MAGNET-PHYSIK
Dr. Steingroever GmbH

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Germany

Operating Instructions

Electronic Fluxmeter
EF 14

CE

Preserve for future application!

BA - No.: 100514EBA02

Introduction

Dear customer,

You have decided on a high-quality product from MAGNET-PHYSIK. We are convinced that our product will be a valuable help in your daily work. Condition is that the operating instructions are read carefully and observed. We will not take over any warranty or liability in case of deliberate faulty operation or disregard of our safety notes.

If you face any problems while working with the equipment or the operating instructions or if you have any proposals for improvements please do not hesitate to contact us.

Purpose

The operating instructions provide an overview of applications and functions of the Electronic Fluxmeter EF 14.

Target group

The operator and the owner of the device will find all the necessary information to operate this device in the following pages.

Manufacturer

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Note

- These operating instructions do not include all detailed information on the product nor do they consider every possible set-up, operation or installation as this would be too extensive.

- Should you require further information or if particular problems arise which have not been dealt with comprehensively in the operating instructions then the required information will be supplied by MAGNET-PHYSIK.

- We would also like to point out that the contents of these instructions are not part of a previous or existing arrangement, agreement or legal relationship, nor are they a modification of the same. All obligations on the part of MAGNET-PHYSIK are explicitly stated in the sales contract which contains the complete and only valid warranty clauses. These warranty clauses are neither extended nor limited by implementation of these instructions.

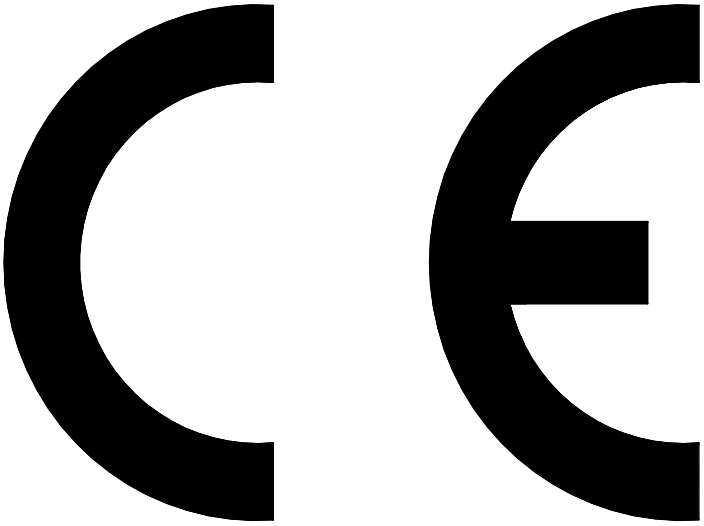


Table of Contents

1 General Information

This chapter gives an introduction to the fluxmeter EF 14. The EF 14 is a multi-purpose, fully equipped electronic fluxmeter. Depending on the measuring coil attached, various measurements can be carried out.

If you have just received your EF 14, make sure you familiarize yourself with the safety instruction in this chapter and the instructions for taking the EF 14 into operation in chapter 2. The complete and detailed user information on the instrument and the measuring modes can be found in chapters 3, 4 and 5. Chapter 6 deals in detail with the remote control of the EF 14 by means of the serial interface. The connectors of the EF 14 are described in chapter 7.

1.1 Safety Instructions

The following general safety measures must be adhered to at all times when the device is in use, being serviced or being repaired. Failure to observe these measures, or warnings given in other parts of these instructions, may influence the safety standards of the construction. MAGNET-PHYSIK Dr. Steingroever GmbH, Cologne, will accept no responsibility should the customer neglect the prescribed safety instructions.

Special safety instructions, whose non-observance may lead to injuries and/or property damage, as well as important hints, are marked within these operating instructions as follows:

Danger!

Means that serious bodily injury resulting in death or considerable material damage may occur if the appropriate safety measures are not taken.

Warning!

Means that serious bodily injury or considerable material damage may occur if the appropriate safety measures are not taken.

Caution!

Means that light bodily injury or material damage may occur if the appropriate safety measures are not taken.

Important!

Indicates important information which is to be paid particular attention.

1.1.1 Intended Purpose

Important!

It must be explicitly stated that the Electronic Fluxmeter EF 14 is to be used only for its intended purpose.

The intended purpose of the EF 14 is the measurement of magnetic flux and quantities that can be derived from this, by means of measuring coils.

Every application not in accordance with this intended purpose is prohibited and implies the deliberate dealing with non-calculable risks for both the operator as well as the equipment.

Unauthorized reconstruction of and/or alterations to the equipment are forbidden for safety reasons!

The instructions as stipulated in this operating manual for operation and installation are to be strictly observed!

1.1.2 Sources of Danger

Danger!

To minimize the danger of electric shock the device casing must always be grounded. The device must be connected to an approved 3-pole socket using a 3-wire power cord. Care must be taken that the grounding wire is securely connected to an electrical ground (PE).

Danger!

Under no circumstances the instrument must come into contact with liquid mediums, such as water, oil, etc. If in spite of all precautions taken, such a medium comes into contact with the electronics of the EF 14, there is considerable danger for the operation of the device. In this case the device must be shut down immediately.

The equipment must always be switched off when being cleaned.

Never clean with water! Use dry cloths only for cleaning!

Danger!

The measuring coil must never be brought into contact with an electrical voltage conductor. The sleeve or paint on the coil surface is not an electrical insulation. Disregard of this warning can cause danger to life of the user. Additionally the device and the coil can be damaged.

Danger!

Do Not Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Caution!

Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Caution!

Do Not Substitute Parts Or Modify Instrument

Due to the risk of electrostatic discharge and because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to MAGNET-PHYSIK Dr. Steingroever GmbH, Cologne, Germany or an authorized representative for service and repair to ensure that safety features are maintained.

1.1.3 Authorized Operator

The EF 14 may only be used and connected by personnel authorized by owner.

The owner must in this case:

- **place operating instructions at the operator's disposal at all times** and
- **make sure the operator has read and understood them.**

1.1.4 Place of Installation

No special safety measures are necessary at the place of installation.

Important!

The EF 14 must always be placed on a solid base, e.g. a table.

Never operate the equipment in places where one or more of the limiting values for the ambient conditions are exceeded.

1.1.5 Safety Checks

All safety checks as described here must be carried out regularly and carefully. Please use the checklist **"**General Check**"** for safety checks

Check Intervals:

- Once a year and
- after every repair

Contents of check:

- specified condition
- specified function

Table 1: Checklist for safety check

General Check and Functional Tests		
General Check: Switch off the device and disconnect it from mains power supply.		
Visual control check of instrument casing	undamaged	☐
Visual control check of connection cables	undamaged	☐
Functional test: Before functional test the device must be connected to mains power supply.		
EF 14	*switch on* with power switch	☐
Display	Display lights up	☐
EF 14	*switch off* with "Power Off"-key	☐
Display	extinguishes	☐
Check Date:_____ Operator (Signature): _____		

Important!

We recommend having the instrument and, if appropriate, the measuring coils periodically recalibrated to ensure traceability of the measuring results.

The suitable recalibration interval depends on the operating conditions and of the quality management stipulations of the owner. Intervals of one to two years are usual, depending whether the instrument is continuously used in rough production environment or from time to time under laboratory conditions.

1.1.6 Emergency Measures

In the case of emergency, when all safety instructions fail, disconnect the device from the power supply and proceed as follows:

Important!

Take emergency measures, such as "First-aid", securing the device and work place against further use and finally write the case report.

1.2 Instrument Description

The EF 14 is easy to operate via the front panel keys and has an easily readable LC display. The alphanumerical display allows user control supported by help texts.
To use the EF 14, a suitable measuring coil must be connected to the input. The following coil types are most frequently used:

- **Field measuring coils,** often also called **search coils,** are used for the measurement of the magnetic field strength or flux density at the pole faces or in air gaps of magnet systems. They have defined area turns, usually given in cm². Field measuring coils with particularly small dimensions are also referred to as point coils. To measure the flux density in the air gap of loudspeaker systems, stray field compensated coils are used.
- **Potential measuring coils** are required to measure magnetic potentials on magnets or magnet systems. The measuring results can be used to determine where losses occur in a magnet system. Furthermore the inner field strength of a magnet can be determined with a potential measuring coil.
- **Moment measuring coils,** particularly Helmholtz coils, allow the determination of the magnetic moment, dipole moment and polarization of two-pole magnetized components of hard magnetic materials. Measurement with a moment coil is a particularly fast method which is frequently employed in quality control. The combination of a moment measuring coil with a field generating system is referred to as a saturation coil. It can be used to determine the saturation polarization of soft magnetic materials.
- **Surrounding coils** are used to measure the magnetic polarization of permanent magnets or soft magnetic magnetized parts. They are mostly used in measuring systems like the PERMAGRAPH® or the REMAGRAPH® to record the magnetization curve.

The EF 14 is a highly sensitive electronic measuring instrument for the measurement of magnetic flux. For this reason the measuring results may be influenced by electromagnetic stray fields.

