

MAGNETIC FIELD METER 10

Operator's Manual

The MFM 10 is a professional instrument to measure extremely low frequency (ELF) magnetic fields.

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

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Section 1

INTRODUCTION

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The Magnetic Field Meter 10 (MFM 10) is a professional instrument designed to measure extremely low frequency magnetic fields. The MFM 10 has been developed for self-contained field operation with such features as built-in rechargeable batteries, LCD display and large data logging memory.

MFM 10 has been especially designed for measurement of ELF magnetic fields, emitted by VDU's according to MPR 1990:8 "Test methods for Visual Display Units".

1.1 Magnetic Fields in the Environment

Increasing use of electrical equipment has meant that there is increased exposure to low frequency magnetic fields. In recent years this has led to concern that a health hazard could arise from these low frequency magnetic fields. A number of medical and environmental studies have indicated that there may be a relationship between magnetic field exposure and the frequency of leukemia occurring where there is exposure to field levels of only 0.2 to 0.3 μ T.

Strong magnetic fields can also cause electrical interference problems, for example disturbance of video monitors from external power frequency magnetic fields. The largest magnetic fields are found around power transmission lines and power supply installations. Electrical equipment in the home and working environments i.e. photo-copying machines generate comparatively strong magnetic fields.

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 μ T, but decreases to less than 1 μ T at distances of 50 to 200 meters.

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 electrical equipment and wiring.

The usual electrical equipment found in the home or office generate magnetic fields with dipole characteristics. The field strength decreases rapidly with distance. Close to the source the field strength can be as high as 10 μ T, but this decreases to a background level at only one meter's distance. In general the background magnetic field should be less than 0.1 μ T, but in certain cases this could be as great as 1 - 3 μ T.

The presence of such magnetic fields in the environment is beginning to cause concern, and has led to demands for action to decrease these fields. This has led to the development of the MFM 10 which can be easily and quickly used to identify the source of magnetic fields so that the appropriate action can be taken.

1.2 The Instrument (Fig. 1.1)

The MFM 10 is a compact, reliable and environmentally protected instrument to measure low frequency magnetic fields. When detecting and measuring magnetic fields it offers the following features:

- » Orthogonal coils, which means that fields can be measured independent of field direction.
- » A frequency range of 10 to 1,000Hz for all low frequency magnetic fields.
- » A wide dynamic range of 0.01 to 10,000 μ T with auto ranging, ensuring that the instrument is set at the optimum sensitivity for the detected field.
- » True RMS flux measurement, directional component and dominant frequency indication.
- » Polarization detection and presentation.

For the operator in the field the designed portability of the MFM 10 means that the instrument is entirely self-contained. These features are:

- » Built-in rechargeable sealed lead batteries for portability and additionally avoiding power supply interference.
- » A flexible measurement data logging facility, for up to 100 hours of measurements at frequent intervals. The stored results can later be printed out or transferred to a PC.
- » A complete set of accessories: transport case, tripod, battery charger, communication cable and this operator's manual.
- » Fiber optic interface kit for communication and remote control.

The electronics in the instrument comprise analog amplifiers, a micro computer with communication peripherals and an alphanumeric LCD-display with back light. A built-in clock and calendar is used in the data logging measurement.

