format. They will be ignored.

7.4.4 Introduction to the SCPI Language

The programming language SCPI (Standard Commands for Programmable Devices) defines the way a measuring device (here the Gaussmeter) can communicate with a controller. The SCPI language uses a hierarchical structure. The command tree consists of root directory commands that are placed on top and several levels below each root directory command. You have to specify the complete path to execute commands of the lower levels.

[①] Trademark of the respective trademark owner

7.4.4.1 Command Structure

The commands generally have a short and a long form. In the following descriptions, the short form is set in upper case. The attached long form is set in lower case. Only the characters of the short form are checked for syntactic correctness. Upper and lower case spelling is not distinguished. The same is true for the parameters. A parameter is always emitted in long form and in upper case.

Example:

```
Command PROBe:POTEntialcoil:LENGth?
Send    PROBe:POTEntialcoil:LENGth?
Send    PROB:POTE:LENG?
Send    PROB:POTEntial:leng?
```

7.4.4.2 Path Separator „:“

If a colon is the first character of a command key word the next command code is a command of the root directory. If a colon is written between two command codes the colon entails a path to the next lower level of the current path of the command tree. Command codes must be separated from one another by a colon. You can omit the colon at the beginning of a command if the command is the first of a new program line.

7.4.4.3 Command Separator „;“

Several commands within the same command character string are separated by a semicolon. By means of a semicolon the indicated path is not changed. The two following statements have the same meaning.

Example:

```
:IO:DIG:LOGI:IN POS;:IO:DIG:LOGI:OUT NEG
:IO:DIG:LOGI:IN POS;OUT NEG
```

7.4.4.4 Parameter Separator „,“

If you require several parameters in one command, they have to be separated by a comma.

Example:

```
:PROB:SEAR:AREA 12,QMM
```

7.4.4.5 The Use of Blanks

A parameter must be separated from a command key word by blanks (tab or space). Blanks are usually only ignored in parameter lists.

7.4.4.6 Query Commands

The controller can send out commands at any time, however a SCPI device (here the Gaussmeter) will only answer, if it has expressly been instructed to do so. Only query commands (commands that end with a question mark) prompt the device to send a response. For queries, the device displays either measuring values or internal device settings.

Note	
	If you send two query commands without having read the reply to the first and thereupon try to read the first response, you might receive some data of the first reply, followed by the complete second response. Therefore do not send any query command without having read the reply beforehand. Commands and queries should not be sent via the same program line. This might result in an overflow of the raw data buffer, in the event that too many data are created.

7.4.4.7 System Commands

Commands starting with an asterisk are called general commands. The commands with asterisk are used for controlling status operations in the Gaussmeter.

7.4.5 SCPI Data Types

The SCPI data language defines different data formats that are used in the program message and in the reply message. SCPI devices can normally accept commands and parameters in different formats. In particular the numerical parameters can be used very freely. Contrary to this general definition, the data formats are restricted in some places here.

7.4.5.1 Numerical Parameters

Commands that require numerical parameters, accept the generally used decimal notation of numerical characters including leading characters, decimal points and leading zeros. The scientific notation is supported. The technical unit is preset for most commands and will then not be transmitted. For some commands the unit is part of the command being an additional parameter.

Example:

```
:PROB:SEAR:AREA 12.345E-3,QM
:PROB:SEAR:RES 123.5
```

7.4.5.2 Discrete Parameters

Discrete parameters are used in order to program setups that have a limited amount of values. You have a long and a short form for command key words. Upper and lower case can be mixed. Replies to queries are always only emitted in long form and in upper case.

Example:

```
:PEAK:MODE FAST
```

7.4.5.3 Boolean Parameters

Boolean parameters represent a single condition that is either true or untrue. As an untrue condition the Gaussmeter accepts "OFF" or "0". As a true condition the Gaussmeter accepts "ON" or "1". If a Boolean setup is interrogated, the device always emits "0" or "1".

Example:

```
:DISP:BARG ON
:DISP:BARG?        Answer:1<cr><lf>
```

7.4.5.4 Character String Parameter

Character string parameters can, in principle, contain a limited amount of ASCII-characters. A character string must begin and end with either an apostrophe (') or a quotation mark ("), with the same character at the beginning and at the end of the character string. The delimiter can be used within the character string by keying it in twice in a row without blank.

Example:

```
:PROB:IDEN "PART x"
:PROB:IDEN 'PART x'
```

7.4.5.5 Entry Endings

Program messages that are sent to the Gaussmeter must end with an <LF> character. Likewise a <CR> character followed by an <LF> character is accepted. By terminating a message, the current path is always set back to the root directory.

7.4.5.6 Output Data Format

Output data have the format that is shown in the following chart. Output data terminate with a <CR> character and by an <LF> character.

Types of Output Data	Output Data Format
Queries	<Parameter><cr><lf>
Text	"Character string" <cr><lf>
Numerical Value	+D.DDDDDDE+DD<cr><lf> (D = 0..9)

7.4.6 The SCPI Status Model

The status system records different device conditions in several register groups. The individual messages are grouped in the several registers. One bit of these registers is related to one message respectively.