1.3 Specifications

Measuring input:	15 pole Sub-D socket on the front panel, pole clamps on the rear panel (alternately usable)
Input resistance:	100 kΩ

Max. input voltage:	40 V
Resolution:	$10^{-7}/10^{-6}/10^{-5}/10^{-4}$ Vs
Range limits:	$\pm 2250 \cdot 10^{-4}$ Vs, $\pm 9999 \cdot 10^{-5}$ Vs, $\pm 9999 \cdot 10^{-6}$ Vs, $\pm 9999 \cdot 10^{-7}$ Vs
Display resolution	4 digits
Accuracy:	DC: 0.5 % of reading ± 0.01 % of range ± 5 · 10^{-7} Vs AC: 10 Hz - 5 kHz: 5 % of reading (see also chapter 5.3)
Precision (reproducibility):	DC: 0.2 % of range
Measuring rate:	Display: approx. 2.7 measurements per second Interface: up to approx. 120 measurements per second
Extreme values:	|Max|, Max, Min, Max-Min, Peak for impulses
Limit comparator:	2-fold, relay output, display: Low, OK, High
Measurement memory:	Memory for up to 100 values. The stored values are kept in memory if the instrument is switched off. They can be read from the display and the computer interface.
Coil data memory:	Memory for up to 10 coil data sets. The values are kept in memory when the instrument is switched off.
Display:	Backlight LCD, 128 x 64 dots
Analog output:	Real analog, ±1 Volt in all ranges
Computer interface:	RS 232C
Operating temperature	+10 °C to +35 °C
Line power:	AC 90 - 250 V, 50 - 60 Hz, 5 Watt
Dimensions:	248 mm (width) x 180 mm (depth) x 100 mm (height)
Weight:	Approx. 1.5 kg

Fig. 1.4.1: EF 14 Front View

1.4 Ambient Conditions

Table 1.5.1: Electromagnetic Tolerance (EMV)

Immunity from discharge of static electricity: based on EN 61000-4-2	Air discharge: 8 kV Contact discharge: 4 kV
Immunity from incident high frequency: based on EN V 50141	0.15 to 80 MHz 10 V 80 % AM (1 kHz)

Table 1.5.2: Details on IEC- / VDE-Safety

Measurement of insulation based on VDE 0160 (05.88): between electrically independent circuits and with a central grounding point for connected circuits	
- Testing voltage at a rated voltage of the circuit (AC/DC) U_e = 0...50 V	500 V, sinus, 50 Hz
Safety test:	IEC 204-1; VDE 0113 Part 1 (06.93)

Table 1.5.3: Climatic and mechanical ambient conditions

Temperature:	- for operation	10 °C to 35 °C
	- for storage and transport	Class 1K4 according to DIN EN 50178 -10 °C to 55 °C
Relative humidity:	- for operation	Class 3K3 according to DIN EN 50178 5 % to 85 %, no dew, 1 g/m^3 to 25 g/m^3
	- for storage and transport	Class 1K3 according to DIN EN 50178 5 % to 95 %, no dew, 1 g/m^3 to 29 g/m^3
Atmospheric pressure	- for operation	Class 3K3 according to DIN EN 50178 86 kPa to 106 kPa
	- for storage	Class 1K3 according to DIN EN 50178 86 kPa to 106 kPa
	- for transport	Class 2K3 according to DIN EN 50178 70 kPa to 106 kPa

Toxic substances:	- SO_2	≤ 0,5 ppm (rel. moisture ≤ 60%, no dew)
	- H_2S	≤ 0,1 ppm (rel. moisture ≤ 60%, no dew)
Oscillations:		acc. to IEC 68-2-6 10 ... 57 Hz (const. amplitude 0.15 mm), 57 ... 150 Hz (const. acceleration 2g)

2 Taking Into Operation

This chapter gives general instructions on setting up the EF 14 fluxmeter. Instructions for unpacking the instrument are given in chapter 2.1. Packing the device for dispatch is described in chapter 2.2. The plug connections are described in chapter 2.3. Finally chapter 2.4 provides instructions on how to put the device into operation.

2.1 Unpacking and Checking

Check the packaging for signs of damage. Any correspondence regarding damage (evident or hidden) or partial loss of the consignment must be made in written form immediately after receipt of goods. Please also inform the freight forwarder immediately.

Open the packaging. A packing list is enclosed which allows you to check that the device, accessories and operating instructions have been received. Use the packing list to check that all parts of the device have been unpacked. Check for damages. Make sure everything has been removed before discarding the packaging.

If the device has been damaged in transit make sure the forwarder and insurance are informed. Inform Magnet-Physik of the same. If there are parts or accessories missing, let Magnet-Physik know immediately. MPS cannot accept responsibility for any missing parts if not informed within 60 days from date of dispatch.

2.2 Packing for Dispatch

If it becomes necessary to send in the EF 14, coils or other accessories for calibration, repair or replacement, inform Magnet-Physik before sending the parts. If an instrument is being sent in for service, the following information is required before the repair can be started:

- Device name and serial number
- User name, company, address, e-mail address and telephone number
- Description of fault
- Description of the measuring coil used
- Description of test arrangement.

The original packaging should be used for dispatch. If this is no longer available, use a stable cardboard or wooden box and mark it “fragile” or “sensitive electronic equipment”. If the EF 14 is shipped together with a measuring coil, pack it in a way that instrument and coil cannot damage each other. Do not place heavy measuring coils onto the EF 14.

2.3 Plug Connections

The socket for the measuring coil connection is located on the front panel of the instrument. On the rear side, pole clamps for measuring coil connection, a plug for the serial interface, a socket

for various in- and outputs and the line power supply socket with fuse and main switch are installed.

Details on the pin configuration of the sockets are given in chapter 7.

Measuring coil connection: the 15-pole socket for the measuring coil connection is located on the front panel. The coil connecting plug must be lined up with the socket and carefully bound to prevent the contacts being bent. It should be fastened using the two screws. A tight connection prevents the connector being pulled out unintentionally and reduces disturbances by drift.

The connector can be plugged and unplugged without switching off the instrument. However, it should not be unplugged immediately after it has been plugged in (within about 2 seconds).

On the rear panel of the instrument you can find a pair of pole clamps, where coils with bunch or banana plugs can be connected or wires can be clamped.

Important!

Only one measuring coil must be connected at one time, either to the socket on the front panel or to the clamps on the rear panel. If both connections are used at the same time, this will cause faulty measurements.

RS 232 plug: The 9 pin Sub-D plug has the connections for RS 232 interface. The EF 14 can be connected to a computer using a so-called Null-Modem-Cable.

I/O socket: This 25 pole socket has multiple functions. It contains the relay output for the limit function, the analog output and digital control lines.

Power supply element: The power supply socket with fuse and On/Off switch is the input for the AC power supply. The power supply connection cable is attached to the power supply socket.

2.4 Connecting and Start

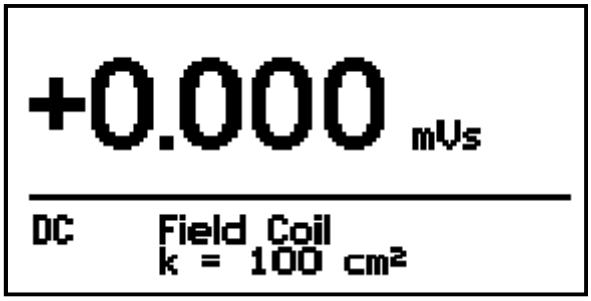
The following procedure describes how the device is put into operation. It serves to check the basic functions of the device before being used for measurements.

Caution!

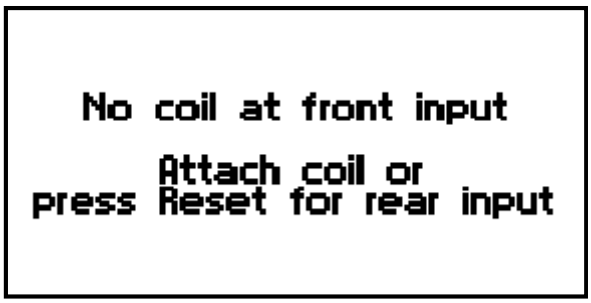
Check that the power line has the correct voltage before you connect the device to the system. The device can be damaged if connected to the wrong voltage! The EF 14 works with 90-250 V alternating voltage.

1. Make sure that the ON/OFF switch is at OFF (0).
2. Connect the coil plug to the input socket. Use the screws to fix the plug to the instrument. Alternatively you can use the pole clamps on the rear panel. Always only connect one coil.
3. Make sure all other necessary connections have been made before switching on the device e.g. interface or analog output.

4. Connect the power cable to the instrument and to a power socket.
5. Switch on the instrument (I). The display lights up and the Magnet-Physik logo briefly appears.
6. If a coil is connected to the front input, the measuring display appears. A typical example is as follows:



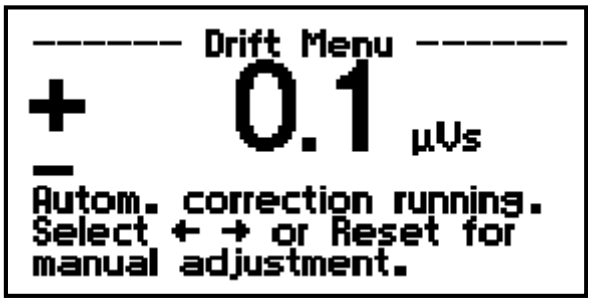
If the coil is connected to the rear input clamps, the following display appears:



In this case, press the **Reset** key to activate the measuring display for the rear input. The word **rear** behind the coil type shows, that the EF 14 assumes a coil at the rear clamps.

To obtain the best results the instrument must warm up for about 20 minutes. The coil plug and the input socket shall have the same temperature to avoid drift due to thermo voltages.

7. Press the **Drift** key on the front panel to start the automatic drift correction. The following display appears:



If the device has functioned properly up to now, it is in order. If you have a field measuring coil and a reference magnet you can continue with the test by using them to check the accuracy of the EF 14.

8. If you proceed with such a test, make sure that a suitable measuring range is selected. Use the range key to set the right measuring range.

Caution!

The measuring coils must be treated with care. They may be fragile.

Important!

The test result with a field coil depends on the angle between the coil and the magnetic potential lines. The greater the angle is between the coil and magnetic potential lines, the greater will be the percentage error. For example: A 5° angle produces an error of 0.4%, a 10° angle produces an error of 1,5%.

3 Operation

The basics for operation of the EF 14 fluxmeter are described here. A description of all the elements of display in measuring operation (standard display) is to be found in chapter 3.1. An overview of the keys and their functions is given in chapter 3.2.

3.1 Display

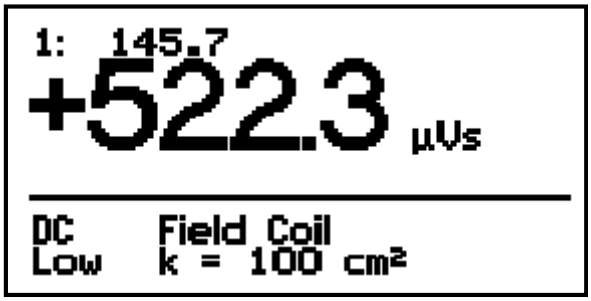


Fig. 3.1.1: Display in measuring operation

In measuring operation the actually measured value is shown in the center of the display in large numbers. It is the numerical value with a maximum of four digits and the unit.

The two bottom lines provide various information:

1. Measuring mode: **AC** or **DC**
2. Limit state: **Low**, **OK**, **High**. Therefore the **Limit** function must be switched on.
3. Coil type: The type of the connected measuring coil, **Field Coil** in the example.
4. Coil constant: Constant of the connected measuring coil, **k = 100 cm²** in the example. If the **Var.** function is switched on, this is shown instead of the coil constant.