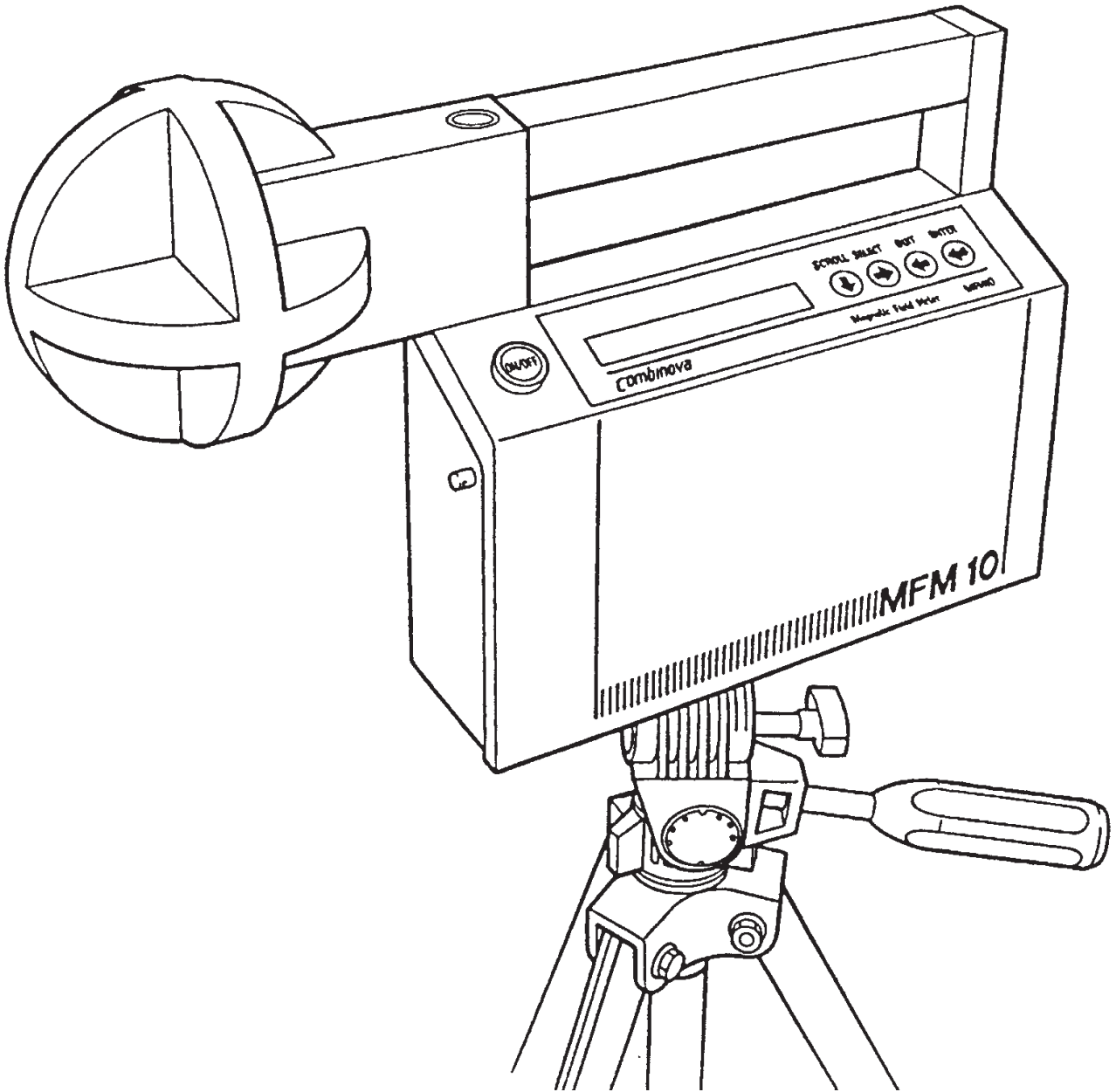


Fig. 1.1 MFM 10

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1.3 Using the MFM 10

The MFM 10 has been designed to be easy to use in the field. A four-key keyboard and LCD display panel allow the instrument operation to be optimised for the particular measurement application. Once the instrument has been set up then measurement is initiated by simply pressing the start button. The display even informs the operator of remaining measurement time until the batteries should be recharged.

The main instrument modes are:

- » **MEASUREMENT**
Measurement mode is used to make the actual measurements. A number of different measurement modes can be selected (single, repetitive and logging).
- » **DATA RETRIEVE**
Data retrieve mode is used to show stored measurement data on the instrument display. Mean period values as well as single measurement data can be accessed in this mode.
- » **PRINT**
Print mode is used to dump stored data to a printer or computer through the built-in RS232 serial interface.
- » **CHECK**
Check mode includes a number of tests to verify different instrument functions.
- » **PARAMETERS**
Parameter mode gives the user a wide variety of possibilities to adapt the instrument for different measurement and communication needs.

Selecting the measurement mode and setting up the MFM 10 is described in Section 3, Operating Instructions.

A technical description of the MFM 10 is given in Section 4.

1.4 Combinova AB - Behind the Product

The Magnetic Field Meter 10 has been developed by Combinova AB, who are also responsible for the manufacture, marketing and after-sales service of the instrument.