The measuring event register stores the messages that are relevant for the measurement. The data error register stores the error messages and the standard event register the SCPI standard messages.

7.4.6.1 Event Register

The event register can only be read. The signal bits are set by the device but are not deleted automatically.

Bits in an event register are deleted either by interrogation of this register (*ESR? or e.g. :STAT:QUES:EVEN?) or by the *CLS command. When interrogating an event register, the device emits a decimal value that corresponds to the sum of the binary place values of all bits that are set in this register.

7.4.6.2 Release Register

The individual bits of the assigned event registers are masked via the release registers. Only the released bits enter into the sum bit as an OR connection. The release registers are read- and writeable. The release registers are not deleted by a query. The *CLR command does not delete the release registers. The command :STATus:PRESet deletes the release register for the error data. When interrogating an event register, the device emits a decimal value that corresponds to the sum of the binary place values of all bits that are set in this register. For setting the bits in a release register, a decimal value is transmitted that corresponds to the sum of the binary place values of all bits set in this register.

7.4.6.3 Sum Register

In the sum register the results of the event registers are summarized after the masking in the release register and assigned to individual bits. The deletion of the event in the event registers also sets back the respective sum bit in the status register. Via the release register of the sum register the individual sum bits can be re-merged to one whole message service request.

7.4.6.4 Overview Status Model

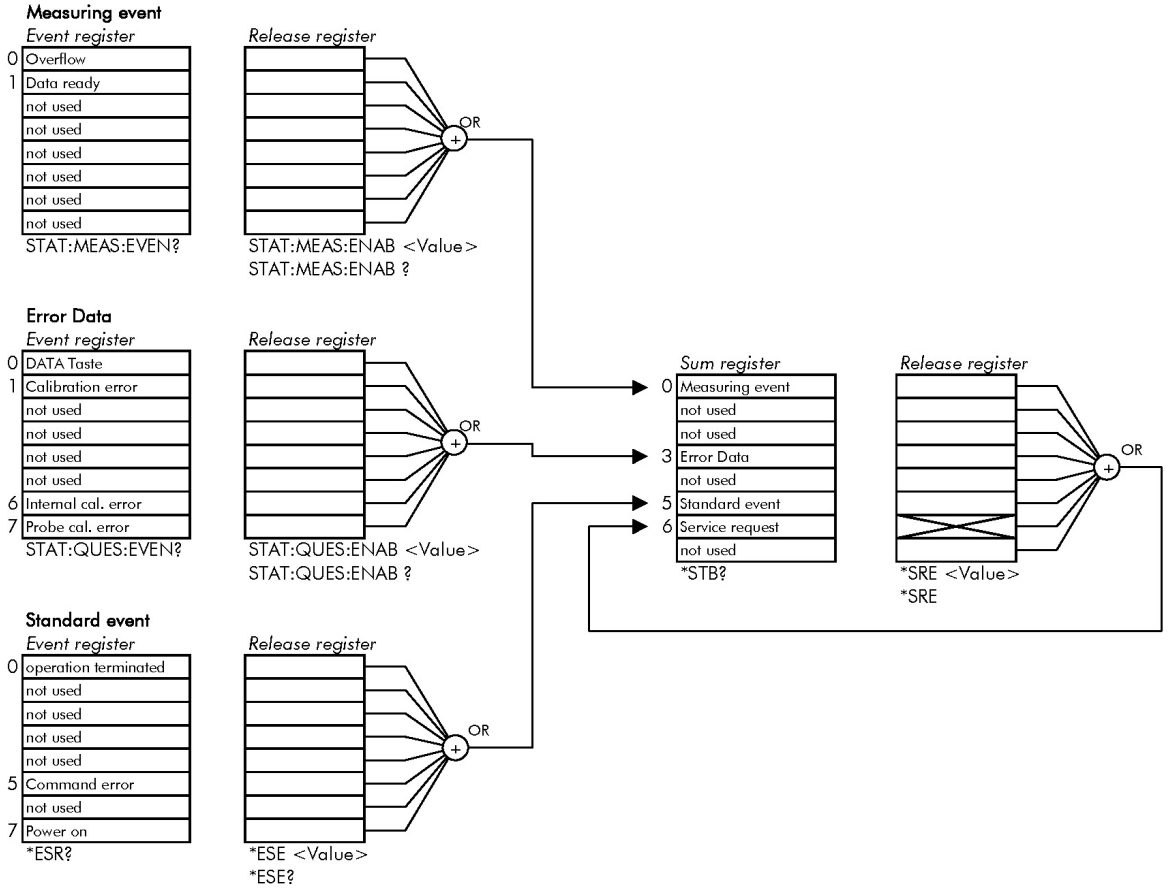


Figure 10 SCPI Status Model

7.4.6.5 Bit Definitions

Bit Definitions Sum Register

Bit		Decimal Value	Definition
0	Measuring Event	1	One or several bits are set in the measuring event register and activated in the release register.
3	Error Event	8	One or several bits are set in the error event register and activated in the release register.
5	Standard Event	32	One or several bits are set in the standard event register and activated in the release register.
6	Maintenance Request	64	One or several bits are set in the sum register and activated in the release register.