Remote mode: If the EF 14 is controlled remotely via the serial interface and the keypad is locked, this is assigned by an **R** in the upper right corner of the display.

If the **Max./Min.** function is switched on, the values measured with this function are shown in the line below the main measured vale.

If the **Peak** function is switched on, the largest peak value is shown, independently of its sign, in the center of the display in large numbers. Below this, the largest value with opposite sign is shown.

Values that are stored in the data memory are shown in the upper left corner of the display.

The unit behind the actual measured value is valid for all displayed values.

3.2 Keypad

There is a numerical keypad for the input of numbers. It consists of the digit keys **0** to **9**, the (+/-) key and the decimal point. Numerical inputs are rounded to 7 significant figures.

You can change the most important instrument settings directly using the keys. The functions are indicated above the keys.

Only a brief description of the key functions will be given here. You can find detailed descriptions in Chapter 4.

Reset Sets the display back to zero in **DC** mode and clears all captured Max., Min. and Peak values.

Max./Min. Captures the highest and if applicable lowest measured value.

Peak Switches the measurement of fast pulses on and off.

Drift Starts the automatic drift correction of the EF 14 (only in **DC** mode).

Unit This key is pressed to show the selectable units. The selection available depends on the connected measuring coil.

Limit The values for the limit function (comparator) and the switching thresholds for the limit relays are input here.

Range The measuring range can be selected in this menu.

Coil Coil type and coil parameters can be input here if coils without an own data memory are connected to the EF 14.

Var. The test value can be multiplied or divided by a constant numerical value when this function is selected.

Mode This key switches between the measuring display and a selection for further menus and functions.

The arrow keys and the keys **Enter** and **Delete** have different functions, whether the measuring display or a menu is active.

In the measuring display:

Enter Save the actual measured value to the data memory. The saved value is shown in the upper left corner of the display.

← → The arrow key are used for navigation in the data memory.

Delete Deletes the value shown in the upper left corner from the data memory.

In a menu:

Enter The inputs shown on the display are accepted.

← → The arrow keys are used to move the selection cursor. The selection is shown inverted.

Delete This key is used to delete a numerical value. The cursor indicates the number to be deleted.

Escape This key is used to discontinue an input without changing the previously set values.

In the single menus it is indicated which keys can be used for inputs. The keys **Enter**, **Mode** and **Escape** are nearly always available. These keys have the following functions:

With **Enter** you complete the current input. Following the last input in a menu you leave with **Enter**.

Pressing the **Mode** key you will return immediately from the menu to the measuring operation. The last input is accepted.

With **Escape** you go back one step in an input dialog without accepting the latest input.

4 Device Functions

All key and menu functions are described in detail in this chapter.

The most important menus are invoked by the function keys (0 – 9). The names of the menus are assigned above the keys. Some less frequently needed menus can be accessed via a selection that is invoked by the **Mode** key. The menus and functions are then selected by the arrow keys (←, →) and accessed with **Enter**.

In all menus the name of the menu is shown in the first line. In the second line follow operation hints.

If a menu is entered, the EF 14 stops measuring. Then it is also not possible to read a measured value from the computer interface.

If the EF 14 is remotely controlled via the interface (remote operation) the menus, except the **Mode** selection, cannot be entered from the keypad. The remote operation can be identified by an **R** in the upper right corner of the display.

4.1 Reset

The function **Reset** sets in **DC** mode the displayed measuring value, all maximum values (Max., Min., Peak) and the analog output back at zero. Normally the **Reset** key is always pressed in **DC** mode before a measurement is carried out.

In **AC** mode **Reset** sets only the maximum values (Max., Peak) to zero.

4.2 Max./Min.

If the **Max./Min.** key is pressed once, the absolute value of the maximum is shown in the line below the measured value. The maximum is the highest reading that was captured since the **Reset** key was pressed last. Only the absolute value is evaluated, the sign is ignored.

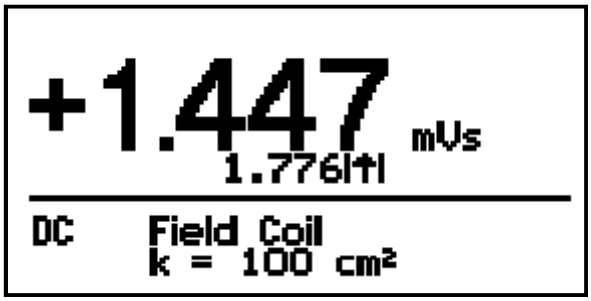


Fig. 4.2.1: Display of the absolute value of the maximum

If the **Max./Min.** key is pressed a second time, the maximum, the minimum and the difference between maximum and minimum are shown. The maximum is the highest reading that was captured since the **Reset** key was pressed last. The minimum is the lowest reading that was captured since the **Reset** key was pressed last. Here the sign of the readings is taken into account. This display is not available in **AC**-RMS operation, as the root mean square is always positive by definition.

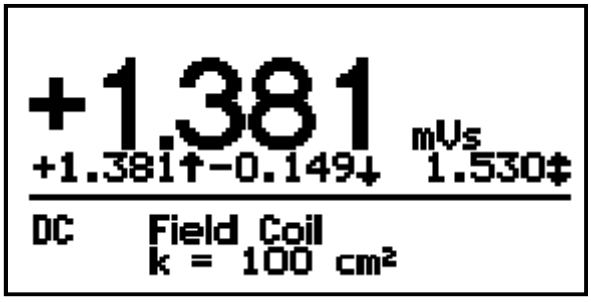


Fig. 4.2.2: Display of maximum, minimum and difference

Pressing **Reset** sets the readings back to zero.

Maximum and minimum are captured with the measuring rate of the EF 14. The **Max./Min.** function is therefore used to capture exactly the extremes of normal, slowly changing magnetic flux. For the measurement of fast changing pulses, the **Peak** function must be used instead.

If the **Max./Min.** key is once more pressed, the display of maximum, minimum, and difference is switched off.

4.3 Peak

The peak values of fast changing pulses can be measured using the **Peak f**unction. This function shows the highest positive and the lowest negative value since **Reset** has been pressed the last time.

In **DC** mode the reading with the largest absolute value is shown, independently of the sign (+ or -) in large numbers in the center of the display. In the line below the absolutely highest value with opposite sign is shown. This value is usually called valley.

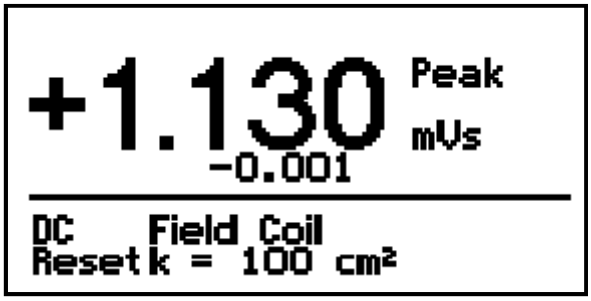


Fig. 4.3.1: Display of peak and valley

In **AC** mode the **Peak** function shows the peak value of the flux waveform and not the peak value of the RMS.

Pressing **Reset** sets all values back to zero.

Main application of the **Peak** function is the measurement of the maxima of magnetizing pulses, see chapter 5.2.

4.4 Drift

A fluxmeter is an extremely sensitive electronic integrator. It integrates every voltage that is applied to its input. This voltage is comprised of the measurement signal and mostly also an interference voltage, e.g. a thermo voltage. A constant interference voltage causes a reading that changes proportional to time, the so-called drift.

A fluxmeter cannot distinguish between the measured signal and interference. The user must ensure that the drift is accordingly corrected. The automatic drift correction of the EF 14 is a considerable help to the user in this case. The drift correction can also be carried out manually.

Fig. 4.4.1: Automatic drift correction in progress

Automatic drift correction:
The automatic drift correction is started by pressing the **Drift** key. The measurement can be regarded during the drift correction. The unit changes automatically to µVs and the range to 10^{-7}. A progress bar indicates that the correction is running. The drift function stops automatically as soon the correction is supposed to be sufficiently stable and the EF 14 returns to the normal measuring display. If this should take too long, the menu can also be left manually by **Enter**. In this case the correction level that is obtained up to this time is taken over. Under normal circumstances the automatic correction will produce a sufficiently stable reading, so that manual correction is not required.

Manual drift correction:
The automatic correction can be stopped by pressing **Reset** or one of the arrow keys. Then the drift can be corrected manually using the arrow keys. If the reading drifts into positive (+) direction, press the left (←) arrow key to stop the change of reading. If the reading drifts into negative (-) direction, press the right (→) arrow key to stop the change of reading. Drift correction is the better the more stable the reading is.

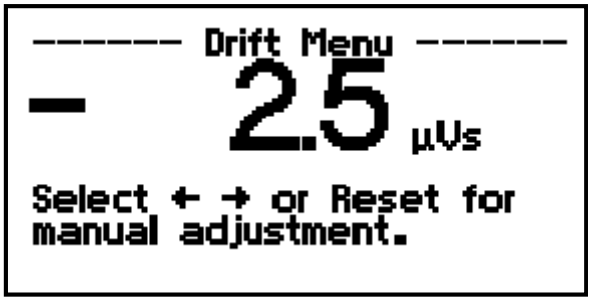


Fig. 4.4.2: Manual drift correction

During the manual drift correction the **Reset** key can be pressed any time to set the reading back to zero. The reading must not be brought to zero using the arrow key. The arrow keys are only used to stop the change of reading, which means to minimize the drift. If the reading is sufficiently stable, the manual drift correction is stopped by **Enter**.

Both, the automatic or the manual correction, can be aborted by **Escape**. Then the new correction value is dropped and the value that was valid before the function was started is applied again.

4.5 Unit

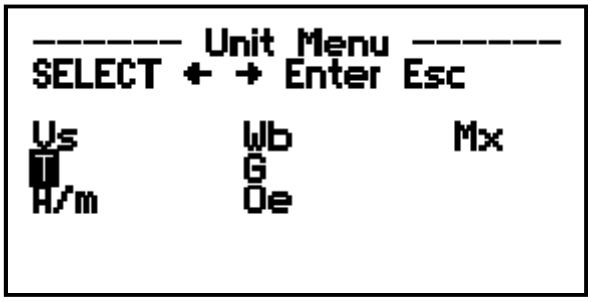


Fig. 4.5.1: Unit menu

The **Unit** menu is used to select the unit in which the measured values will be displayed. If the respective function is switched on, also Max., Min., Peak or stored values are shown in the same unit. If the unit is changed, stored values are not lost. They are converted into the new unit.

