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MAGNETIC FIELD METER 3000

Operator's Manual

The MFM 3000 is a professional magnetic field instrument

To make the best use of the instrument we recommend that you read this manual carefully.

COMBINOVA AB

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Section 1 - INTRODUCTION

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1.1 Magnetic Fields

Increasing use of electrical equipment has meant that there is increased exposure to low frequency magnetic fields. This has led to concern that a health hazard could arise from these low frequency magnetic fields. The largest magnetic fields are found around:

- Power transmission lines and power supply installations
- Induction heating equipment
- Electric welding
- Demagnetizing equipment
- Electrical furnaces
- Industrial electrolysis
- And others

Magnetic fields from power lines are directly related to the phase current. Seasonal and daily variations are caused by different power consumption demands. Close to the power line the magnetic flux can reach a maximum of 10 to 30 µT, but decreases to less than 1 µT at distances of 50 to 200 meters.

The earth magnetic field is a DC field of around 50 µT with rather small variations in time. The MFM 3000 instruments have a lower frequency limit of just 5 Hz and movement of the instrument in the earth magnetic field will result in low frequency alternating magnetic field components. To avoid that type of influence on the magnetic field measurements, especially at low levels of the magnetic field**, it is important to keep the instrument fixed during measurements**.

Based on the latest research reports regarding possible health effects from exposure of electromagnetic fields the international organization ICNIRP has issued guidelines for limiting human exposure.

ICNIRP has published the following documents:

- **Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields up to 300 GHz (April 1998)**
- **Guidance on determining compliance of exposure to pulsed and complex non sinusoidal waveforms below 100 kHz with ICNIRP guidelines, (March 2003)**
- **Guidelines for limiting exposure to time varying electric and magnetic fields (1Hz to 100 kHz) (December 2010)**

The 1998 guidelines are suggesting two exposure limits or reference levels where there is no risk for any health hazard. The first set of limits is for general public exposure and the second set of limits is for occupational exposure.

EU has issued a **Recommendation on the limitation of exposure of the general public to electromagnetic fields (0 – 300 GHz).** This recommendation is based on ICNIRP´s guidelines from 1998 and is using the same limits as ICNIRP Public. A number of standards are also referring to the ICNIRP 1998 Public limits as:

- EN62233 Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure
- EN 50500 Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure
- EN 62110 Electric and magnetic field levels generated by AC power systems – Measurement procedures with regard to public exposure

EU has published a directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents

(electromagnetic fields). This directive states that there are two types effects on human tissue caused by exposure for EMF:

- Thermal effects, such as tissue heating through energy absorption from electromagnetic fields in the tissue. Thermal effects prevail in the frequency range from 100 kHz to 300 GHz.
- Non-thermal effects, such as the stimulation of muscles, nerves or sensory organs. Non-thermal effects prevail in the frequency range from 1 Hz to 10 MHz. Moreover, the stimulation of sensory organs may lead to transient symptoms, such as vertigo or phosphenes. These effects might create temporary annoyance or affect cognition or other brain or muscle functions, and may thereby affect the ability of a worker to work safely (i.e. safety risks)

ICNRP´s reference levels and the directive´s Action Levels are all considering the immediate effects on human exposure for EMF. There are no scientific findings on long term effects but WHO has formulated a precautionary principle to reduce the exposure levels when it can be achieved to reasonable cost and consequences.

Magnetic fields in the home and the working environment are caused both by internal and external sources. Typical external sources are power line and power distribution substations close to buildings, while even water pipes, when carrying unbalanced neutral currents create significant magnetic fields. Internal sources are the variety of household appliances that at user distance can have relatively strong magnetic fields. Since February 1, 2006 all household appliances needs to meet the standard IEC 62233 to get the CE mark needed for sales in the European Union.

1.2 The Instrument

The Magnetic Field Meter 3000 (MFM 3000) is a professional instrument designed to measure magnetic fields in two measuring modes:

- Time Domain Mode in the frequency range from 5 Hz to 150 kHz. with peak detection
- Frequency Domain Mode in the frequency range from 5 Hz to 400 kHz with a full bandwidth real time spectrum analysis to provide detailed information about the magnetic field.

MFM 3000 has been developed for self-contained operation with such features as built in rechargeable batteries, LCD touch panel display, PC communication using a USB 2 interface and a large data logging memory.

MFM 3000 is a flexible general purpose magnetic field instrument and it also has built in evaluation to:

- ICNIRP 1998 limits for general public exposure
- ICNIRP 2010 limits for occupational exposure
- IEC 62233 (equal to EN 62233) exposure limits for electric household appliances (identical to ICNIRP 1998 Public limits)
- European Directive 2013/35/EU Action Level Low (identical to ICNIRP 2010 Occupational limits.

With its flexible digital design the MFM 3000 is well prepared for easy upgrade to future standards concerning magnetic field measurements.

The MFM 3000 instrument is designed using the latest technology in amplifiers, AD-converters and signal processors to achieve the best measurement performance.

The user interface is mainly handled by the graphic LCD-display that has a touch panel to select the type of

measurement, display settings and to define the parameters controlling measurements and related functions. Two push buttons are used. Power ON/OFF and START measurement.

The instrument has a large memory bank to store test results and to provide possibilities for manual or automatic logging of test results. The internal clock displays date and time in the upper left corner and provides time information for logged data.

External communication to a PC is handled by the USB 2 interface and the PC software handles a variety of applications including remote control for laboratory use and handling of logged data for field applications.

1.3 Combinova AB - The company behind the product

Magnetic Field Meter 3000 has been developed by Combinova. We are also responsible for the manufacturing, marketing and after sales service of the instrument.

Combinova has been making instruments for magnetic and electric field measurements for the last 25 years. Other products in this product family are:

MFM 2000 - Magnetic Field Meter, dual band 5 Hz – 2 kHz and 2 kHz – 400 kHz with spectrum analysis for TCO testing applications.

EFM 100 - Electric Field Meter for alternating electric fields in two bands 5 Hz – 2 kHz and 2 kHz – 400 kHz.

FD 1 – Field Detector for magnetic and electric fields in the frequency range 20 Hz – 2 kHz.

FD 2 - Field Detector for magnetic and electric fields in the frequency range 2 kHz – 400 kHz.

FD 3 – Field Dosimeter for logging of magnetic fields in the frequency range 20 Hz – 2 kHz.

More details about these products are available at www.combinova.se

SECTION 2 - UNPACKING AND INSPECTION

The MFM 3000 is delivered in a specially designed transportation case, which also contains the standard accessories that are used with the instrument.

Open the case and check that the following items have been supplied.

Standard Instrument 14-01

- MFM 3000 instrument
- Universal Battery Charger
- USB Communication Cable
- CD with PC Software
- Calibration Certificate
- Operator's manual / PC Software manual

For 14-02 MFM 3000 separate probe version and 14-12 MFM 3000H High field separate probe version the following items also shall be included.

- Antenna
- Cable for connecting the antenna to the instrument

Inspect the transportation case, the instrument and the accessories for any damage caused during transit. If damage has occurred, please contact the shipping company who delivered your instrument.