Bit Definitions Measuring Event Register

Bit		Decimal Value	Definition
0	Overflow	1	An area overflow has emerged during the measurement.
1	Data available	2	A measurement is terminated. The data are available.

Bit Definitions Error Data Register

Bit		Decimal Value	Definition
0	DATA Button	1	Is set when the DATA button has been pressed.
1	General Calibration Error	2	Is set if the calibration data of the measuring probe could not be read or if the internal calibration data are not consistent.
6	Internal Calibration Error	64	Is set if the internal calibration data are not consistent.
7	Probe Calibration Error	128	Is set if the calibration data of the measuring probe are not consistent.

Bit Definitions Standard Event Register

Bit		Decimal Value	Definition
0	OPC	1	Is set at the end of the SCPI command processing.
5	CME	32	An error has emerged upon the SCPI command processing.
7	PON	128	Is set when the device is ready for use.

7.5 Summary of SCPI Commands

The following spellings are used in the SCPI command syntax: optional key words or parameters are indicated in square brackets [ ]. Parameters within a command character string are indicated in braces { }. The parameter indicated in angle brackets < > must be replaced by a value.

7.5.1 Control Commands

*CLS	Reset the status registers.
*ESE?	Readout the event release register.
*ESR[?]	Readout and reset the standard event register.
*IDN?	Read the identification.
*OPC?	Display "1" for synchronization.
*OPC	Set the event bit "Operation terminated".
*RST	Reset the Gaussmeter.
*SRE[?]	Readout and set the status byte release register.
*STB?	Readout the status byte sum register.
:STAT:PRES	Reset the error byte release register.
:STAT:QUES:ENAB	Readout and set the error byte release register.
:STAT:QUES:EVEN	Readout the error byte register.
:STAT:MEAS:ENAB	Readout and set the event release register.
:STAT:MEAS:EVEN	Readout the event register.

7.5.2 Main Commands

:MEAS?	Display the current measurement.
:READ?	Display the current measurement.
:UNIT[?]	Preset the physical unit.
:MODE[?] {DC|AC}	Preset the DC or AC field operation mode.
:RANG:SET {0|1|2|3}	Preset the measuring range.
:RANG:AUTO	Activate the automatic measuring range switch.
:RANG?	Interrogate the current measuring range.
:NULL	Null compensation of the measuring probe.
:READ:DC?	Readout of the DC value
:MEAS:DC?	Readout of the DC value
:AC?	Readout of the AC value
:READ:AC?	Readout of the AC value
:MEAS:AC?	Readout of the AC value

7.5.3 Peak Value Functions

:PEAK?	Interrogate the current peak value mode.
:PEAK:MODE {OFF|SLOW|FAST}	Select the peak value mode.
:PEAK:NULL	Reset the current peak values.
:PEAK:READ?	Display the stored peak value.
:PEAK:READ:MIN?	Display the stored minimum peak value.
:PEAK:READ:MAX?	Display the stored maximum peak value.

7.5.4 Probe Functions

:PROB:NAME?	Interrogate the probe designation.
:PROB:SN?	Interrogate the probe serial number.
:PROB:TYPE?	Interrogate the probe type.

7.5.5 Parameters

:PAR:USB[?]	Select the operating mode of the USB interface.
:PAR:UNIT[?]	Select the magnetic unit.
:PAR:PEAK[?]	Select the peak value recording mode.
:PAR:ACDC[?]	Select the DC or AC field measurement.
:PAR:RANGe[?]	Switch on/off the automatic range selection.
:PAR:POLDetect[?]	Switch on/off the north/south pole display.
:PAR:POFF[?]	Set the automatic turn off time.
:PAR:CHARing[?]	Switch on/off the battery charging.
:PAR:LIGHt[?]	Set the brightness of the display illumination.
:PAR:CONTrast[?]	Set the display contrast.
:PAR:SAVE	Store the set parameters.

7.5.6 Device Functions

:SN:UNIT?	Readout the device serial number.
:SN:SW?	Readout the software version.
:SN:HW	Readout the hardware version.
:SN:CALI	Readout the calibration information.

7.6 Explanation of the Individual SCPI Commands

7.6.1 Control Commands

7.6.1.1 *CLS

Description: Resets the status register.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:
```
send   *CLS<LF>
```

7.6.1.2 *ESE[?]

Description: Reads out the event register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Command and query

Parameter: {<value>} (within the range 0..255)

*RST value: Not relevant

Example:
```
send   *ESE 22<LF>
send   *ESE?<LF>     receive      22<CR><LF>
```

7.6.1.3 *ESR[?]