Depending on the coil type different units can be selected. In all cases the units for the magnetic flux, Volt Seconds (short name for the product of Volt and seconds, Vs), Weber (Wb) and Maxwell (Mx) are available. The following table gives an overview of the units that are, depending on the coil type, additionally selectable.

Field Coil:	T	magnetic flux density in Tesla
	G	magnetic flux density in Gauss
	A/m	magnetic field strength in Ampere per meter
	Oe	magnetic field strength in Oersted
Moment Coil:	Vs · cm	magnetic dipole moment
	Vsm	magnetic dipole moment
	Am²	magnetic moment
Potential Coil:	A	magnetic potential in Ampere
	Gb	magnetic potential in Gilbert
Surrounding Coil:	Vs/n	magnetic flux per turn
	Wb/n	magnetic flux per turn
	Mx/n	magnetic flux per turn

Vs/n, Wb/n and Mx/n are strictly speaking not units. They only acquaint that the division of the magnetic flux by the number of turns *n* of the measuring coil is already carried out by the fluxmeter.

The EF 14 assigns the required prefix automatically, depending on range and coil constant.

G	10^{9}
M	10^{6}
k	10^{3}
m	10^{-3}
µ	10^{-6}
n	10^{-9}
p	10^{-12}

The required unit is selected with the arrow keys. At the beginning or end of a line the arrow keys are used to move the selection mark into the preceding or following line. The selection is confirmed with the **Enter** key. The instrument then returns to the measuring operation.

When the input is canceled with the **Escape** key the new selected unit is not accepted. The values will continue to be given in the previously valid unit.

4.6 Limit

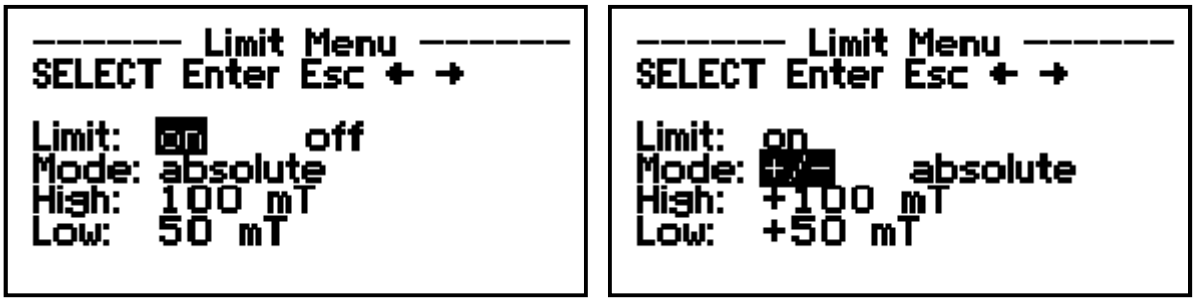


Fig. 4.6.1: ***Limit*** *menu*

The **Limit** menu is used to configure the **Limit** function. In the first line the function can be switched on or off. The selection is done with the arrow keys and confirmed with **Enter**.

In the second line the Limit Mode is selected: +/- or **absolute.** If **+/- is** selected, the sign of the measured value is take into account. If **absolute** is selected, only the absolute value is evaluated. The **absolute** mode can e.g. be used to sort magnets according to their field strength or magnetic moment without paying attention to the polarity. In the +/- mode magnets can be sorted according to their polarity.

The values for the switching levels are entered in the two following lines: first the upper limit and then the lower limit. The lower limit must always be smaller then the upper limit. A negative sign can only be entered if +/- is selected.

In the measuring operation **Low** is shown in the lower left corner of the display if the measured value is below the lower limit. The display changes to **OK** if the value is between the two limits. If the upper limit is exceeded, **High** is shown.

If both limits are set to the same value the display changes directly from **Low** to **High**.

If the respective limit is exceeded the assigned relay switches. The relay contacts can be accessed via the 25 pole socket on the rear panel of the instrument. You can find the pin assignment in chapter 7.3.

4.7 AC/DC

The **AC/DC** key switches between the integration of alternating and direct voltages. You can find detailed information about these operation modes in chapter 5.

4.8 Range

The **Range** menu allows the selection of the measuring range.

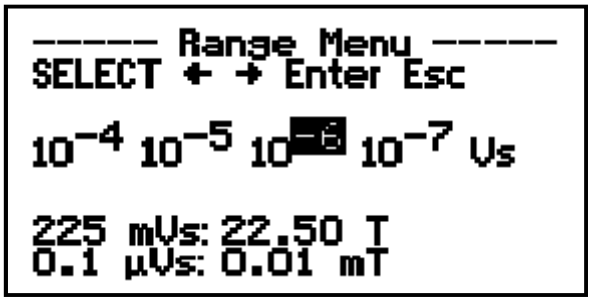


Fig. 4.8.1: ***Range*** *menu*

The selection window is opened with the **Range** key. The range that is actually active is shown inversely. Selection is carried out using the arrow keys. Press **Enter** to confirm the new selection or **Escape** to return to the measuring operation discarding any changes.

For almost all occurring measuring tasks the measuring ranges 10^{-4} Vs, 10^{-5} Vs and 10^{-6} Vs are sufficient. The measuring range 10^{-7} Vs should only be selected if really necessary. The unavoidable drift, especially over a longer measuring time, is considerably stronger here.

In the two lower lines you can see the maximum value that can be measured and which lowest resolution is available. In the 10^{-4} Vs range the EF 14 can measure 225.0 mVs at maximum. In the 10^{-7} Vs range the resolution is 0.1 µVs. Beside you can see the values in the currently selected unit that correspond to these flux values.

If the maximum reading of the currently selected range is exceeded in measuring operation, the display starts to blink and the maximum measurable value is shown. In this case select a less sensitive range.

4.9 Coil

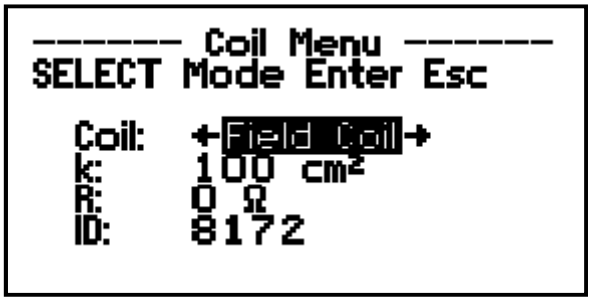


*Fig. 4.9.1: **Coil** menu*

In the **Coil** menu the data of measuring coils that have not an own data memory (EEPROM) can be entered. If you are using a measuring coil with an own data memory all the necessary settings are done automatically. (The parameters can also be changed if a coil with incorporated EEPROM is used, however, the changes are only kept in memory until the instrument is switched off or the coil is disconnected).

The following parameters can be entered or selected:

- the coil type *Coil,*
- the coil constant *k*,
- the coil resistance *R*,
- the identification number of the coil *ID*.

Due to the high input resistance of the EF 14 of 100 kΩ the resistance of the measuring coil can be often neglected and simply set to zero. If it is not small compared to 100 kΩ, the real resistance must be entered. It can be taken from the label of the coil or measured using an ohmmeter.

The coil constant is only then required if a unit other than Volt seconds, Weber or Maxwell is selected.

The following coil type selections are possible:

- **Field Coil** for field strength measuring coils (search coils, FS, DFS…) and point measuring coils (PKS...)
- **Surrounding Coil** for surrounding coils (J...)
- **Moment Coil** for magnetic moment measuring coils (MS...), e.g. Helmholtz coils and for Saturation Coils (JS…)
- **Potential Coil** for magnetic potential measuring coils (PS…)
- **Pole Coil** for pole coils (P...)
- **Flux Etalon** for flux reference standards (FE…)
- **Integrator Mode** for all coils

In the **Integrator Mode** the EF 14 ignores the input values for the coil constant as well as the coil resistance. The integrator mode is especially for compatibility with older fluxmeters. Eventually required calculation must be carried out manually in **Integrator Mode**. Take into account that the input resistance of the EF 14 is 100 kΩ. In the **Integrator Mode** a voltage of 1 mV at the analog output corresponds to 1 digit in the display.

The coil constants are:

- for field measuring coils or point coils: the area turns or winding area (in cm^2), i.e. the number of turns multiplied by the average cross-sectional area
- for surrounding coils: the number of turns

- for moment measuring coils: the measuring constant (in cm)
- for potential measuring coils: the measuring constant (in kA/Vs)
- for pole coils: the area turns or winding area (in cm²)
- for flux reference standards: any, not required for measurements in Vs

Numerical values are entered using the numerical keypad.

To delete a digit the cursor is placed with the arrow keys on the respective digit and the **Delete** key is pressed.

If you own measuring coils with bunch or banana plugs or if you design your own measuring coils, you can connect them to the pole clamps on the rear panel of the EF 14. If you prefer a connection to the front side socket, you can find the pole configuration in chapter 7.1.

If your coil was calibrated by the calibration laboratory for magnetic measurands of Magnet-Physik, you can find all necessary coil data in the calibration certificate. Select the coil type and enter coil constant and resistance to the EF 14.

For other Magnet-Physik coils with bunch plugs the coil data can be obtained as follows:

- for field measuring coils FS 100, FS 100 C, FS 1000, DFS etc. and point coils PKS 3, PKS 5 etc.:

  Older coils of these types show on the coil label the virtual area turns $NA_{10\,\mathrm{k\Omega}}$ if the coil is connected to a fluxmeter with an input resistance of 10 kΩ. As the EF 14 has an input resistance of 100 kΩ, the coil constant must be converted. The real area turns NA are obtained from the virtual area turns by

  $$NA = \left(1 + \frac{R}{10\,\mathrm{k\Omega}}\right) \cdot NA_{10\,\mathrm{k\Omega}},$$

  where R is the coil resistance that should be measured using an ohmmeter.

  Example: A coil FS 100/2 has virtual area turns of $NA_{10\,\mathrm{k\Omega}}$ = 100 cm² and a resistance of R = 220 Ω. The real area turns are

  $$NA = \left(1 + \frac{220\,\Omega}{10\,\mathrm{k\Omega}}\right) \cdot 100\,\mathrm{cm^2} = 1.022 \cdot 100\,\mathrm{cm^2} = 102.2\,\mathrm{cm^2}.$$

  These area turns, which are the coil constant k in this case, and the resistance R shall be input in the coil menu of the EF 14.