Other field measurement products from Combinova are:

- » MFM 1000 - Magnetic Field Meter for the VLF (2-400kHz) range.
- » MFM 1020 - Automatic VDT magnetic field measurement system.
- » EFM 200 - Electrostatic fields and alternating fields in the ELF (5-2,000Hz) and VLF (2-400kHz) frequency ranges.
- » EFM 100 - Alternating electric fields in the ELF (5-2,000Hz) and VLF (2-400kHz) frequency ranges.

Combinova AB works with Swedish and international industrial clients in the area of broad technical development. The principle areas of development expertise are:

- instrument development
- technical trouble shooting
- manufacturing equipment development

This depth of technical experience makes it possible for the company to handle all stages of product development, including project management and technical co-ordination.

The logo for Combinova, featuring the word "combinova" in a bold, italicized, lowercase sans-serif font.

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Section 2

UNPACKING AND INSPECTION

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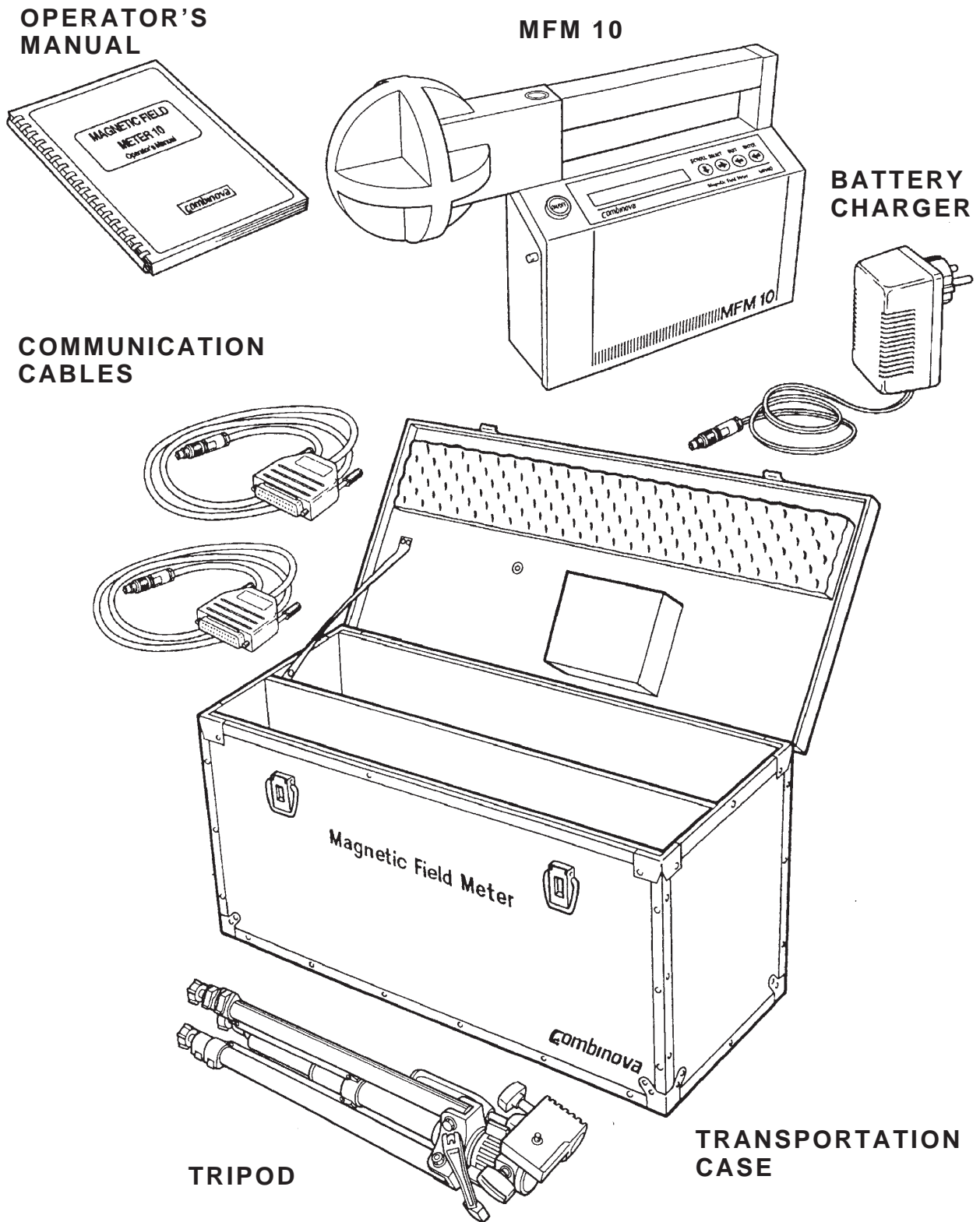