Description: Reads out and resets the standard event register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Command and query

Parameter: {<value>} (in the range 0..255)

*RST value: Not relevant

Example:
```
    send   *ESR?<LF>
receive   160<CR><LF>
```

7.6.1.4 *IDN?

Description: Reads the Gaussmeter identification character string. The Gaussmeter displays the following identification text:

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    *IDN?<LF>
receive
MAGSYS-MAGNET-SYSTEME,HGM09,0,150310,VI<CR><LF>
```

7.6.1.5 *OPC?

Description: Issue of "1" to the output buffer after the command has been executed. The command *OPC? can be placed at the end of a command line in order to synchronize the controller with the command processing. The command itself has no function.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    *OPC?<LF>
receive 1<CR><LF>
```

7.6.1.6 *OPC

Description: Sets the bit "Operation terminated" (bit 0) in the standard event register after the command has been executed.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:
```
send    *OPC<LF>
```

7.6.1.7 *RTS

Description: The Gaussmeter is reset to the initial state. The internal parameters are set to the preset value. The device carries out a complete reset. As the device interface is also reset, further commands on the interface might get lost.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:
```
send    *RTS<LF>
```

7.6.1.8 *SRE[?]

Description: Reads out and sets the status byte release register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Command and query

Parameter: {<value>} (within the range 0..255)

*RST value: Not relevant

Example:
```
    send   *SRE<LF>
 receive   76<CR><LF>
```

7.6.1.9 *STB?

Description: Reads out the status byte sum register.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   *ESR 23<LF>
    send   *STB?<LF>
 receive   0<CR><LF>
```

7.6.1.10 :STAT:PRESet

Description: Resets the error byte release register.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:
```
    send   :STAT:PRES<LF>
```

7.6.1.11 :STAT:QUES:ENABle[?]

Description: Reads out and sets the error byte release register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Command and query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :STAT:QUES:ENAB 64<LF>
    send   :STAT:QUES:ENAB?<LF>
 receive   64<CR><LF>
```

7.6.1.12 :STAT:QUES:EVENt?

Description: Reads out the error byte register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :STAT:QUES:EVEN?<LF>
 receive   0<CR><LF>
```

7.6.1.13 :STAT:MEAS:ENABle[?]

Description: Reads out and sets the event release register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Command and query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :STAT:MEAS:ENAB 123<LF>
    send   :STAT:MEAS:ENAB?<LF>
 receive   123<CR><LF>
```

7.6.1.14 :STAT:MEAS:EVENt?

Description: Reads out the event register. The Gaussmeter displays a decimal value that corresponds to the sum of the binary place values of all set bits in this register.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :STAT:MEAS:EVEN?<LF>
 receive   2<CR><LF>
```

7.6.2 Main Commands

7.6.2.1 :MEAS?

Description: Emits the current measurement (Like :READ?)

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :MEAS?<LF>
 receive   2.546313e-01<CR><LF>
```

7.6.2.2 :MODE[?]

Description: The DC or AC field operation mode is preset.

Mode: Command and query

Parameter: {DC | AC}

DC	DC operation mode
AC	AC operation mode

*RST value: DC

Example:
```
    send   :MODE AC<LF>
    send   :MODE?<LF>
 receive   DC<CR><LF>
```

7.6.2.3 :NULL

Description: Null compensation of the measuring probe. This function should only be carried out in sufficiently field-free areas.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:
```
    send   :NULL<LF>
```

7.6.2.4 :RANGe:SET

Description: The Gaussmeter measuring range is preset.

Mode: Command

Parameter: { 0 | 1 | 2 | 3 }

0	Most sensitive range
3	Most insensitive range

*RST value: Not relevant

Example:
```
send    :RANG:SET 2<LF>
```

7.6.2.5 :RANGe:AUTO

Description: The automatic measuring range switch is activated.

Mode: Command

Parameter: None

*RST value: Not activated

Example:
```
send    :RANG:AUTO<LF>
```

7.6.2.6 :RANGe?

Description: Interrogates the current measuring range. 0 = most sensitive range.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :RANG?<LF>
receive 3<CR><LF>
```

7.6.2.7 :READ?

Description: Displays the current measurement.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :READ?<LF>
receive 2.546313e-01<CR><LF>
```

7.6.2.8 :UNIT[?]

Description: The physical unit of the measuring value is preset or interrogated.

Mode: Command

Parameter: {TESL|APM|GAUS|OE|G|T}

TESL T	Unit is Tesla
APM	Unit is A/m
GAUS G	Unit is Gauss
OE	Unit is Oersted

*RST value: Tesla

Example:
```
    send   :UNIT TESL<LF>
    send   :UNIT?<LF>
 receive   TESL<CR><LF>
```

7.6.2.9 :READ:DC?

Description: Like :READ?

Example:
```
    send   :READ:DC?<LF>
 receive   2.546313e-01<CR><LF>
```

7.6.2.10 :MEAS:DC?

Description: Like :READ?