IMPORTANT! Complete the warranty form and return a copy to:

Combinova AB
Domkraftsvägen 1
S 197 40 Bro
Sweden

NOTE! Before switching on the instrument, read this manual carefully.

Section 3 - OPERATING INSTRUCTIONS

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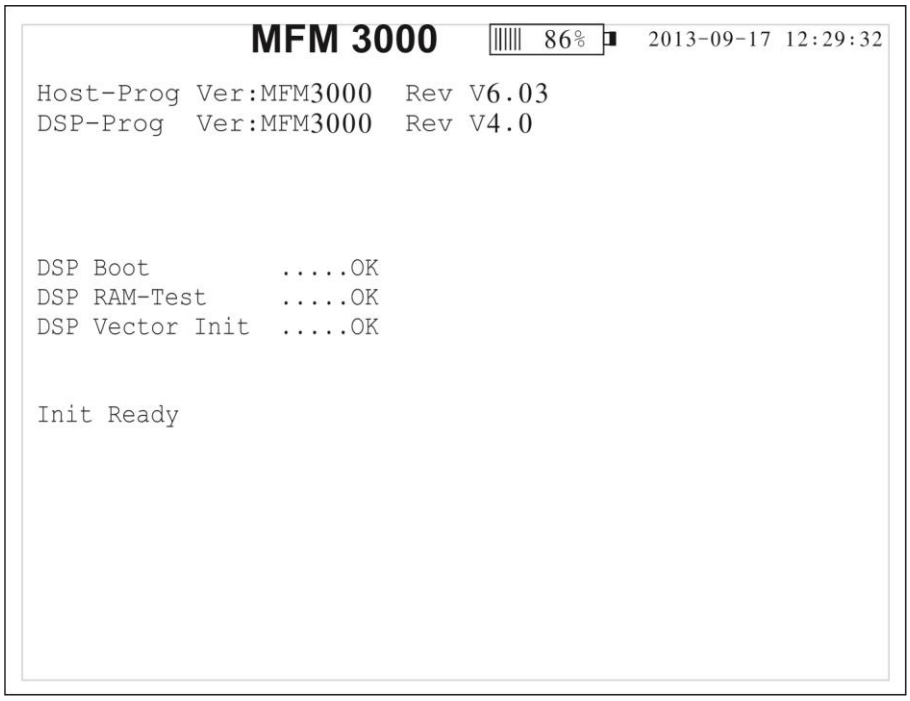
3.1 General Operation

The instrument is operated by the ON-OFF button and the MEASURE button on the front panel. All other settings are handled by menus on the touch panel.

ON-OFF

To turn on the instrument is turned on by pressing the ON-OFF button on the front panel until the display is lit up. After power on a start up display is shown with program versions and some initial tests. The initial tests shown on the display are:



When tests are completed it shows the text “Init Ready” and automatically moves to the measurement display selected last time the instrument was used.

To turn off the instrument depress the ON-OFF button for a few seconds and wait for the display to turn off.

MEASURE

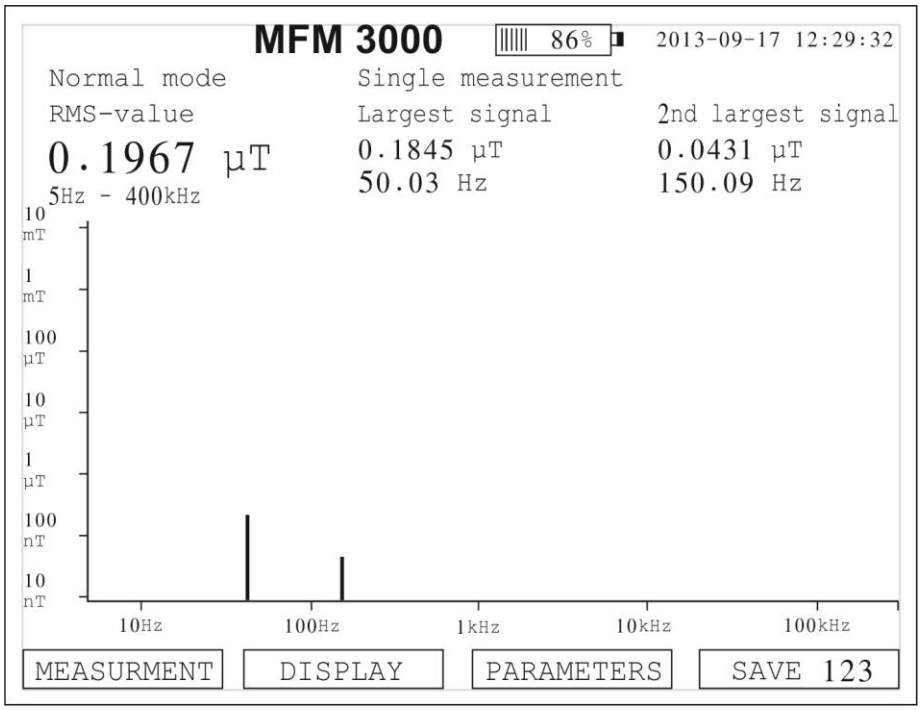
The measure button is used to start a single measurement. If the button is depressed until the single measurement is completed a **continuous measurement** is started and keeps on running until the measure button is depressed again. After stopping a continuous measurement the last result is shown on the display.

The instrument can also be set up to make logging measurements at predefined time intervals. Selection of logging and time intervals is made in the **parameter menu**. When logging measurements are selected or in progress the measure button or the touch panel is used to start and stop the logging operation. For more details about logging measurements see 3.4 Parameters.

TOUCH PANEL

The display is also a touch panel where all selections and settings in the instrument can be made.

To calibrate the coordinates on the touch screen keep the “MEASURE” button depressed at power on until you to get into the calibration function. A screen with a square in the upper left and another square in the lower left corner will appear. Mark the upper left corner with the pointer and keep it there until the instructions on screen asks you to mark the lower right corner. Keep the pointer on the square until the screen reports calibration ready. Wait for the saving of calibration data. The instrument will automatically return to the measurements after the calibration is completed. This calibration procedure can be repeated at any time if the positions of different screen selections are changing.
After the instrument has been turned on you three menus will be presented at the bottom line of the display.



The three menus are:

”MEASUREMENT” menu contains selections of different measurement modes. They are described separately in chapters 3.2

”DISPLAY” menu contains the selection of time or frequency domain measurement modes. Details are described in chapter 3.3.

”PARAMETERS” menu contains all other instrument settings. Details are described in chapter 3.4.