Fig. 2.1 Unpacking the MFM 10

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The MFM 10 is delivered in a specially designed transport box, which also contains all the accessories that are used with the instrument.

2.1 Unpacking

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

Open the case and check that the following items have been supplied (see Fig. 2.1) :

Standard Instrument

- » MFM 10 instrument
- » Battery Charger PS10 (110V or 220V)
- » Standard Tripod
- » Two Communication Cables (for Printer/Computer)
- » Operator's Manual.

Fiber Optic Remote Control

Included are the following additional items:

- » Fiber Interface (internally)
- » Fiber Cable (10m) with connectors
- » Fiber Adapter 10, for use with an RS232 25-pin PC serial port, is available by separate order

If the MFM 10 instrument is to be used for the MFM 1020 Automatic system then it is delivered with a Fiber Optic Remote Control without accessories.

IMPORTANT! Complete the warranty form and return a copy to Combinova AB. The warranty is only valid when the warranty form has been completed and received by Combinova AB.

Before switching on the instrument, read this manual carefully.

2.2 Inspection

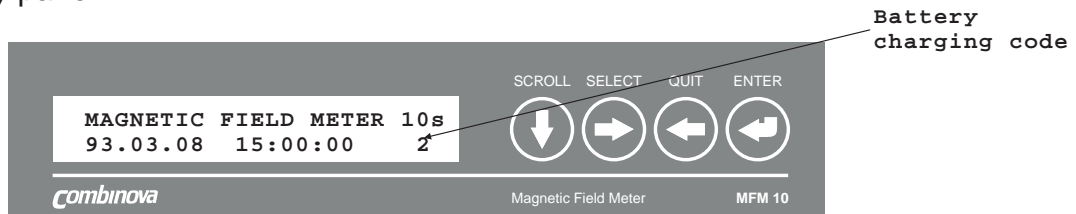
Inspect the MFM 10 and the accessories supplied for any sign of damage.

Before the MFM10 can be used the voltage of the re-chargeable battery should be checked. The battery is fully charged when it leaves the factory. However, if for any reason it has become discharged then the instrument will not operate correctly, and will need to be recharged.

MFM Checks

- Switch on the instrument, using the ON/OFF button (see Fig. 2.2).

The MFM carries out a number of checks and then displays the following message in the display panel:



Note: Refer to Section 3.6 to set the correct time and date!

- Check the battery charging code in the bottom-right of the display panel.

When "0" or "1" is indicated then the battery should be fully charged. Check the battery voltage if any of the other codes are shown. To check the battery voltage, see Section 2.3.

2.3 Checking the Battery Voltage

This procedure is fully described in Section 3.5, but a brief guide is given here.

- Switch on the instrument.
- On the control panel select "CHECK" by pressing the "SCROLL" button (⬇️) **four** times so that the display panel shows:



- Press the "SELECT" button (➡️), and the display panel will show:



where XX.XV is the battery voltage.

- Check that the battery voltage is greater than 11.5V. If it is below this voltage then recharge the instrument (see Section 3.7).