Example:
```
    send   :MEAS:DC?<LF>
 receive   2.546313e-01<CR><LF>
```

7.6.2.11 :AC?

Description: Output of the current AC measurement.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :AC?<LF>
 receive   5.25321e-01<CR><LF>
```

7.6.2.12 :READ:AC?

Description: Like :AC?

Example:
```
send      :READ:AC?<LF>
receive   5.25321e-01<CR><LF>
```

7.6.2.13 :MEAS:AC?

Description: Like :AC?

Example:
```
send      :MEAS:AC?<LF>
receive   5.25321e-01<CR><LF>
```

7.6.3 Peak Value Function

7.6.3.1 :PEAK?

Description: Interrogates the current peak value mode.

Mode: Query

Parameter: None

*RST value: Not relevant

Example: `receive OFF<CR><LF>`

7.6.3.2 :PEAK:MODE[?]

Description: Selects and interrogates the peak value mode.

Mode: Command and query

Parameter: {OFF | SLOW | FAST}

OFF	No peak value recording
SLOW	Slow peak value recording
FAST	Fast peak value recording

*RST value: OFF

Example: `send :PEAK:MODE SLOW<LF>`

7.6.3.3 :PEAK:NULL

Description: Resets the current peak values.

Mode: Command

Parameter: None

*RST value: Not relevant

Example: `send :PEAK:MODE NULL<LF>`

7.6.3.4 :PEAK:READ?

Description: The stored peak value is displayed. For SlowPeak the absolute larger peak value with signs; for FastPeak the peak value; for normal measurement 0 is emitted.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send     :PEAK:READ?<LF>
receive  -4.761955e-02<CR><LF>
```

7.6.3.5 :PEAK:READ:MIN?

Description: The stored minimum peak value is displayed. For SlowPeak the smaller peak value of max/min; for FastPeak the absolute larger peak value with signs; for normal measurement 0 is emitted.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send     :PEAK:READ:MAX?<LF>
receive  7.187624e-02<CR><LF>
```

7.6.3.6 :PEAK:READ:MAX?

Description: The stored maximum peak value is displayed. For SlowPeak the larger peak value of max/min; for FastPeak the absolute larger peak value with signs; for normal measurement 0 is emitted.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send     :PEAK:READ:MIN?<LF>
receive  -2.711216e-02<CR><LF>
```

7.6.4 Probe Functions

7.6.4.1 :PROB:NAME?

Description: Interrogates the probe name.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :PROB:NAME?<LF>
 receive   "HGM09 Probe     T02.047.33.13   "<CR><LF>
```

7.6.4.2 :PROB:SN?

Description: Interrogates the probe serial number.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :PROB:SN?<LF>
 receive   "121109070"<CR><LF>
```

7.6.4.3 :PROB:TYPE?

Description: Interrogates the probe type.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
    send   :PROB:TYPE?<LF>
 receive   0<CR><LF>
```

7.6.5 Parameters

7.6.5.1 :PAR:USB[?]

Description: Selects the USB interface operating mode. A change of this parameter has an effect only after the next switching-on of the device. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {OFF | KEYB | COMP | SERL}

OFF	No data connection
KEYB	Keyboard emulation
COMP	HMI interface
SERL	Connection via serial interface

*RST value:Not relevant

Example:

```
   send   :PAR:USB COMP<LF>
   send   :PAR:USB?<LF>
receive   COMP<CR><LF>
```

7.6.5.2 :PAR:UNIT[?]

Description: Selects the magnetic unit. For ALL, the unit is also switched by means of the **RANGE** button. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {ALL | TESL | GAUS | OE | APM}

TESL T	Unit is Tesla
APM	Unit is A/m
GAUS G	Unit is Gauss
OE	Unit is Oersted

*RST value:Not relevant

Example:

```
   send   :PAR:UNIT ALL<LF>
   send   :PAR:UNIT?<LF>
receive   ALL<CR><LF>
```

7.6.5.3 :PAR:PEAK[?]

Description: Selects the peak value acquisition mode. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {OFF | SLOW | FAST}

OFF	No peak value recording
SLOW	Slow peak value recording
FAST	Fast peak value recording

*RST value: Not relevant

Example:
```
   send   :PAR:PEAK SLOW<LF>
   send   :PAR:PEAK?<LF>
receive   SLOW<CR><LF>
```

7.6.5.4 :PAR:ACDC[?]

Description: Selects the DC or AC field measurement. For BOTH, the DC/AC field mode is also switched by the **RANGE** button. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {BOTH | DC | AC}

BOTH	Selection via the **RANGE** button
DC	DC field operating mode
AC	AC field operating mode

*RST value: Not relevant

Example:
```
   send   :PAR:ACDC DC<LF>
   send   :PAR:ACDC?<LF>
receive   DC<CR><LF>
```

7.6.5.5 :PAR:RANGe[?]

Description: Switches on/off the automatic range selection. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {MANU | AUTO}

MANU	Selection via the **RANGE** button
AUTO	Automatic range selection

*RST value:Not relevant

Example:

```
send    :PAR:RANG MANU<LF>
send    :PAR:RANG?<LF>
receive MANU<CR><LF>
```

7.6.5.6 :PAR:POLDetect[?]

Description: Switches on/off the north/south pole display. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {OFF | ON}

OFF	Switch off the pole display
ON	Switch on the pole display

*RST value:Not relevant

Example:

```
send    :PAR:POLD ON<LF>
send    :PAR:POLD?<LF>
receive OFF<CR><LF>
```

7.6.5.7 :PAR:POFF[?]

Description: Sets the turn-off time or switches off the function respectively. The device is switched off automatically after a determined period of inactivity. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {MANU | 2MIN | 5MIN}

MANU	Switch off the automatic turn-off
2MIN	Automatic turn-off after 2 minutes
5MIN	Automatic turn-off after 5 minutes

*RST value:Not relevant

Example:

```
send     :PAR:POFF MANU<LF>
send     :PAR:POFF?<LF>
receive  MANU<CR><LF>
```

7.6.5.8 :PAR:CHARing[?]

Description: Switches on/off the battery charging. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {OFF | ON}

OFF	Switch off the battery charging
ON	Switch on the battery charging

*RST value: Not relevant

Example:

```
send     :PAR:CHAR OFF<LF>
send     :PAR:CHAR?<LF>
receive  OFF<CR><LF>
```

7.6.5.9 :PAR:LIGHt[?]

Description: Sets the brightness of the display illumination or switches off the illumination respectively. The changes must be stored by the command :PAR:SAVE, if necessary.

Mode: Command and query

Parameter: {100 | 75 | 50 | 25 | OFF}

25 .. 100	Brightness of the display illumination in %
OFF	Switch off the display illumination

*RST value: Not relevant

Example:

```
   send   :PAR:LIGH 75<LF>
   send   :PAR:LIGH?<LF>
receive   100<CR><LF>
```

7.6.5.10 :PAR:CONTrast[?]

Description: Sets the display contrast. The changes must be stored by the command :PAR:SAVE, if necessary. The value corresponds to 5% steps.

Mode: Command and query

Parameter: {<value>} (within the range 0..20)

0 .. 20	Display contrast in 5%

*RST value: Not relevant

Example:

```
   send   :PAR:CONT 15<LF>
   send   :PAR:CONT?<LF>
receive   11<CR><LF>
```

7.6.5.11 :PAR:SAVE

Description: Stores the set parameters.

Mode: Command

Parameter: None

*RST value: Not relevant

Example:

```
   send   :PAR:SAVE<LF>
```

7.6.6 Device Functions

7.6.6.1 :SN:UNIT?

Description: Emits the serial number of the device.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :SN:UNIT?<LF>
receive 010110078<CR><LF>
```

7.6.6.2 :SN:SW?

Description: Emits the software version.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :SN:SW?<LF>
receive 180310<CR><LF>
```

7.6.6.3 :SN:HW

Description: Reads out the hardware version.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :SN:HW?<LF>
receive VI<CR><LF>
```

7.6.6.4 :SN:CALI

Description: Reads out the calibration information.

Mode: Query

Parameter: None

*RST value: Not relevant

Example:
```
send    :SN:CALI?<LF>
receive 01JAN10 / 01JAN12<CR><LF>
```

8 Unit Conversion Table

This table shows the relationship between the displayed measuring values.

Size		Unit	Display	Conversion
Mag. flux density B	SI	Tesla	T	$1\ T = 10^{4} \cdot G$
Flux density	CGS	Gauss	G	$1\ G = 10^{-4} \cdot T$
Mag. field strength H	SI	Ampere/meter	A/m	$1\ Am^{-1} = \frac{4\pi}{1000} Oe$
Magnetic field strength	CGS	Oersted	Oe	$1\ Oe = \frac{1000}{4\pi} Am^{-1}$

9 Technical Data

General

Power Supply	Power supply unit 100..240 VAC, 50/60Hz, 0.3 A_{max}
	USB interface
	Battery 2 x AA 1.2 V NiMH (rechargeable)
Power Consumption	approx. 2.5 W
Environmental Conditions	-10 °C to 40 °C; < 80 % relative humidity at 40°C non-condensing
Storage	-40 °C to 70 °C
Housing Dimensions	approx. 145 x 80 x 40 mm
Weight	approx. 250 g (incl. batteries, without probe)
Warranty	2 years
Accessories	Power supply unit, data carrier with user manual, USB cable

Mathematical Functions	Conversion of units and derived parameters Linearization of the probe measurement
Data Protocol	SCPI (standard commands for programmable measuring devices)
External Interfaces	USB 2.0
Display	Graphical, high-contrast LCD contrast adjustable via menu
Parameter Memory in Probes	Storage of the calibration values