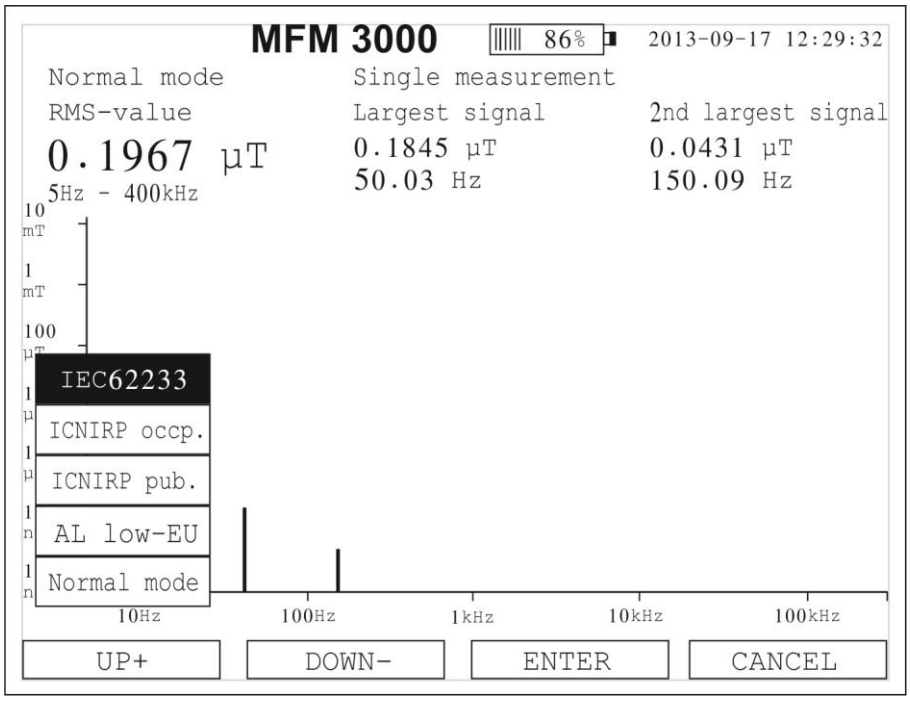
”SAVE X” is a function key that saves the last measurement. X is the number of the results that will be saved when activated. If no measurement has been done or the data is already saved the response when attempting to save is “NO DATA”. You cannot save data from continuous measurements. The memory can handle up to around 7,000 sets of data including results and spectra. When automatic logging is selected the same key is changed to “START X” and “STOP X” and is used to start and to stop logging operation. The measure button also can be used

to start and stop logging.

To enter a menu, use the touch panel pointer to enter the menu.

3.2 Measurement

The available selections are shown when a menu is selected and the text for the current selection is shown inverted (white text on a black background).



As soon as a menu is selected a new line of keys will appear at the bottom part of the display. These keys and their functions are:
”UP +” key is used to move up among available selections in the menu or to increase the setting of a variable.

”DOWN –“ key is used to move down among available selections in the menu or to decrease the setting of a variable.

Pointing directly at a selection in a menu is also possible.

”ENTER” key is used to confirm a selection and if there are available sub-menus they will appear after confirming the first selection until all related selections are made.

”CANCEL**”** key is used to leave a menu without changing of any selections or settings.

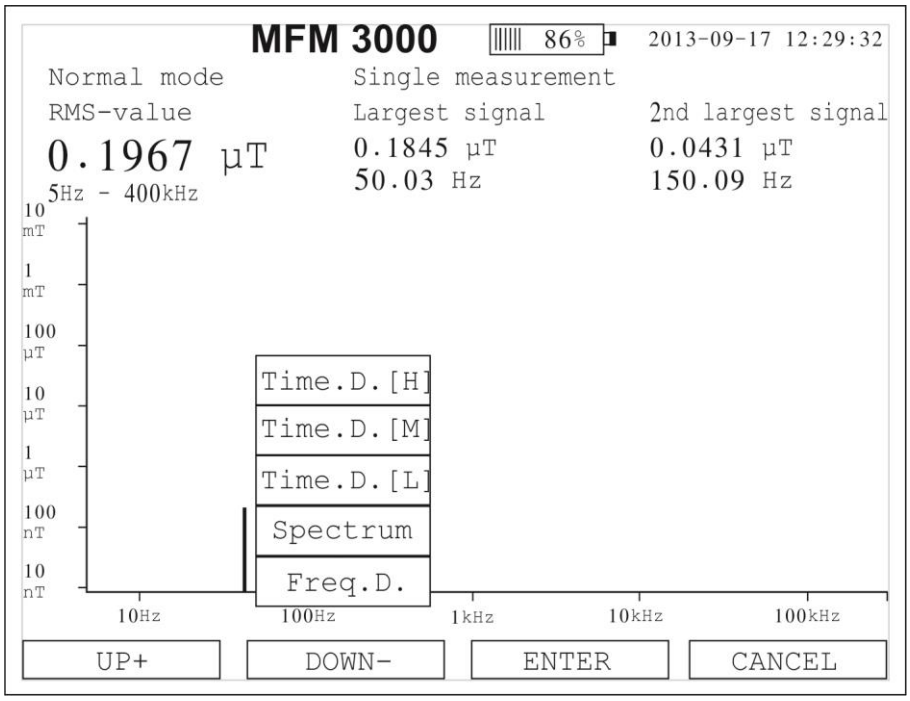
Available selections are

- **IEC 62233** which is equal to EN 62233 (and equal to ICNIRP reference levels for **Public** exposure1998)
- **ICNIRP occp.** - reference levels for occupational exposure from Guidelines 2010
- **ICNIRP pub.** - reference levels for public exposure from Guidelines 1998
- **AL Low-EU** - action levels low from EU directive 2013/35-EU (Equal to ICNIRP reference levels for **Occupational** exposure 2010)
- **Normal** or flat frequency response.

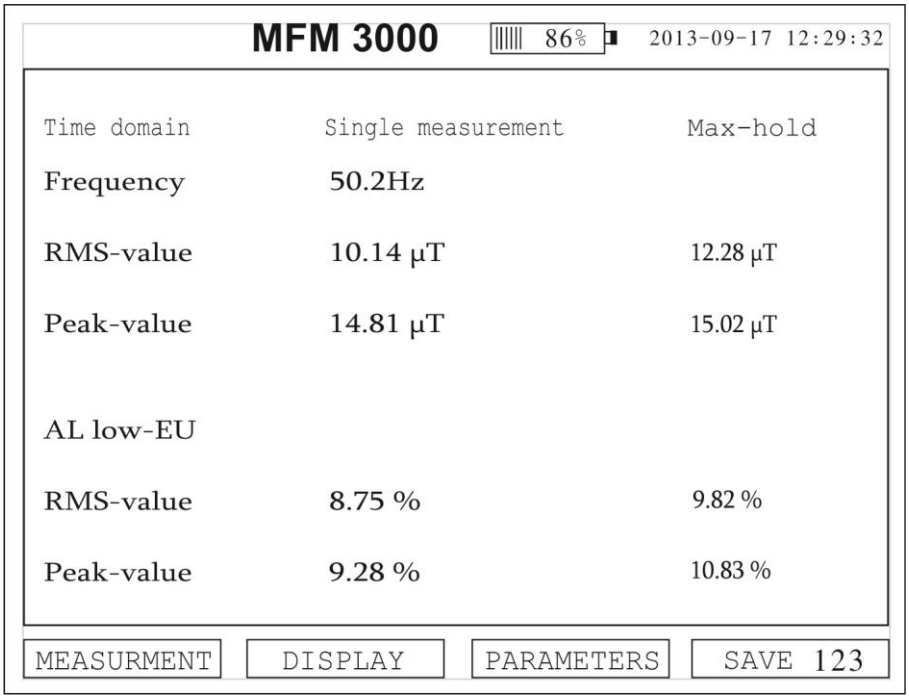
3.3 Display

In the “Display” menu you can select between:

- Time.D.[H]. (Time Domain) 2µT-250µT/10mT$_{RMS}$
- Time.D.[M]. (Time Domain) 200nT-25µT/500µT$_{RMS}$
- Time.D.[L]. (Time Domain) 20nT-2.5µT/500µT$_{RMS}$
- Spectrum (Frequency Domain) 10nT-250µT/10mT$_{RMS}$
- Freq.D. (Frequency Domain) 10nT-250µT/10mT$_{RMS}$



Time Domain measurements present the following data from each measurement.



Frequency – the dominating frequency is presented. If the frequency is not stable or several frequencies are competing this is presented as **Mixed.** If

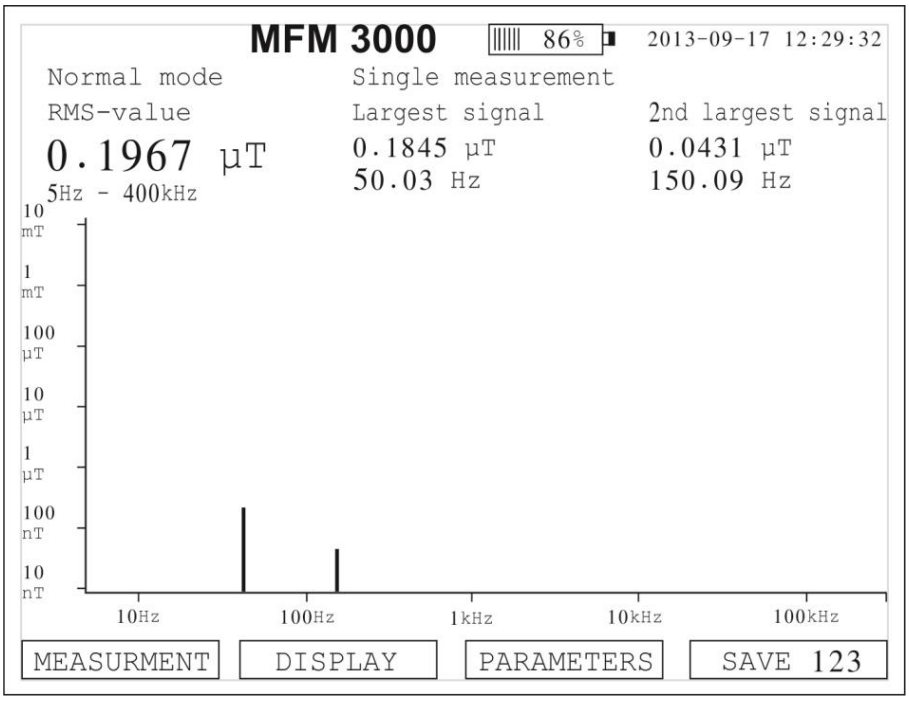
	the signal is too low to identify a dominating frequency, this is presented as **Noise**
RMS-value	In the left column the RMS value in Tesla is presented. In the right column is the max hold RMS-value presented if you are doing a continuous measurement. When you stop the continuous measurement the value will remain on screen until your next measurement. If you are doing single measurements max hold will be equal to the measurement.
Peak-value	The peak value and max hold value are presented in Tesla

If an exposure limit is selected under the measurement menu this will be displayed which limit selected.

RMS-value %	In the left column the RMS-value is presented in % of the limit. In the right column the max hold value is presented.
Peak value %	In the left column the peak value is presented in % of the limit. In the right column the max hold value is presented.

Spectrum

The next choice is to present the result in a spectrum graph. This is a frequency domain mode.



In the spectrum graph in the upper left corner the selection of limits are presented. In this example Normal mode or no limits is selected.
On top of the y-axis the selected band width are presented. Above the band width the broad band value in Tesla is presented. The two largest frequency components are also presented with amplitude and the frequency.
The spectrum graph is presenting all frequency components.

To enable you to look at different parts of the full spectrum there is a sub-menu under “Spectrum” with a choice of five different ways to zoom in the spectrum.

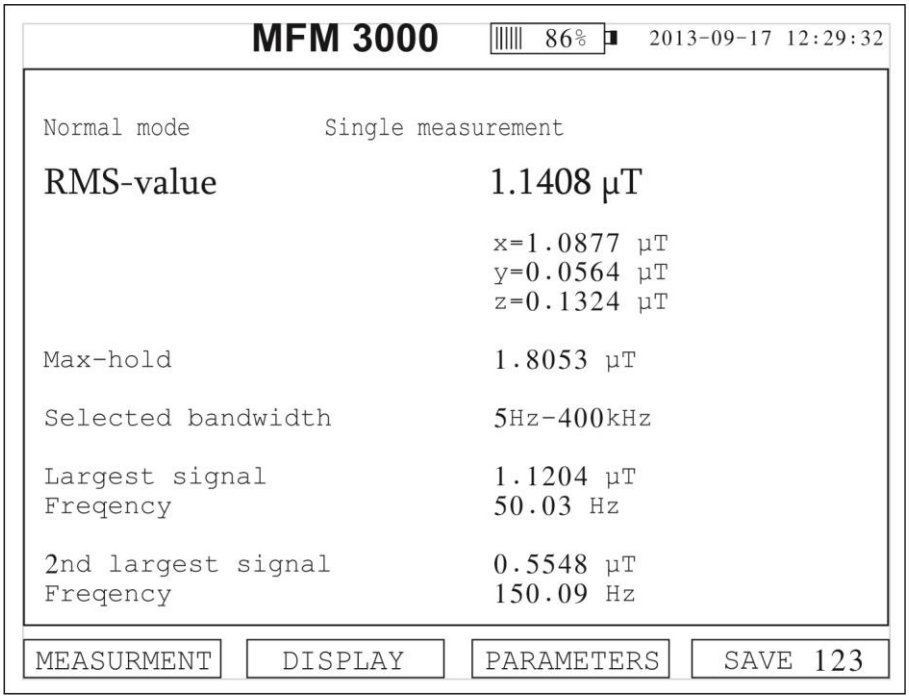
The choices are:
no zoom (5 Hz – 400 kHz) with logarithmic frequency scale
5 Hz - 400 Hz with linear frequency scale
100 Hz - 4000 Hz with logarithmic frequency scale
1 kHz - 40 kHz with logarithmic frequency scale
10 kHz - 400 kHz with logarithmic frequency scale

Please note that the RMS-value will show the field strength for the total bandwidth and are not influenced by the zooming. The

largest and second largest signal refer to the selected zooming interval.