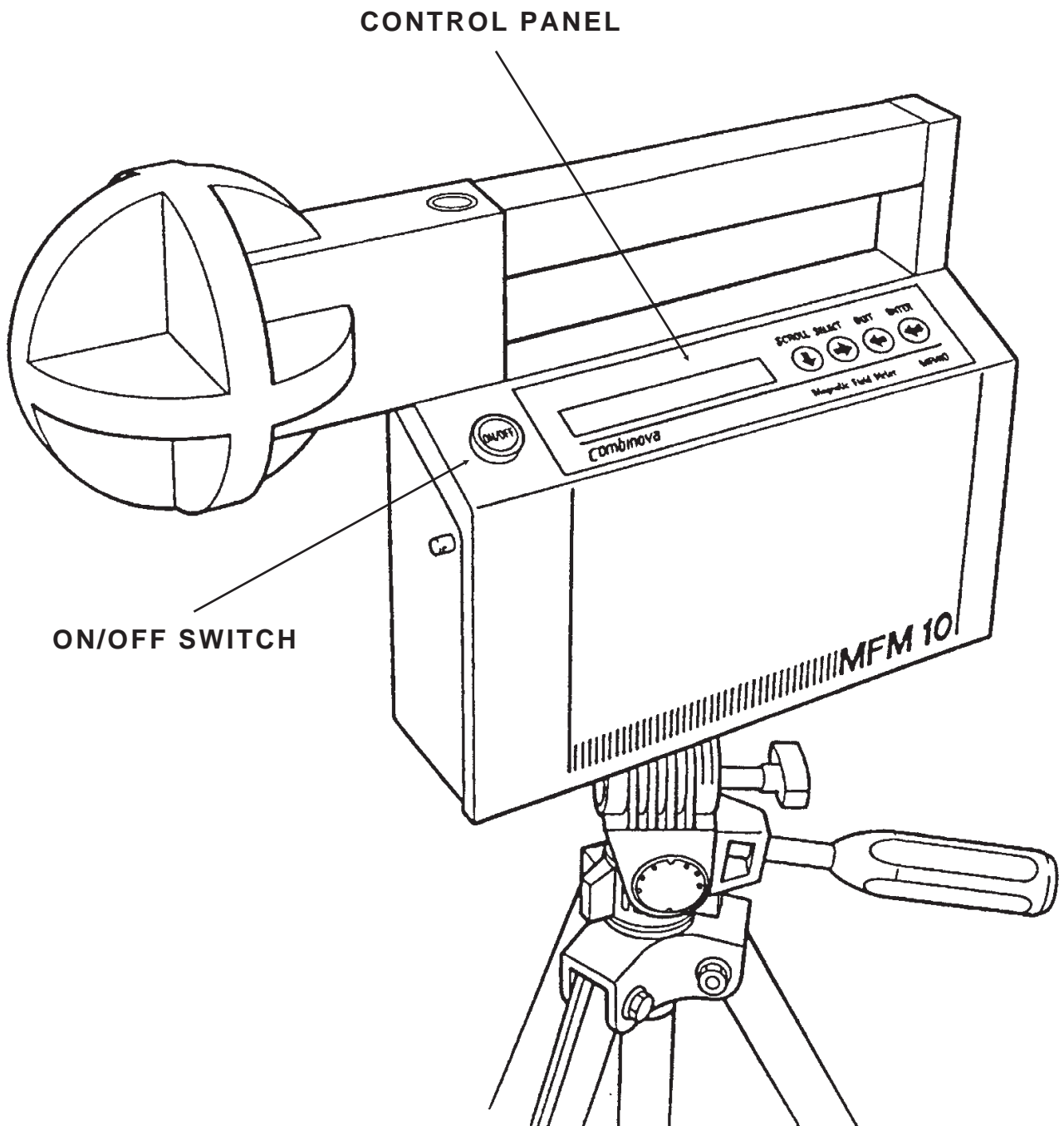


Fig. 2.2 MFM 10

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Section 3

OPERATING INSTRUCTIONS

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General

The MFM10 has been designed to be simple to operate, while still retaining great operational flexibility. This section details how to operate the MFM 10 and how to obtain measurement results. The controls and display panel are described in Section 3.1 together with details of how to select functions and enter parameter values.

The MFM 10 uses a number of main operational modes, which are listed below, together with a reference to the section in which they are fully described.

- **MEASUREMENT (Section 3.2)**
Initiate magnetic field measurement, select measurement method.
- **DATA RETRIEVE (Section 3.3)**
Display measurement results, either in summarised form or individual results.
- **PRINT (Section 3.4)**
Obtain hard copy of measurement results, either summarised or individually.
- **CHECK (Section 3.5)**
Initiate internal instrument checks.
- **PARAMETERS (Section 3.6)**
Set up the instrument according to requirements.