Measurement Properties

Measuring Method	Continuous acquisition of the magnetic field; conversion via 16 Bit A/D-converter; analysis via 16 bit microprocessor system.
Display Updating Time	Measuring values: approx. 100 ms;
Display Resolution	3- to 4-digit, range-depending
Frequency Range	DC/AC 0 Hz..5 kHz (effective value)
Measurement accuracy	Accuracy (1σ)

DC Field Measurement		B	Error
		≤1.5 T	≤±0.5 %
		> 1.5 T	≤±1.0 %
AC Field Measurement	Frequency	B_{eff}	
	≤2 kHz	≤1 T	≤±1.0 %
See Text	≤5 kHz	≤2 T	≤±2.0 %
Peak Value Measurement	Range	≤±1.0 %	≤±2.0 %
	10 mT	≤70 Hz	≤100 Hz
See Text	100 mT	≤100 Hz	≤150 Hz
	1 T	≤300 Hz	≤500 Hz
	4.5 T	≤500 Hz (B <1.5T)	≤700 Hz

Units	Tesla	Gauss	Oersted	Ampere/meter
Measuring Ranges (Resolution) DC Field Measurement	4.5 T (1 mT)	45 kG (10 G)	45 kOe (10 Oe)	3800 kA/m (1 kA/m)
	1 T (100 µT)	10 kG (1 G)	10 kOe (1 Oe)	1000 kA/m (100 A/m)
	100 mT (10 µT)	1 kG (100 mG)	1 kOe (100 mOe)	100 kA/m (10 A/m)
	10 mT (1 µT)	100 G (10 mG)	100 Oe (10 mOe)	10 kA/m (1 A/m)
Measuring Ranges (Resolution) AC Field Measurement	3.0 T (10 mT)	30 kG (100 G)	30 kOe (100 Oe)	2500 kA/m (10 kA/m)
	1 T (1 mT)	10 kG (10 G)	10 kOe (10 Oe)	1000 kA/m (1 kA/m)
	100 mT (100 µT)	1 kG (1 G)	1 kOe (1 Oe)	100 kA/m (100 A/m)
	10 mT (10 µT)	100 G (100 mG)	100 Oe (100 mOe)	10 kA/m (10 A/m)
Measuring Ranges (Resolution) Fast Pulse Measurement	4.5 T (10 mT)	45 kG (100 G)	45 kOe (100 Oe)	3800 kA/m (10 kA/m)
	1 T (1 mT)	10 kG (10 G)	10 kOe (10 Oe)	1000 kA/m (1 kA/m)
	100 mT (100 µT)	1 kG (1 G)	1 kOe (1 Oe)	100 kA/m (100 A/m)
	10 mT (10 µT)	100 G (100 mG)	100 Oe (100 mOe)	10 kA/m (10 A/m)
Peak Hold	$t_{signal} > 250\ \mu s$			
Probes (Special Designs on Request)	HGM Transversal Standard (incl. in delivery): dimensions probe tip approx. 1.3 x 3.8 x 50 mm HGM Transversal S: dimensions approx. 0.6 x 3.8 x 50 mm HGM Axial: dimension approx. Ø4.6 mm x 65 mm All probes: Active range ∅ 0.3 mm Handle bar approx. ∅11 mm x 100mm Cable length: 1.3 m (special lengths available) Integrated parameter memory			
Environmental Conditions				
Operating Environment	Specified accuracy for 0 °C up to 40 °C			
Relative Operating Humidity	Up to 80 % relative humidity for temperatures up to 30 °C, linearly decreasing to 50 % relative humidity at 40 °C.			
Storage Environment	-20 °C up to 70 °C			
Altitude	0 – 2000 meters as per IEC 61010-1 2nd Edition CAT III, 1000 V			
Degree of Pollution	Degree of pollution II			

Notes: The technical data apply for a one-hour warm-up phase.

10 Warranty and Copyright

Copyright

Liability

We do not take any liability for the correctness of this manual nor for any damages which might originate through the use of it. Since mistakes can never be avoided completely, despite all efforts, we would appreciate any given hint. We will be striving to fix any mistake as fast as possible.

Verification of Suitability

MAGSYS magnet systeme GmbH hereby certifies that this product has been inspected and tested before shipment in accordance with the stated technical data. Furthermore, MAGSYS magnet systeme GmbH declares that its calibration measurements are traceable to the Physikalisch-Technische Bundesanstalt, Braunschweig, or to the United States National Institute of Standards and Technology (former National Bureau of Standards) and to other members of the International Standardization Organization (ISO), provided that the calibration possibilities of these institutes allow this.

Warranty

The warranty is valid for two years starting from the date of shipment and comprises material and fabrication errors. Within the warranty period MAGSYS magnet systeme GmbH replaces or repairs products which have proved to be defective.

Return under Warranty

In case of warranty the device must be returned to a service point determined by MAGSYS magnet systeme GmbH. On returning the device under warranty, the buyer bears the costs for the shipment to MAGSYS magnet systeme GmbH, while MAGSYS magnet systeme GmbH bears the costs for returning the device to the buyer. However, the buyer bears all the costs for shipment, taxes and duties, if the device is returned to MAGSYS magnet systeme from abroad.