Freq. d.

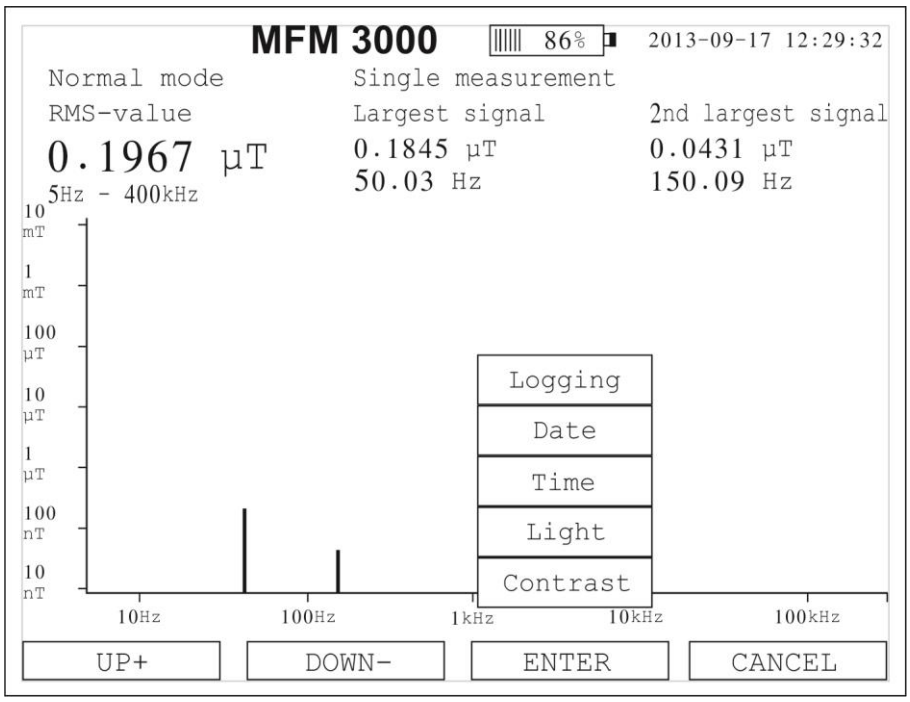
The last choice is presenting a frequency domain measurement in a numerical display.



Compared to the spectrum graph display the RMS-values for each of the x-, y- and z-axis are presented in Tesla and the max-hold values are presented. The max-hold value is updated in continues measurement, it will be cleared by the next measurement. Please note that the numerical display is not indicating that the measurements have been done in frequency domain.

3.5 Parameters

The parameter menu is used to define settings in the instrument.



Below is a detailed description of the different settings and their function.

Logging

The logging menu defines possibilities to perform automatic measurements at predefined time intervals from start of logging.

The selections in the logging menu are:
”No logging” means that the automatic logging function is disabled. Time intervals that can be chosen are: 2s, 5s, 10s, 20s, 30s, 1min, 2min, 5min, 10min, 20min, 30min and 60min.

When a time interval from this list is selected the bottom right key changes from “Save X” to “Start X” indicating that this key now is used to start a logging session. During logging the “X” value indicates the number of measurements stored in the instrument. Once a logging is started the bottom right key is

changed to ”Stop X” and is now used to stop the logging session. The measure button also can be used to start and stop logging.

The logging function is possible for all measurements modes defined in the measurement menu. Logging results from a frequency domain mode measurement consist of a measurement values and a spectrum with the zoom setting selected. More details about the stored results can be found in the MFM 3000 software manual.

The logging function can be disabled by selecting “no logging” in the menu. After a power off the instrument always starts with the logging function disabled.

NOTE! **Use charger when logging for more than 10 hours.**

Date and Time

The parameter Date is used to set the date in the internal clock. Use “UP +” and “DOWN –“ keys to set the correct Year and confirm the setting with the “ENTER” key. Use the same procedure for Month and Date settings.

The parameter Time is used to set the time in exactly the same way by setting the correct Hour (24 hour clock), Minute and Second.

Light

The Light parameter is used to set the background light of the display in steps from 0 (no background light) to 255 (maximum background light). Use “UP +” and “DOWN –“ keys to set the light wanted and confirm the setting with the “ENTER” key. Background light is turned off after 60 sec of inactivity in order to save battery. A short touch anywhere on the screen or a new

measurement activates the background light for another 60 sec.

Contrast

The Contrast parameter is used to set the contrast of the display in steps from 0 to 75. Use “UP +” and “DOWN –“ keys to set the best contrast for the used viewing angle and confirm the setting with the “ENTER” key.

3.6 Measurements in time domain vs. frequency domain

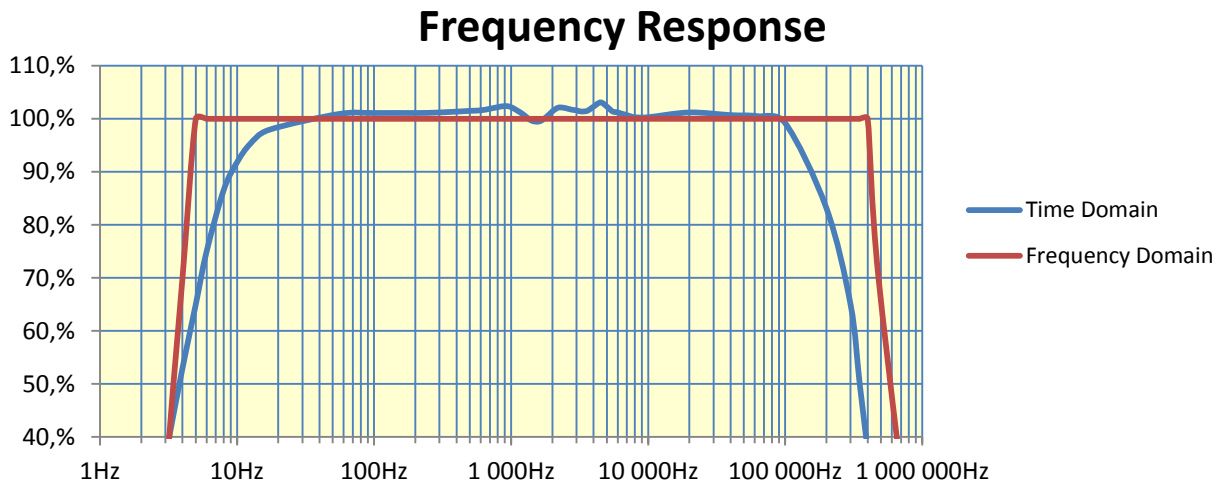
MFM 3000 has two modes to measure magnetic fields:

- Time domain measurements
- Frequency domain measurements

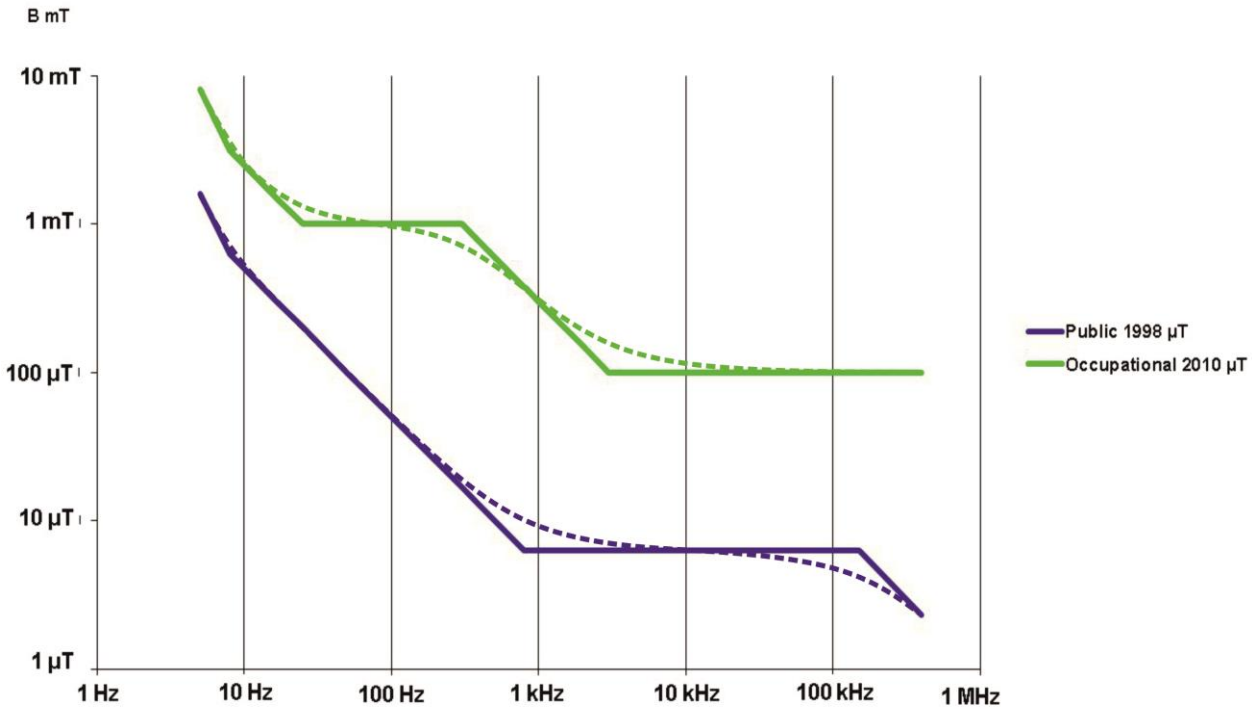
In time domain measurements the waveform is kept. To achieve a flat frequency response all adjustments are made by digital filters. With these filters it is possible to get an accuracy of +/- 5 % from 15 Hz to 100 kHz. – 3 dB from 5 Hz to 6 Hz to 200 kHz.

In frequency domain a FFT calculation is providing field amplitude in Tesla for more than 8 000 frequencies. This data is used for calculation of the broadband RMS and for the spectrum graph. To achieve a flat frequency response each of the more than 8000 frequency components are adjusted which results in excellent accuracy within +/- 1% from 5 Hz to 400 kHz.

In the graph below is presented the frequency response in time domain and in frequency domain measurements.



To get the frequency response for the exposure limits from ICNIRP the same technics are used, filtering technic for the time domain measuring mode and detailed individual adjustment of each frequency component for the frequency domain measuring.This will give some different result as it is described in the graph below. Both methods are approaved by ICNIRP.



The dotted line is presenting the frequency response when using a first order filter in time domain measurements and the

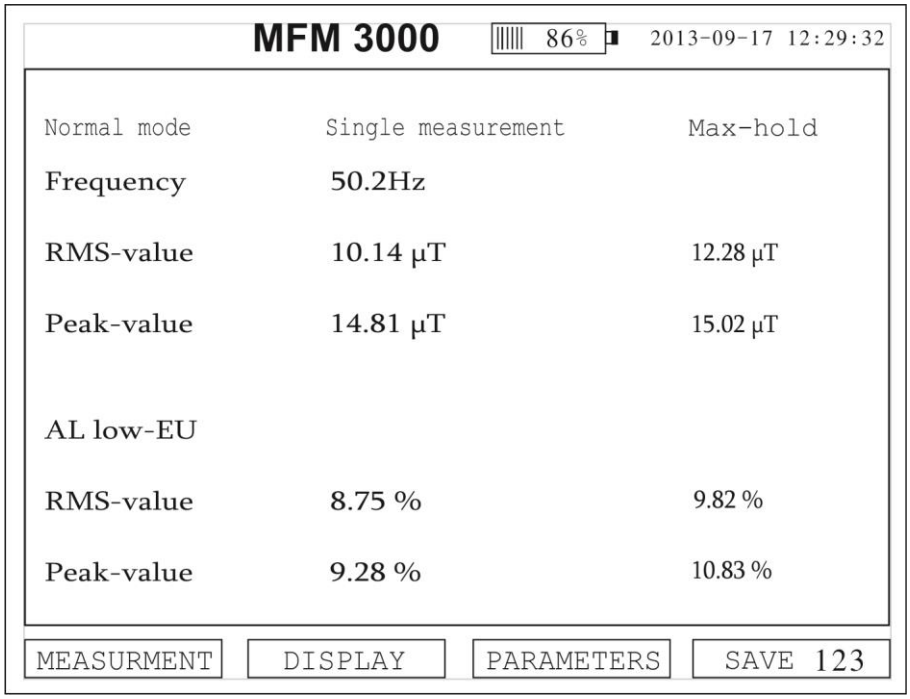
continuous line the frequency response achieved in frequency domain measurements.

The differences between time domain and frequency domain measurements will give different measuring results if you are measuring the same field in time domain or frequency domain.

3.6 Measurement general purpose (normal mode)

For general purpose measurements of magnetic fields select ”Normal” from the “Measurement” menu.

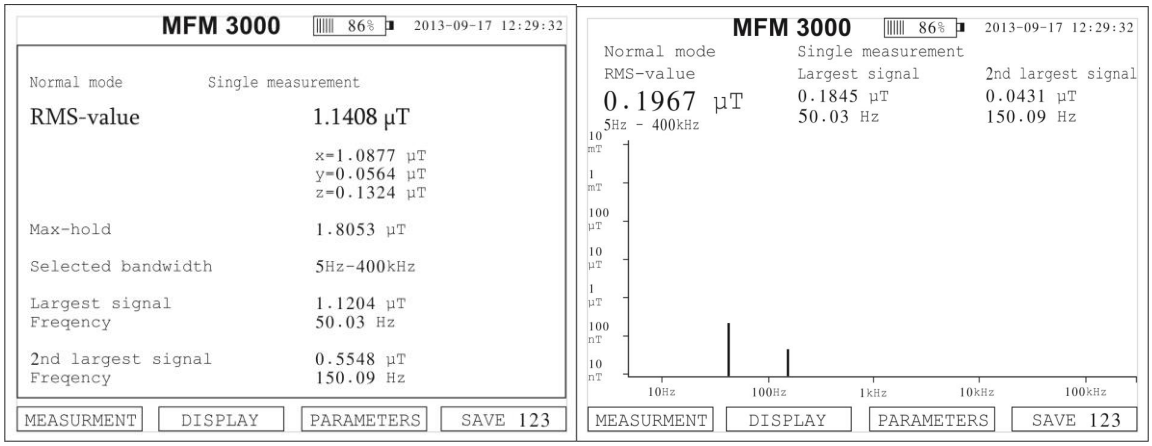
RMS-value presented in measurement display is a wideband value taking onto account all magnetic field components in the frequency range.