IMPORTANT...

ALWAYS KEEP THE INSTRUMENT IN A STILL POSITION
DURING MEASUREMENT CYCLES TO AVOID THE
INFLUENCE FROM THE EARTH'S MAGNETIC FIELD.

3.1 General Operation

Figure 3.1 shows the location of the controls and display on the MFM 10. These are described below:

ON/OFF Switches the instrument on or off.

Start Measurement This button initiates measurement, see Section 3.2

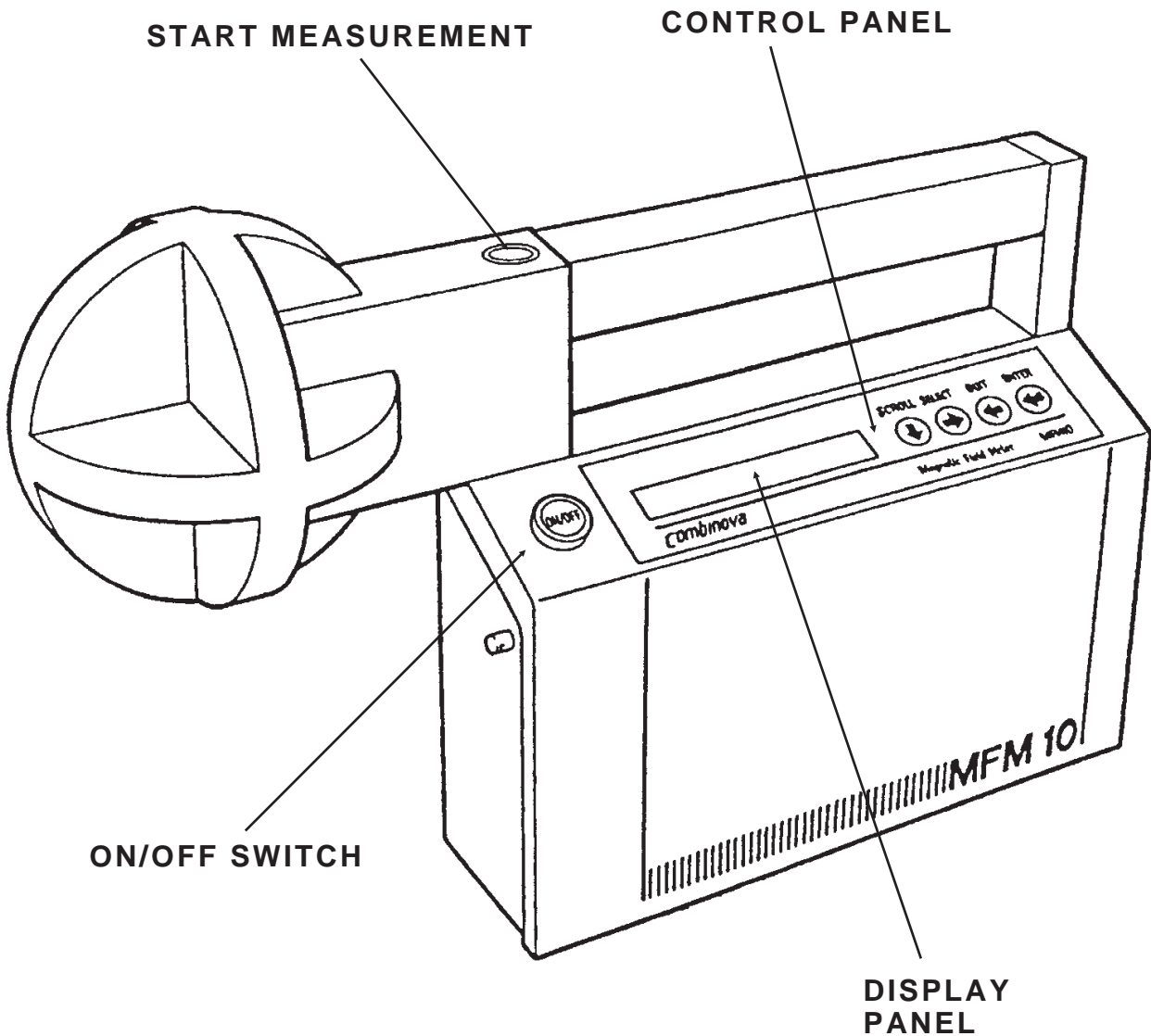


Fig. 3.1 Controls and Indicators

Fig.3.2 shows the control panel with its four function switches, which are described below:

- SCROLL (⬇️) Goto next function, sub-function result or value (see Fig. 3.3)
- SELECT (➡️) Select the displayed function.
- QUIT (⬅️) Quit the selected function and return to the next level (see Fig. 3.3).
- ENTER (↩️) Enter the selected value or parameter on the second line of the display panel.