- for the potential coil PS 150:

  The constant of $1 \cdot 10^6$ A/Vs = 1000 kA/Vs that is given on the coil label is a virtual constant for the case that the coil is connected to the 0 Ω-Input of a fluxmeter that normally has an input resistance of 10 kΩ. The real coil constant k must be calculated from

  $$k = \frac{10\,\mathrm{k\Omega}}{R} \cdot 1000\,\mathrm{kA/Vs},$$

where *R* is the coil resistance that is given on the coil label or can be measured using an ohmmeter. Both *k* and *R* must be entered in the coil menu.

- for other potential coils:

  k: the constant K_{S0} as given in the coil label, in kA/Vs
  R: the actual coil resistance (from the coil label or measured using an ohmmeter)

- for moment measuring coils MS-...

  k: the constant as given on the coil label, in cm
  R: the coil resistance as given on the coil label

- for the flux etalon FE

  k: any, this input is not required for measurements in Vs
  R: the actual coil resistance (measured using an ohmmeter)

  The Flux Etalon FE is designed to generate a virtual flux of 0.01 Vs if it is connected to an input with an input resistance of 10 kΩ. The real flux can be calculated from

$$\phi = \left(1 + \frac{R}{10\,\mathrm{k\Omega}}\right) \cdot 0.01\,\mathrm{Vs},$$

  where *R* is the resistance of the coil that is incorporated in the flux etalon. It should be measured using an ohmmeter.

  If *R* is entered in the coil menu, the EF 14 should display the real flux ϕ.

- for J-compensated surrounding coils for the J coil (B-H):

  k: the number of turns as given on the coil label
  R: the coil resistance (usually 10 kΩ)

Once the data has been entered it can be saved in one of the coil data memories and called up again whenever the respective coil is to be used (see chapter 4.12.1 and 4.12.2).

4.10 Var.

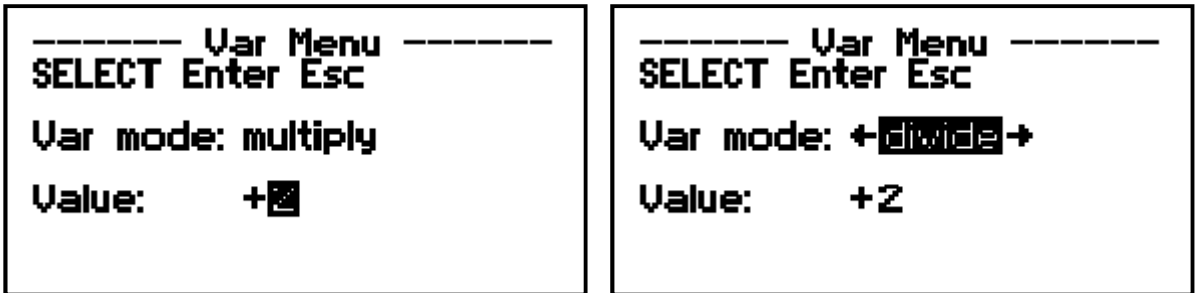


*Fig. 4.10.1: **Var.** menu (multiplication and division)*

In the **Var.** menu a variable numerical value can be set for multiplication or division of the measuring value. Input is via the numerical keypad.

The measured value is converted using the numerical value before it is displayed or send via the interface. If the **Var.** function is active, this is shown instead of the coil constant in the measuring display.

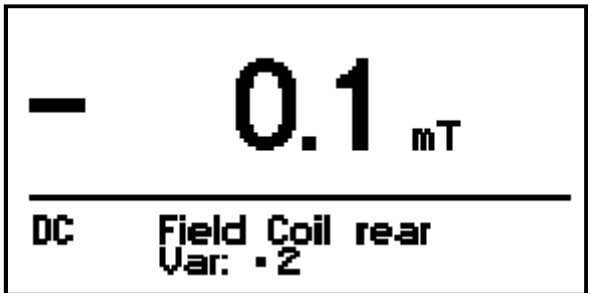


*Fig. 4.10.2: Display in measuring operation, function **Var.** switched on*

If "off" is selected for **Var mode**, the function is disabled (normal operation).

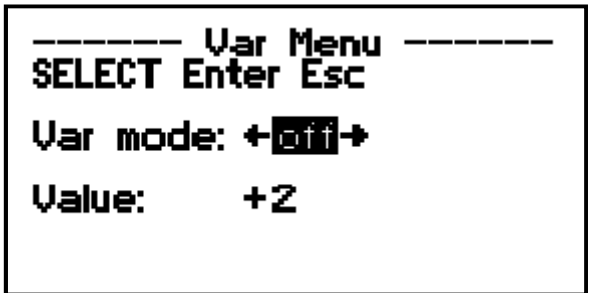


*Fig. 4.10.3: Switching off **Var.***

4.11 Measuring Data Memory

The EF 14 has a data memory that allows to store up to 100 measurements. The stored values remain in the memory even if the instrument is switched off.

To store measurements, the instrument must be in measuring operation. Any menu must be active.

Press **Enter** to store the displayed measurement. In the upper left corner of the display first the number of the memory is shown and next to this the stored value.

By pressing **Enter** repeatedly you can store further measurements. A new measurement is appended at the end of the memory list.

Previously stored values can be called up from the memory using the arrow keys (←, →). You can, independently from the current position in the memory list, append a new measurement to the end of the list using **Enter**. This value is then displayed.

To delete a measurement you must select it first with the arrow keys. Then press shortly **Delete** to erase the shown value. If you keep the **Delete** key pressed for a longer time, further values are deleted until you release the key.

If the deleted value was not at the end of the memory list, it is replaced by the value from the following memory location. Following values move accordingly.

If the unit for the measuring display is changed, then the stored values are also shown in the new unit.

Please take into account that the stored values are also recalculated if the coil constant and resistance are changed.

4.12 Mode Menu

Further menus and functions can be accessed from a selection menu that is invoked with the **Mode** key. These menus and functions are then selected with the arrow keys (←, →) and activated with **Enter**.

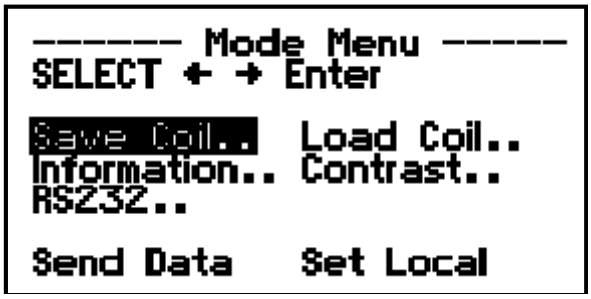


*Fig. 4.11.1: **Mode** Menu*

4.12.1 Save Coil

Using **Save Coil** you can save the data of measuring coils which do not have their own data memory in the EF 14. There are ten memory locations available for this (No. 0 – 9). Before the can data can be stored it must first be entered using the **Coil** menu.

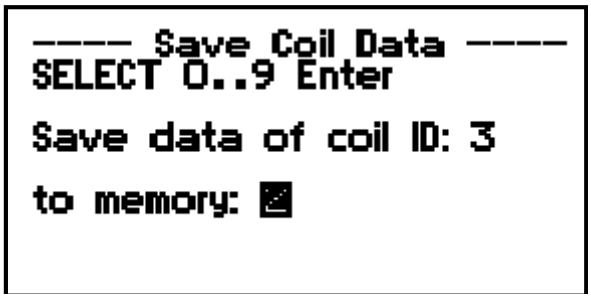


*Fig. 4.12.1.1: **Save Coil** menu.*

The coil in the example has the identification number (ID) 3. Its data will be stored to memory 2. The number of the memory is set using the respective numerical key.

If you confirm the selection with **Enter**, the data are stored and you get back to the **Mode** menu. Instead of **Enter** you can press **Mode** to start the measuring operation directly.

Data previously stored in this memory location is overwritten.

The data remains saved even when the EF 14 is switched off. It can always be loaded again with **Load Coil** when the respective coil is to be used.

4.12.2 Load Coil

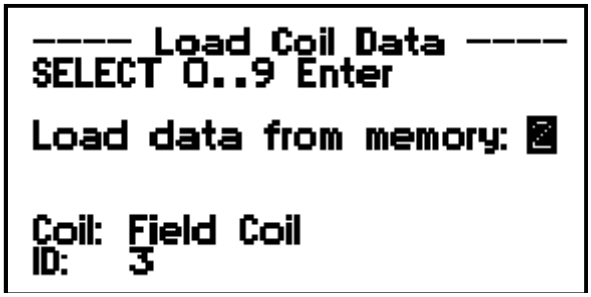


Fig. 4.12.2.1: ***Load Coil*** *menu*

The menu **Load Coil** allows loading sets of coil parameters that were previously saved using **Save Coil**. The number of the memory (0 – 9) is selected with the respective numerical key. Then the coil type and identification number (ID) are shown.

If you confirm the selection with **Enter**, you get back to the **Mode** menu. Instead of **Enter** you can press **Mode** to start the measuring operation directly.

4.12.3 Information

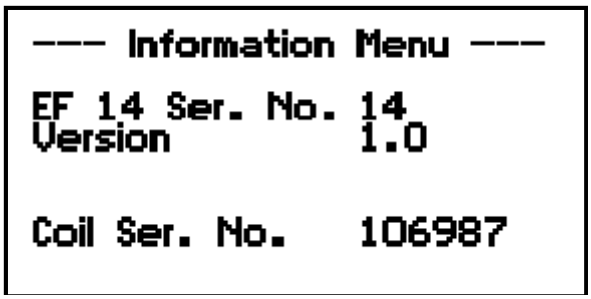


Fig. 4.4.1: ***Information*** *menu*

The **Information** menu shows the serial number of your EF 14. It must be the same as the serial number than on the label on the rear panel of the instrument. The version number of the instrument software is displayed below the Serial number.

If the serial number of the connected measuring coil is available in the data memory of the coil, it will also be shown.