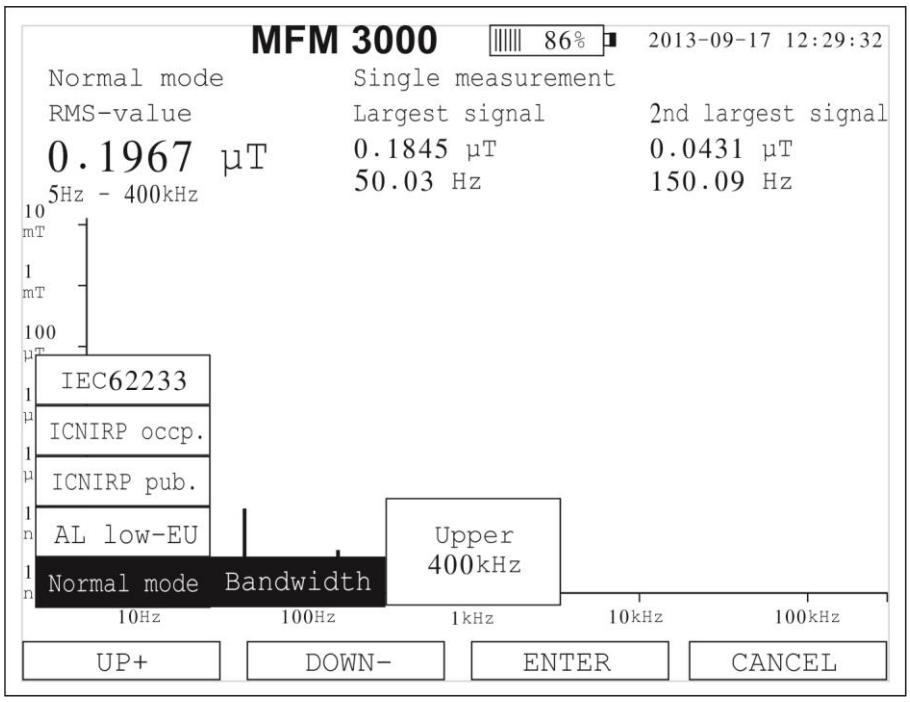
In **time domain** the result will be presented in a numerical display with an RMS value and a peak value. The dominating frequency will also be presented. If the frequency is unstable the frequency will be presented as “Mixed”. If no dominating frequency will be possible to identify the result will be presented

as “Noise”.

In **frequency domain** the result can be presented either in a numerical display or as a spectrum graph.



In a sub-menu to “Normal” it is possible (only in **frequency domain**) to reduce the “Bandwidth” if only a limited part of the frequency range is of interest.



The fixed choices for frequency limits are:

Lower frequency limit:
5 Hz, 10 Hz, 20 Hz, 40 Hz, 100 Hz, 200 Hz, 400 Hz, 1 kHz, 2 kHz, 4 kHz, 10 kHz, 20 kHz, 40 kHz, 100 kHz and 200 kHz

Upper frequency limit
10 Hz, 20 Hz, 40 Hz, 100 Hz, 200 Hz, 400 Hz, 1 kHz, 2 kHz, 4 kHz, 10 kHz, 20 kHz, 40 kHz, 100 kHz, 200 kHz and 400 kHz.

The upper frequency limit must be at least one step higher than the lower frequency limit. When selecting a reduced bandwidth it is useful to first study the broadband spectrum (5 Hz to 400 kHz)to determine where to set the limits. Reduced bandwidth limits should not be chosen at frequencies where significant magnetic fields are present in the broadband spectrum.

There are of course many applications where it is of interest to get an RMS-value representing a reduced bandwidth. It can also be of interest to limit the bandwidth at the lowest frequencies to avoid influence from movements in the earth magnetic field. Another use of a limited bandwidth is to study only the fundamental or just the harmonic components of a magnetic field source.

Compared to a broadband RMS-value the limited bandwidth RMS-value has less noise content and will give an even more accurate reading of specific components of interest.

3.7 Evaluation to IEC/EN 62233

Measurements according to IEC/ EN 62233 are evaluating the magnetic field as a percentage value related to the reference level at different frequencies within the frequency range 10 Hz to 400 kHz when measuring in frequency domain and in the frequency range from 15 Hz to 100 kHz when measuring I time domain.

- The result is presented in the same format as described in chapter 3.6 above but the result is presented in % of the ICNIRP 1998 reference levels for Public exposure.

  The standards specify that the largest magnetic field at the specified distance should be found. A good way to find the position for the largest magnetic field is to use continuous measurements and move the instrument across the specified surfaces until the highest reading is found. When the position is found it is recommended to make a single measurement with the instrument in the found fixed position to avoid any influence form movements in the earth magnetic field. As can be seen in the result displays below the “Weighted result” is a combination of all magnetic field components in the fixed frequency range of the standard. The two largest components contributing to the result are also shown.