Extent of Warranty

The warranty already mentioned does not apply for errors due to inadequate or insufficient maintenance on the part of the buyer, due to unauthorized modifications or maloperation, to software or interfaces provided by the buyer, or to operations beyond normal ambient conditions. The buyer is solely responsible for design and assembly of electric circuits in connection with this product. MAGSYS magnet systeme GmbH cannot be made liable neither for customers' circuits nor for malfunctions of the product resulting from these. Moreover, MAGSYS magnet systeme GmbH will not accept warranty for damage which is traceable to customers' circuits or to products provided by the customer. Any further explicit or tacit warranty is excluded; MAGSYS magnet systeme GmbH especially rejects any tacit warranty concerning the qualification for a special purpose or to marketability.

Exclusive Measures

The above-mentioned measures are the only and exclusive measures on the side of the buyer. MAGSYS magnet systeme GmbH is not liable for direct, indirect, particular damages or damages resulting from negligence or consequential damages, no matter if they are founded on warranty, contract, offence or any further legal theory. This does not apply as far as MAGSYS magnet systeme GmbH is necessarily made liable by law.

Annotation

The information in this document is subject to alterations without prior announcement. MAGSYS magnet systeme GmbH does not take over warranty for this material including the marketability or its qualification for any determined purpose beyond. MAGSYS magnet systeme GmbH do not take over liability for errors in this manual or for accidental or consequential errors within the context of shipment, performance or usage of this material. No portion of this document may reproduced, translated or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the express written permission of MAGSYS magnet systeme GmbH.

Safety

Do not replace any parts and do not make alterations to the product without our explicit and written consent. Send the product to MAGSYS magnet systeme GmbH for repair and maintenance to safeguard that all safety features be preserved. Handling malpractices may lead to damage at the device and possibly to injuries and death of persons.

MAGSYS magnet systeme GmbH

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11 Index

*

*CLS 53
*ESE 53
*ESR 53
*IDN 54
*OPC 54
*RTS 54
*SRE 55
*STB 55

:

:MEAS 57
:MODE 57
:NULL 57
:PAR
  ACDC 65
  CHAR 67
  CONT 68
  LIGH 68
  PEAK 65
  POFF 67
  POLD 66
  RANG 66
  SAVE 68
  UNIT 64
  USB 64
:PEAK 61
  MODE 61
  NULL 61
  READ 62
    MAX 62
    MIN 62
:PROB
  NAME 63
  SN 63
  TYPE 63
:RANG 58
  AUTO 58
  SET 58
:READ 58
:SN
  CALI 69
  HW 69
  SW 69
  UNIT 69
:STAT
  MEAS
    ENAB 56
    EVEN 56
  PRES 55
  QUES
    ENAB 55
    EVEN 56
:UNIT 59

A

AC Field Measurements 28
Accuracy 15

B

Batteries 18
Blanks 44
Boolean Parameters 46

C

Character Set 43
Character String Parameters 46
Charging 38
Charging Batteries 19
Command Separator 44
Command Structure 44
Connector Plug 41
Contents 3
Contrast Adjustment 38
Control Commands 51, 53
Cross Current Resistance 12

D

Data Format 43
DC Field Measurements 27
DC/AC Field 36
DC/AC Field Measurements 26
Device Functions 52, 69
Direct Operation 41
Discrete Parameters 46
Display 9, 22
Display Brightness 38
Display Units 35

E

Endings 46

F

Fast Peak Value Recording 31
Field strength 70
Flux density 70
Front Side 17

G

Gaussmeter Function 10

H

Hall Effect 10

I

Illustrations 4
Installation 43
Interface 43
Introduction 7

K

Keyboard 21

L

Linear Properties 10

M

Main Commands 51, 57
Measurement Details 13
Measuring Range 8, 25
Measuring Unit 8, 26

N

Non-linear Properties 11
Null 24
Numerical Parameters 45

O

Operating Mode 35
Operation 21
Output Data 47

P

Parameter Separator 44
Parameters 52, 64
Path Separator 44
Peak Value 36
Peak Value Functions 52, 61
Peak Value Measurement 30
Peak Value Recording 30
Polarity 37
Ports Overview 17
Power Supply 18
Preparing a Measurement 7
Probe Connection 20
Probe Data 33
Probe Functions 52, 63

Q

Query Commands 45

R

Range Selection 37
Remanence 14
Running a Measurement 7

S

Safety Instructions 5, 6
Safety Symbols 6
Sample Measurement 13
SCPI 45, 51, 53
SCPI Language 43
Sensitivity 12
Serial Interface 40
Settings 35
Setup Menu 34
Static Magnetic Fields 16
Status Display 9, 22
Summary 51
Switching off 37
Switching on/off 24
System Commands 45

T

Technical Data 71

U

Unit 70
USB 41
USB Interface 20

V

Version Remarks 39

W

Warranty 73