4.12.4 Contrast

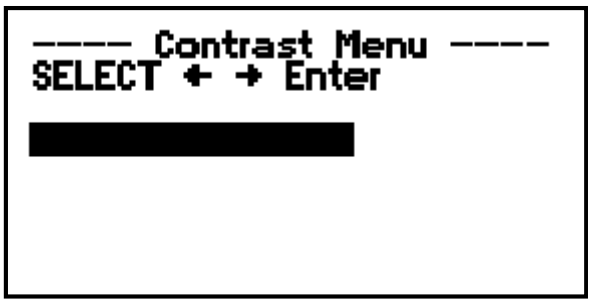


Fig. 4.12.4.1: ***Contrast*** *Menu*

In the **Contrast** menu you can adapt the contrast of the LC display to the ambient lighting conditions. Use the right arrow key (→) to achieve more contrast. Use the left arrow key (←) to achieve less contrast.

4.12.5 RS 232

*Fig. 4.12.5.1: **RS 232** menu*

The transfer speed (baud rate) for the interface can be set in the **RS 232** menu. Make sure that the same baud rate is set on the PC that will communicate with the EF 14. The other communication parameters are fixed: 8 data bits, 1 stop bit, no parity bit. The EF 14 does not support handshaking.

The interface can be accessed via the 9 pin Sub-D connector on the rear panel. The pin configuration is given in chapter 7.2.

4.12.6 Send Data

If **Send Data** is chosen in the **Mode** menu, the EF 14 starts to send continuously measurements from the computer interface. This is carried out in the same way as with the `#NMEAS` and `#MULTI` interface commands (see chapter 6.3.1), if `NMEAS` is set to 0 and `MULTI` is set to 1. If **Send Data** is active, the menu entry changes to **Stop Sending**. This can be chosen to stop the data output.

4.12.7 Set Local

As soon as the EF 14 receives a write command at the computer interface it turns into remote mode and the keypad is locked. The **Set Local** function is the only one that can be carried out from the keypad in this mode. It enables the full keypad operation again. **Set Local** has the same effect as sending `#LOCAL` to the interface.

5 Operating Information

The magnetic flux ϕ can be represented by the number of the magnetic field lines that is penetrating a defined cross-section A of a magnetic field,

$$\phi = \int_0^A B \, \mathrm{d}A ,$$

where B is the magnetic flux density. In a homogeneous magnetic field it is $\phi = B \cdot A$.

The flux cannot be measured directly but must be determined using the electric voltage to which it is coupled through one of Maxwell's equations.

When the flux changes, the electric voltage induced in a coil surrounding the magnetic flux is

$$u(t) = - N \cdot \frac{\mathrm{d}\phi}{\mathrm{d}t} ,$$

where N is the number of turns of the measuring coil. From this follows by integration

$$\phi = - \frac{1}{N} \int_{t_1}^{t_2} u(t) \, \mathrm{d}t + \phi_0 .$$

Accordingly only the flux change occurring between t_1 and t_2 can be measured. The measurement is tied on integration and thus the measuring instrument, the fluxmeter, is an integrator.

The integration constant ϕ_0 becomes zero, when the Reset key is pressed in DC operation. In AC operation the integrator is continuously discharged, a Reset is therefore not required.

5.1 Input Resistance and Coil Resistance

The electrical resistance of the measuring coil is connected in series with the input resistance of the fluxmeter. The output voltage u_a of the integrating amplifier depends on the total resistance R,

$$u_a(t) = - \frac{1}{RC} \int u(t) \, \mathrm{d}t .$$

R is the sum of the input resistance of the fluxmeter and the coil resistance.

In the past simple fluxmeters often had an input resistance of few hundred or thousand ohms, which sometimes even depended on the measuring range. With these fluxmeters it always was necessary to take the resistance of the measuring coil into account. For every coil and every range an individual correction factor had to be calculated.

Modern fluxmeters have an input resistance of 10 kΩ or 100 kΩ that is independent of the range. The input resistance of the EF 14 is 100 kΩ. The resistance of many measuring coils is

only a few ohms and can therefore be neglected. In this case the coil resistance in the coil menu can simply be set to 0. If the coil resistance exceeds about 100 Ω it should be measured and entered.

Then the EF 14 calculates the magnetic flux using the formula

$$\phi' = \frac{R + 100\ \mathrm{k\Omega}}{100\ \mathrm{k\Omega}} \cdot \phi\,,$$

where ϕ' is the flux after and ϕ the flux before resistance correction. The user can apply this formula to calculate the output voltage at the analog output.

5.2 Measurement of the Maxima of Magnetizing Impulses

Main application of the **Peak** function in **DC** mode is the measurement of the maxima of magnetizing impulses.

A magnetizing pulse is generated using a capacitor discharge. It causes a high current pulse in a connected magnetizing coil or fixture that generates the required magnetic field. The field strength can be measured with a coil.

Caution!

If a coil is exposed to fast changing, high magnetic fields, high voltages can be induced. These can destroy the coil itself or a connected measuring instrument.

The induced voltage u is calculated as follows:

$$u = -NA\frac{\mathrm{d}B}{\mathrm{d}t}\,.$$

Here are NA the area turns of the coil, B the flux density and t the time.

Thus the acceptable change of the flux density, dB/dt, is limited by the maximum input voltage of the fluxmeter, $u_{\max}$ = 60 V, and from the area turns of the coil.

The change of flux density can be approximated by the quotient of maximum flux density and rise time of the magnetizing impulse,

$$\frac{\mathrm{d}B}{\mathrm{d}t} \approx \frac{B_{\max}}{t_{\mathrm{r}}}\,.$$

From this follows for the largest acceptable area turns

$$NA < \frac{u_{\max} t_{\mathrm{r}}}{B_{\max}}$$

or for the rise time of the magnetizing pulse at given area turns

$$t_r > \frac{NAB_{max}}{u_{max}}.$$

The following table shows flux densities and area turns that are typical in magnetizing technology and the resulting limits for rise times:

B_{max}	NA	t_r
3 T	100 cm²	> 0,75 ms
5 T	100 cm²	> 1,25 ms
7 T	100 cm²	> 1,75 ms
3 T	10 cm²	> 75 µs
5 T	10 cm²	> 125 µs
7 T	10 cm²	> 175 µs

To demagnetize or stabilize permanent magnets often an alternating capacitor discharge is used, which generates sinusoidal field strength with exponentially decreasing amplitude. In this case the **Peak** function shows in large numbers the maximum of the first amplitude. The maximum of the second amplitude, which has an opposite sign, is shown below.

5.3 AC Measuring Operation

For a sinusoidal flux it is

$$\phi(t) = \hat{\phi}\,\sin(\omega t)$$

with $\omega = 2\pi f$. Here is f the frequency and $\hat{\phi}$ the amplitude of the flux.

The voltage induced by this flux in a measuring coil with N turns is

$$u(t) = -N\frac{\mathrm{d}\phi}{\mathrm{d}t} = -N\omega\hat{\phi}\cos(\omega t).$$

The amplitude of this voltage depends on the frequency of the flux.

The fluxmeter integrates the voltage that is induced in the coil. The voltage at the output of the integrator is

$$u_a(t) = -\frac{1}{RC}\int u(t)\,\mathrm{d}t = \frac{N}{RC}\hat{\phi}\,\sin(\omega t).$$

Its amplitude is particularly independent of the frequency. As every flux can be represented by a sum of sinusoidal fluxes, this is also true for a non-sinusoidal flux, as long as the frequency

range of the integrator is not exceeded and the inductance of the measuring coil can be neglected.

In **AC** RMS mode the output voltage of the integrator is supplied to an integrated circuit that generates the root mean square (RMS) of the alternating voltage. This converter requires a minimum amplitude of about 3 % of the full range limit to generate a valid reading. If the reading is below this limit this is announced by a downwards pointing arrow above the unit. Additionally the amplitude of the flux must be below the full range limit to avoid a range overflow. This means for a sinusoidal waveform that the RMS value must be below the full range limit divided by $\sqrt{2}$. If the RMS value is above this limit this is announced by a upwards pointing arrow above the unit. The RMS converter limits also the frequency response; an accuracy of ±5 % is maintained in the range of 10 Hz < f < 5 kHz.

The functions **Max./Min.** and **Peak** can also be used in **AC** mode. **Max./Min.** shows the maximum RMS.

If the peak function is enabled in **AC** mode, the EF 14 shows the peak value of the measured flux waveform (and not the peak value of the RMS). The analog peak hold circuit is active but the peak value is not digitally stored. Therefore it will follow slowly the amplitude of the waveform if this decreases. Pressing **Reset** causes fast settling to a changed amplitude.

5.4 Measuring Rate

Depending on the mode of operation, the EF 14 uses different measuring rates.

Normal operation, Peak off:

In this mode the A/D converter performs a conversion every 187 ms. The display shows the average of two subsequent measurements, thus it is actualized every 374 ms. The same values can be requested from the computer interface. The Max. and Min. values are also derived from these values and actualized in the same time interval.

Normal operation, DC, Peak on:

Peak and valley are captured by fast analog circuits that are alternating sampled by the A/D converter. The displayed values are alternating actualized, each of them every 748 ms. There is no averaging.

Fast data mode:

In this mode the A/D converter uses a faster sample rate that can be selected using the interface command `#SPEED x` (see chapter 6.3.1). The parameter x of the command determines the interval between two measurements in steps of x · 0.732 ms. Values of 254 (lowest speed, approx. 5.4 measurements per second) to 27 (highest speed, approx. 50 measurements per second) are possible. The measured values are transferred with this rate thru the interface. The normal operation can be restored with `#SPEED 255`.

The display cannot be actualized that fast and is therefore deactivated in the fast data mode. The functions **Max./Min.** and **Peak** are not available. The keypad operation is completely blocked. The operation from the digital control lines is also impossible. The fast data mode setting is not

stored if the EF 14 is switched off. After switching on the instrument is always in normal operation.

6 Remote Control

6.1 Serial Interface

The EF 14 accepts 3 different kinds of commands:

Basic commands: These commands are understood by many measuring instruments. They start with a star (*).

```
*COMMAND^C_R
```

Read commands: each read command starts with a question mark (?). Thereafter follows one of the command texts that are described below. Some commands require additionally a parameter. This must be separated from the command text by a blank.

```
?COMMAND^C_R
?COMMAND PARAMETER^C_R
```

Write commands: each write command starts with a (#). Thereafter follows one of the command texts that are described below. Some commands require additionally one or more parameters. The first parameter must be separated from the command text by a blank. If the command requires a second parameter, this must be separated from the first parameter by a comma.

```
#COMMAND^C_R
#COMMAND PARAMETER^C_R
#COMMAND PARAMETER, PARAMETER^C_R
```

The commands must be sent in capitals. The decimal separator for numbers must be a dot.