The next section shows how these controls and indicators are used.

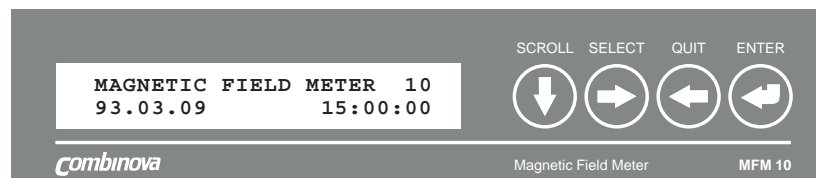


Fig. 3.2 Control Panel

MFM10 Function Modes

By using the four keys on the control panel, all functional modes of the instrument can be accessed. The available functions are shown in the flow diagram, Figure 3.3. The key presses required to select the function or enter values are also shown.

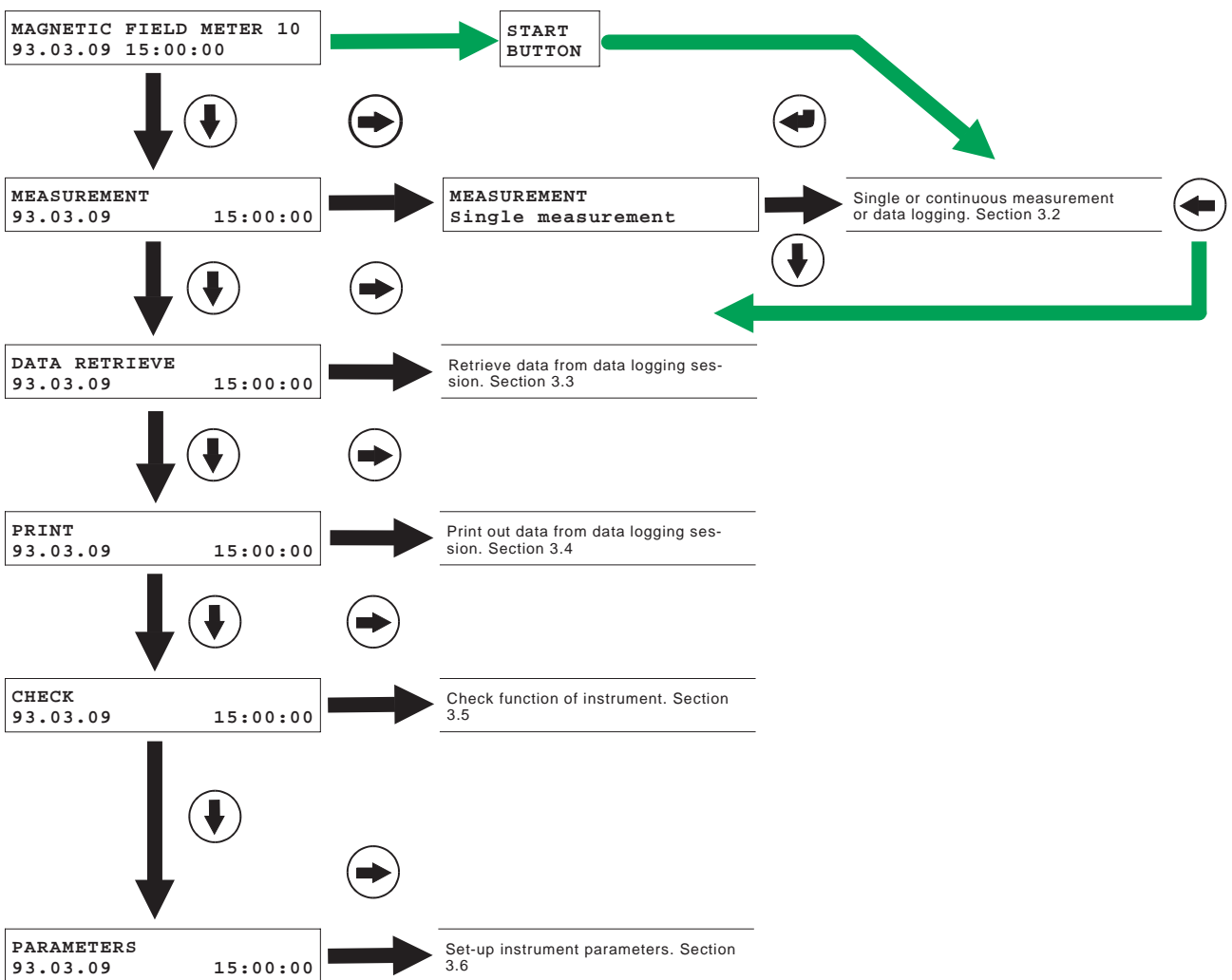


Fig. 3.3 MFM 10 Function Modes

3.2 Measurement

The instrument can perform either single/repetitive measurements or data logging:

- » Single measurement with direct read-out on the display.
- » Repeated measurements with direct read-out on the display for manual observation of field variation.
- » Data logging, automatic repeated measurements or manually initiated burst measurements with results logged in the MFM 10 for future evaluation. The parameters for the automatic logging are set up in the PARAMETERS mode, see Section 3.6.

Single and Repeated Measurements

Switch on the MFM 10 using the ON/OFF button. Single measurements can be initiated by either using the control panel keys, as shown in Fig. 3.3, or alternately by simply pressing the 'green' start button and wait until the "Waiting for start" message appears.

When single measurement has been selected using the 'ENTER' key the following message appears for approximately four seconds:

Max time Xh Z.YV

where X indicates the number of hours that the MFM 10 can operate before recharging the batteries and Z.Y is the battery voltage.

When the "Waiting for start" message is displayed the MFM 10 is ready to start measurements. Press the green start button to carry out a single measurement. The result of the measurement is displayed as:

Magnetic flux B in μT (or mG) = true rms value
 Magnetic field strength in A/m = ampere/meter
 Frequency in Hz = dominant frequency of the largest coil signal
 Polarization in % = $B_{\text{min}}/B_{\text{max}}$