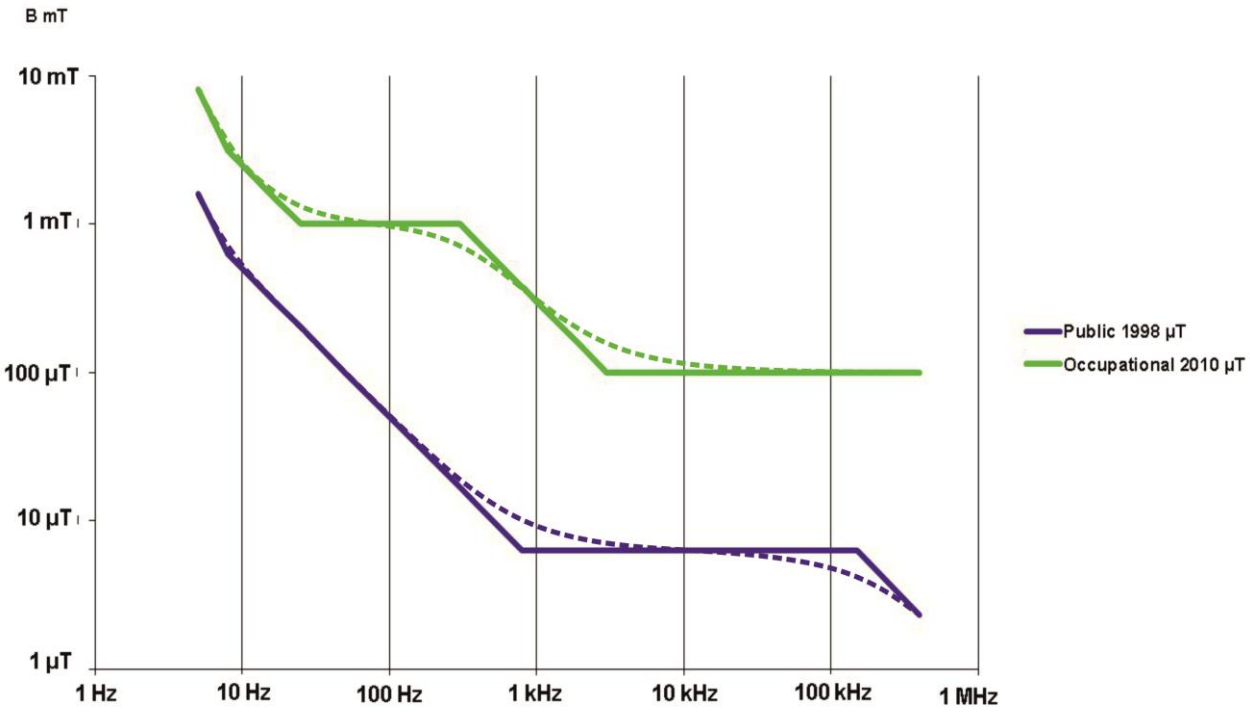
3.8 Evaluation to ICNIRP

Measurements according to ICNIRP are either related to public exposure or to occupational exposure to magnetic fields. The weighted results are shown in percent of the reference level and represent an evaluation across the full frequency range.

MFM 3000 provides evaluation to Public reference levels from ICNIRP 1998 Guidelines and evaluation to Occupational reference levels from ICNIRP 2010 Guidelines.

EU recommendation 1999/519 is referring to the reference levels for public exposure from ICNIRP 1998 Guidelines. A number of Cenelec standards are also referring to ICNIRP 1998 reference levels.

EU directive 2013/35 is referring to the Occupational reference levels from ICNIRP 2010 Guidelines,



The dotted lines represent the time domain limits and the continuous lines represents the frequency domain limits.

3.9 Evaluation to EU directive 2013/35

EU commission has published an directive 2013/35 ***on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields***

The directive is stating three exposure limits to EMF for non-thermal effects (at low frequencies (1 Hz – 10 MHz), These limits are:

- Low Action Levels
- High Action Levels
- Action Levels for exposure of limbsto localized fields

Low action levels is identical to ICNIRP´s reference levels for occupational exposure from 2010 Guidelines. MFM 3000 has implemented evaluation to this Low action level.

3.10 Battery Charging

The MFM 3000 can be operated either from the mains using the battery charger or from the internal rechargeable battery. When having the battery charger connected during measurements make sure the charger is located as far away from the instrument as possible to make sure that the magnetic field from the charger has a minimum influence on the measurement results.

The charging status in percent of full charge of the battery is indicated in battery symbol on the display. Charging the battery should be done when the charging level drops below 20 %.

Whenever the battery needs charging just connect the battery charger to the instrument. If the instrument is off, the charging will start automatically. During charging the battery symbol alternates between percent value and “<<<<” symbol.

Battery charging cycle is controlled by the firmware in the instrument so there is no risk involved if the battery charger is left connected to the instrument even after the battery has been fully charged. Charging time for an empty battery is around four hours.

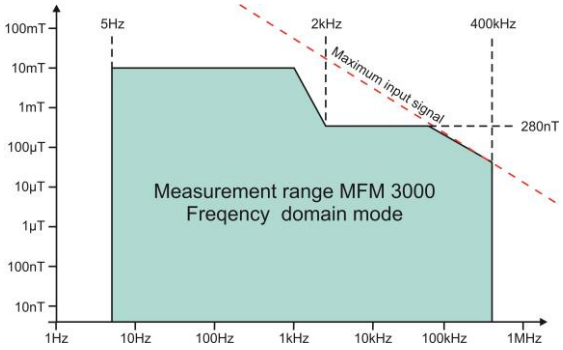
If the battery is replaced, the charger must be connected to start the instrument and initialize the new battery.

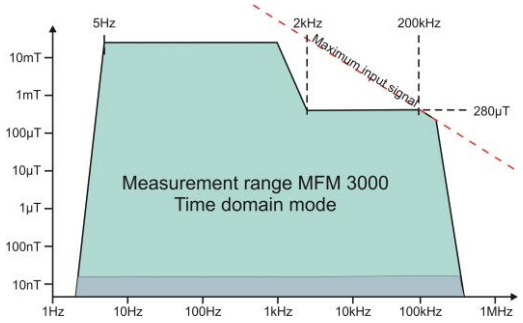
NOTE! The battery is a smart battery with its own electronics and no other type of battery can be used with the instrument

SECTION 4 - PRODUCT SPECIFICATION
MAGNETIC FIELD METER MFM 3000

Specifications are given at the temperature Tamb = 23 ± 5 °C.
Specifications subject to change without notice.

Measurement range





ALTERNATING MAGNETIC FIELDS

Antenna system	3-axis, concentric, orthogonal. Coil area 100 cm²
Frequency range:	
Time domain	5Hz – 400 kHz (-3dB) 15Hz - 200 kHz (± 5 %)
Frequency domain	5Hz - 400 kHz (± 1 %)
Frequency response Selectable	Flat According to IEC/EN 62233 according to ICNIRP Public 1998 According to ICNIRP Occup. 2010 According to EU directive 2013/35
Accuracy Freq.D.	±(1% of reading +2 nT)
Accuracy Time D.[H]	±(5% of reading +1 µT)
Accuracy Time D.[M]	±(5% of reading +0.1 µT)
Accuracy Time D.[L]	±(5% of reading +10 nT)
Measurement rates	1s single or continuous

MISCELLANEOUS

Display	Graphical 5,7" LCD display, with touch panel
Parameter storage	Instrument parameters and corrections are stored in a non-volatile memory
Result memory	64 Mbit
Power	Smart Lithium ion battery, 10.8 V and 4.8 Ah. Universal battery charger 90-250 V, 45 – 65 Hz
Communication	USB 2 interface for PC communication
Operating temperature	10°C to +50°C.
Operating humidity	10 - 85%.
Dimensions	400 x 110 x 190 mm (LxWxH)
Weight	Instrument weight 3.5 kg.

WARRANTY FORM for MFM 3000 (customer copy)

Customer :

Customer address :

Delivery date:
Warranty period:
Serial number:
Program version:

The warranty includes material and labour cost for service and repair, but not transportation costs in any direction. A condition for the warranty is that a correctly filled in copy of the warranty form is sent to Combinova.

NOTE! Always return the instrument in its own transportation case.

If service is required the instrument should be sent to:

Combinova AB
Domkraftsvägen 1
S-197 40 BRO
SWEDEN

WARRANTY FORM for MFM 3000 (Combinova copy)

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Delivery date:
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