Each command must be terminated with a Carriage Return character (ASCII No. 13). This can be don e.g. by appending chr$(13) in Basic or \n in C.

The EF 14 accepts also combinations of Carriage Return (ASCII No. 13) and Line Feed (ASCII No. 10) as a valid termination of a command. In this case the line feed is simply ignored.

For nearly every command the EF 14 sends an answer after the command has been executed. Although the EF 14 can store a few commands and execute them one after the other, it is good practice to wait for the answer before the next command is sent. Each answer of the EF 14 ends with a Carriage Return, followed by a Line Feed, as long as anything else is set using the `TERM` command.

After switching on, the instrument is in Local mode, it can be operated from the keypad. As soon as the EF 14 receives a write command, the keypad operation is restricted. To enable the keypad again, the `#LOCAL` command has to be sent.

If the EF 14 receives a write command after a menu was manually accessed, the menu function is aborted and the measuring operation is started before the command is executed. An exception

is the **Drift** menu, as any write commands are accepted as long as this menu is active (see also the description of the `DRIFT` command).

6.2 Basic Commands

`*IDN?` Identification. The EF 14 answers with manufacturer name, device name, serial number and software version:

`MAGNET-PHYSIK, EF 14 Electronic Fluxmeter, xxxxxx, Vx.x`

`*OPC?` Operation complete query. The EF 14 sends a 1, after all previously received and stored commands have been processed.

`*OPT?` Option query. The EF 14 answers with the serial number of the connected measuring coil, if this has a data memory and the serial number is available. Otherwise 0 is returned.

`*RST` Empties the command queue and reinitializes the interface.

6.3 Read and Write Commands

Read commands start with a question mark, write commands with a # (see above).

6.3.1 Measuring Commands

The EF 14 can send single measurements or cyclically a series of measurements. Single measurements can be requested using the `?MEAS` command. The cyclic output is controlled by the `#NMEAS` and `#MULTI` commands. For the fast data mode (see chapter 4.4) the `#SPEED` command is used.

`MEAS` Request a current measurement. Parameter: none, 0, 1.

Read: `?MEAS`
Answer: `MEAS value unit`

Read: `?MEAS 0`
Answer: `value unit` (without MEAS)

Read: `?MEAS 1`
Answer: `MEAS value unit` (like without parameter)

Instead of a letter as prefix for the decimal power, the value is sent in exponential notation via the interface. Positive values are sent without the sign.

Example: Display reading: +123.4 mT
Answer of `?MEAS`: `MEAS 123.4E-3 T`

This representation allows an easier conversion of the strings into numbers.

If the peak function is enabled, ?MEAS returns the peak value.

NMEAS Number of values for the cyclic output.

Write: #NMEAS n n = 0: cyclic output runs unlimited
n > 0: cyclic output stops automatically after n values (max. 65535).
Answer: NMEAS n

Read: ?NMEAS
Answer: NMEAS n

MULTI Start or stop cyclic output.

Write: #MULTI 0 stop cyclic output
Answer: MULTI 0

Write: #MULTI 1 start cyclic output with counter
Answer: MULTI 1
xxxx: value unit
xxxx is a four digits hexadecimal number that gives the serial number of the value. Counting starts with 0000.

Write: #MULTI 2 start cyclic output without counter
Answer: MULTI 2
The EF 14 starts to send values in the following format:
value unit

Read: ?MULTI
Answer: MULTI n n = 0, 1, 2

SPEED Enable or disable fast data mode (see chapter 5.4)
Write: #SPEED x
Answer: SPEED x

Parameter x:
27 to 254 enable fast data mode with a distance of x · 0.732 ms between 2 readings
255 disable fast data mode

As soon as the fast data mode is enabled, the instrument starts to send data. Only numerical values are sent, without an unit. If required, the unit can be requested using ?UNIT or ?MEAS before.

During the fast data mode the EF 14 accepts any other commands despite of #SPEED and #RESET.

6.3.2 Measuring Modes

`MODE` **AC** or **DC** mode

Write:	`#MODE 0`	for AC
	`#MODE 1`	for DC
Answer:	`MODE n`	n = 0, 1
Read:	`?MODE`	
Answer:	`MODE n`	n = 0, 1

`MAX` **Max./Min.** function

Write:	`#MAX 0`	disables the function
	`#MAX 1`	enables the display of the maximum
	`#MAX 2`	enables the display of maximum, minimum and difference (available only in DC mode)
Answer:	`MAX n`	n = 0, 1, 2
Read:	`?MAX`	
Answer:	`MAX n`	n = 0, 1, 2

`MMAX` Request of maximum value

Read: `?MMAX`
Answer: `value unit`

The command returns an answer only if the **Max./Min.** function is enabled.

`MMIN` Request of minimum value, available only in DC mode

Read: `?MMIN`
Answer: `value unit`

The command returns an answer only if the display of maximum, minimum and difference is enabled.

`MDELTA` Request of the difference between maximum and minimum values, available only in DC mode

Read: `?MDELTA`
Answer: `value unit`

The command returns an answer only if the display of maximum, minimum and difference is enabled.

`PEAK` Enable or disable the **Peak** function

Write:	`#PEAK 0`	disable the function
	`#PEAK 1`	enable the function
Answer:	`PEAK n`	n = 0, 1
Read:	`?PEAK`	

Answer: `PEAK n` n = 0, 1

`MPEAK` Request of the peak value
Read: `?MPEAK`
Answer: `MPEAK value unit`

The command returns an answer only if the **Peak** function is enabled.

As the captured peak value is shown as the main value, it can also be requested using `?MEAS`.

`MVALLEY` Request of the valley value
Read: `?MVALLEY`
Answer: `MVALLEY value unit`

The command returns an answer only if the **Peak** function is enabled.

6.3.3 Instrument Functions

`RESET` **Reset** function, write only, no parameter
Write: `#RESET`
Answer: `RESET`

`DRIFT` Automatic drift correction, write only
Write: `#DRIFT 0` ends the automatic drift correction. The established correction value is applied (like **Enter** in manual operation).
`#DRIFT 1` starts the automatic drift correction

Answer: `DRIFT 1` drift correction has started
If the drift correction was started by `#DRIFT 1` the end is reported with the answer `DRIFT END`, regardless whether the function finished automatically or by `#DRIFT 0`.

When the drift correction is active, only the `#DRIFT 0` write command is accepted.

To find out, if the drift correction is still active, the `?STAT` commend can be used.

The `DRIFT` command is not available in **AC** mode.

`UNIT` Unit of the measured values, available parameters (0...27) depend on coil type.

Write: `UNIT x` (x = 0...27)

0	Vs	magnetic flux in Volt · Seconds for all coils
2	Vs cm	magnetic dipole moment for moment coil

5	Wb	magnetic flux in Weber for all coils
8	T	magnetic flux density in Tesla for field coil
10	G	magnetic flux density in Gauss for field coil
13	A/m	magnetic field strength in Ampere pro Meter for Field Coil
16	Oe	magnetic field strength in Oersted for Field Coil
18	A	magnetic potential in Ampere for Potential Coil
21	Vs/n	magnetic flux per turn for Surrounding Coil
22	Wb/n	magnetic flux per turn for Surrounding Coil
23	Mx/n	magnetic flux per turn for Surrounding Coil
24	Mx	magnetic flux in Maxwell for coils
25	Vsm	magnetic dipole moment for Moment Coil
26	Am²	magnetic moment for Moment Coil
27	Gb	magnetic potential in Gilbert for Potential Coil

Answer: `UNIT x` (x = 0...27)

The settings for other than the listed parameters values are not defined.

If a parameter that is not valid for the selected coil is sent, then the EF 14 switches to Vs.

`RANGE`

Write: `#RANGE x` Measuring range: x = -4, -5, -6, -7 (for the ranges 10^{-4} to 10^{-7} Vs)
Answer: `RANGE x` x = -4, -5, -6, -7

Read: `?RANGE`
Answer: `RANGE x` x = -4, -5, -6, -7

`VAR`

Var. function

Write:	`#VAR 0`	disable function
	`#VAR *x`	multiply the measured value by x
	`#VAR /x`	divide the measured value by x
Answer:	`VAR NONE`	function disabled
	`VAR *x`	the measured value is multiplied by x
	`VAR /x`	the measured value is divided by x

Read: `?VAR`
Answer: the same as for Write.

`MEM`

Request data from the measured data memory, parameter x: number of the memory cell
Read: `?MEM x`
Answer: Value of the memory content, if the memory cell is occupied, otherwise “void”.

6.3.4 Limit Commands

`LIMIT` enable and disable limit function

Write: `#LIMIT 0` disables the function
`#LIMIT 1` enables the function
Answer: `LIMIT x` (x = 0, 1)

Read: `?LIMIT`
Answer: `LIMIT x` (x = 0, 1)

`LMODE` mode of the limit function

Write: `#LMODE 0` absolute
`#LMODE 1` +/-
Answer: `LMODE x` (x = 0, 1)

Read: `?LMODE`
Answer: `LMODE x` (x = 0, 1)

`LVAL` Write and Request limit values, parameter `x`: upper limit, `y`: lower limit

Write: `#LVAL x, y`
Answer: `LVAL x unit, y unit`

If a value for the upper limit is sent that is lower than the value for the lower limit, the EF 14 exchanges the values.

The unit needs not to be sent in the write command. The EF 14 expects the values in the actual basic unit without prefix (e.g. in T, not in mT; to set 1 mT send 0.001).

Read: `?LVAL`
Answer: `LVAL x unit, y unit`

`LSTAT` Limit status, for request only

Read: `?LSTAT`
Answer: `LSTAT LOW`
`LSTAT OK`
`LSTAT HIGH`

The command returns only an answer if the **Limit** function is switched on.

6.3.5 Coil Data Commands

`COIL` Coil type, possible parameters: 0 … 6

0 for Field Coil
1 for Surrounding Coil
2 for Moment Coil
3 for Potential Coil

4 for Pole Coil
5 for Flux Etalon
6 for Integrator Mode

Answer: `COIL x` (x = 0...6)

Read: `?COIL`
Answer: `COIL x` (x = 0...6)

For compatibility with the EF 5, the EF 14 accepts instead of the command `COIL` as well the command `DEVICE`.

`CONST` Coil constant

Write: `#CONST x` x: numerical value 0.000001 ≤ x ≤ 90000000

Depending on the coil type, the following unit for the coil constant is assumed:

cm²	for Field Coil (area turns, winding area)
no unit	for Surrounding Coil (number of turns)
cm	for Moment Coil (measuring constant)
kA/Vs	for Potential Coil (measuring constant)
cm²	for Pole Coil (area turns, winding area)

The parameter must be converted into the required unit, if necessary. It is not necessary to send the unit to the EF 14.
The coil types 5 and 6 do not require a constant.

Answer: `CONST x`

Read: `?CONST`
Answer: `CONST x`

`OHM` Coil resistance in Ohm, parameter: number ≥ 0, max. 90000000
Write: `#OHM x`
Answer: `OHM x`

Read: `?OHM`
Answer: `OHM x`

`ID` Coil identification number, Parameter: number ≥ 0, max. 9999
Write: `#ID x`
Answer: `ID x`

Read: `?ID`
Answer: `ID x`

6.3.6 Interface Commands

`LOCAL` Enable the keypad again after it has been disabled by a write command

Write:	`#LOCAL`	without parameter: keypad enabled.
Answer:	`LOCAL 1`	
Read:	`?LOCAL`	
Answer:	`LOCAL 0`	Remote mode (keypad disabled)
	`LOCAL 1`	Local mode (keypad enabled)

The Remote mode is automatically enabled when the EF 14 receives any write (#) command.

`TERM` Terminator that the EF 14 uses to terminate an answer

Write:	`#TERM 0`	Terminator Carriage Return
	`#TERM 1`	Terminator Carriage Return and Line Feed
Answer:	`TERM x`	x = 0, 1
Read:	`?TERM`	
Answer:	`TERM x`	x = 0, 1

`CLR` Sets all user settings, which remain stored when the EF 14 is switched off, back to default values. Write only (`#CLR`), no parameter

The default settings are:

Coil:	Field Coil
Unit:	Vs
ID:	0
k:	1
R:	0
Range:	10^{-4}
Max./Min.	off
Peak	off
Limit	off
Limit-Modus	absolute
Upper limit	0
Lower limit	0
AC/DC	DC
Var.	off
Var.-Wert	1
Contrast	mid setting
Drift	mid setting
Memory	erased
Coil data memory	erased
NMEAS	0
Baud rate	9600

	Terminator	Carriage Return and Line Feed

`STAT` Instrument status, Read only (`?STAT`), the following answers can appear:

`STAT WAIT`	The instrument is not yet ready for measurement.
`STAT DRIFT`	Drift function is running.
`STAT INACT`	The instrument cannot send a measurement, e.g. if a menu is activated in manual operation.
`STAT OK`	The instrument is ready for measurement.

`BAUD` Baud rate, write only (`#BAUD x`) **.**
The communication is interrupted after changing the baud rate and must be re-initialized from the computer. Therefore the command does not return an answer.

`UPD` Update, write only (`#UPD`) **.**
Forces the display content to be redrawn.

7 Pin Assignments of Plugs and Sockets

7.1 Measuring Coil Connections

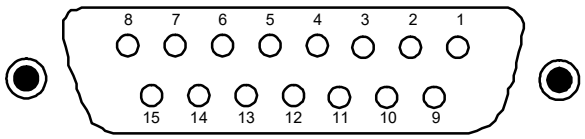
Important!

Only one measuring coil must be connected at one time, either to the socket on the front panel or to the clamps on the rear panel. If both connections are used at the same time, this will cause faulty measurements.

Caution!

The negative measuring input (-) is only designed for the connection of a measuring coil. It must not be tied to ground or earth or used otherwise.

7.1.1 Input Socket on the Front Panel



Plug side

DB15 socket

Table 7.1.1.1: Assignments of the 15-pole Sub-D socket

PIN	Function
1	Measuring input +
2	Reserved
9	Measuring input -
10	Reserved
11	Digital ground
12	Reserved
13	Reserved
14	Reserved
5	Reserved
4	Coil attached = Digital Ground
8	PE

Important!

A connection between pin 4 and pin 11 tells the EF 14 that a measuring coil is attached to the input socket on the front panel.

7.1.2 Pole Clamps on the Rear Panel

Table 7.1.2.1: Assignments of the pole clamps

Color	Function
red	Measuring input +
black	Measuring input -

The pole clamps can be used to connect measuring coils with bunch or banana plugs or to clamp the coil wire directly.

7.2 RS 232 Interface

Table 7.2.1: Assignments of the 9-pole Sub-D plug on the rear panel

Pin	Function	Signal direction
2	RxD, received data	input
3	TxD, transmit data	output
4	DTR, data terminal ready	output
5	Digital ground	

The RS 232 interface can be fully operated by connecting only the following 3 wires: TxD, RxD and digital ground. TxD of the EF 14 must be connected to the RxD pin on the computer side. RxD of the EF 14 must be connected to the TxD pin on the computer side. A null-modem cable can be used.

The DTR pin is not actively controlled. It goes to high potential as soon as the EF 14 is switched on. CTS/RTS handshake is currently not supported.

7.3 Multi-functional Socket

Table 7.3.1: Assignments of the 25-pole Sub-D socket

Pin	Function
1	Low limit relay, normally open
2	Low limit relay, center contact
3	Low limit relay, normally closed
4	High limit relay, normally open
5	High limit relay, center contact
6	High limit relay, normally closed
7	Digital ground
8	Reserved, do not connect!
9	Digital Input/Output, reserved for future use
10	Digital ground
11	Digital ground
12	Digital ground
13	Digital output, ready for measurement
14	Auxiliary analog output, AC RMS
15	Analog ground
16	Auxiliary analog output, ±5 V
17	Analog ground
18	Analog output, ±1 V
19	Digital ground
20	Digital ground
21	Digital ground
22	Digital input, Drift
23	Digital input, Reset
24	Digital input, Hold
25	No connection

7.3.1 Limit Relays

If the limit function is disabled or if the measured value is below the limit the normally closed contact is connected to the center contact. If the limit is exceeded the normally open contact is connected to the center contact.

Attention!

Maximum values for the relay contacts: Voltage u_{max} = 30 V
Current: i_{max} = 1 A

7.3.2 Digital Control Lines

Using the digital control lines, some functions of the EF 14 can be remotely controlled by switches, relays or TTL lines. The functions are activated by pulling the respective line low (active low).

Attention!

The maximum input voltage for the digital inputs is 5.5 V.

Assignments of the inputs:

Pin 24: HOLD Holds the momentary reading in the display. The integrator continues to operate.

Pin 23: RESET **Reset** function. It sets the displayed value as well as Max., Min., and Peak back to zero.

Pin 22: DRIFT **Drift** function: If this pin is pulled to ground for a short time, the automatic drift correction starts. After that, the pin must be left open or set to high again, to prevent the drift correction from starting again after ending. A request, if the drift correction is still active, can be carried out using the ready output (pin 13).

The status of the EF 14 can be requested using Pin 13:

Pin 13: HIGH The instrument is ready for operation:
LOW The instrument is currently not measuring. For example a menu is activated in manual operation or the drift correction is running.

7.3.3 Analog Outputs

The analog output of the EF 14 is a real analog, real-time output. The main analog output can be accessed on pin 18. It is scaled in Vs, the coil resistance is not taken into account. Particularly in the integrator mode, one digit in the display corresponds to 0.1 mV output voltage. An output voltage of ±1 V is achieved, if the range limit (±9999 digits) is exceeded.

The EF 14 has two other analog outputs, than are mainly designed for service purposes, but may also be used by the operator.

Auxiliary analog output, ±5 V, pin 16: This output supplies a voltage that is amplified by a factor of 5, compared to the main output. It can be used for example to connect the output of the

EF 14 to low sensitivity data acquisition systems. The voltage range for a valid output is limited to about ±4.9 V. The auxiliary output can have a considerable offset voltage of several millivolts. Therefore it is recommended to measure the offset voltage during a reset and subtract it from the voltage that is obtained during the measurement.

Auxiliary analog output AC-RMS, pin 14: This output supplies a voltage that is a function the RMS value in AC mode. The RMS value is proportional to u_{out} - 2.5 V. The measurements are valid in an output voltage range between approximately 2.525 V and 4 V.

8 Maintenance

8.1 Maintenance Plan

WHAT?	WHEN?	WHO?
Checking the instrument and the accessories for damages	monthly	Operator
Calibrating the instrument and accessories	e.g. once a year or every two years	Manufacturer or authorized calibration laboratory

The checks shall be periodically repeated and documented.

8.2 Checking for Damage

The EF 14 and all accessories must be checked once a month for damages. If any of the components, in particular the instrument housing or a measuring coil are damaged, the device must only be used if it has been cleared for operation by an authorized person. The damaged parts shall be replaced or sent to the manufacturer (Magnet-Physik) for repair as soon as possible.

8.3 Calibration

Only regular calibration ensures accurate and reliable measuring results.

The EF 14 and the accessories should be calibrated using suitable references normally once a year. We recommend having this calibration carried out by the manufacturer (Magnet-Physik) or an authorized calibration laboratory.

8.4 Troubleshooting

1. Fault: The instrument cannot be switched on.

⇒Measure: Check if the line power socket used has current and if both ends of the power cable are properly plugged in.

If this is the case, check the line fuse. Remove the power cable and open the small cover below the power switch to gain access to the fuse. Check the fuse using an Ohmmeter or a line tester. Do not rely on a visual test alone.

If the fuse has blown, replace it by a new fuse. The required type and rating is given on a label next to the fuse holder. Only use the rated type. If an unsuited fuse is used or the fuse is bypassed, there is an increased risk of fire!

2. Fault: No test result is displayed.

⇒Measure: If no measurement is displayed although the measuring coil is exposed to a changing magnetic field, first check the settings of **AC/DC**, **Range**, **Coil** and **Var**. The AC mode can only measure periodically alternating flux.

Then check the measuring coil with an Ohmmeter for wire failure.

3. Fault: The instrument is showing excessive drift that cannot be compensated using the drift function.

⇒Measure: Make sure that the input connector of the EF 14 and the plug of the coil have the same temperature. Check if the coil wire is insulated from ground, shield or other voltage potentials. Check the measuring coil with an Ohmmeter for wire failure.

8.5 Taking Out of Operation

Switch the device off and store it in a safe place under suitable environmental conditions to allow future reuse. It is advisable to register the date of the last operation.

Important!

To prevent any possible environmental pollution or violation of environmental regulations, only a specialized company should carry out disposal.