Directional components B_x , B_y , B_z can be displayed if 'SELECT' is depressed after the initial results have been displayed. Refer to Sec. 4 for a detailed description of measurement output from MFM 10.

Repeated measurements can be selected by keeping the start button depressed during the first measurement. Measurements are then carried out every four seconds, with the results displayed on the display panel, as for single measurement.

Repeated measurement is stopped by pressing the start button (return to single measurement mode) or the QUIT key. Repetitive mode will be automatically stopped after approximately 8 minutes.

Single measurement mode is left by pressing the QUIT key.

Data Logging Mode

There are two alternate logging modes, 'Start logging' or 'Continue logging'. If 'Start logging' is selected then the instrument's memory is cleared and a new logging sequence can be initiated. If 'Continue logging' is selected then the new measurement results are stored, continuing on from the previously stored results. The time break is indicated on the print-out.

Select the 'logging' mode as shown in Fig. 3.4. When the mode is entered using the 'ENTER' key the following message is displayed for approximately two seconds:

Max time Xh (XV if battery is limiting factor)

where X is the maximum time remaining for automatic logging, limited by the size of memory.

The logging parameters, period, sample rate, are selected in the PARAMETERS mode, see Section 3.6. This determines whether manual or automatic logging is selected.

When the "Waiting for start" message is displayed the MFM 10 is ready to start logging measurements. Press the green start button to initiate measurements. Stop logging by pressing the QUIT key.

Press the green start button to initiate measurements.

When manual logging has been selected PARAMETERS" mode, then the instrument should be used as for 'single measurements' except that a "burst" of measurements is taken and the results are stored in the instrument.

The measurement results can be retrieved using the 'DATA RETRIEVE' or 'PRINT' modes, see Sections 3.3 and 3.4.

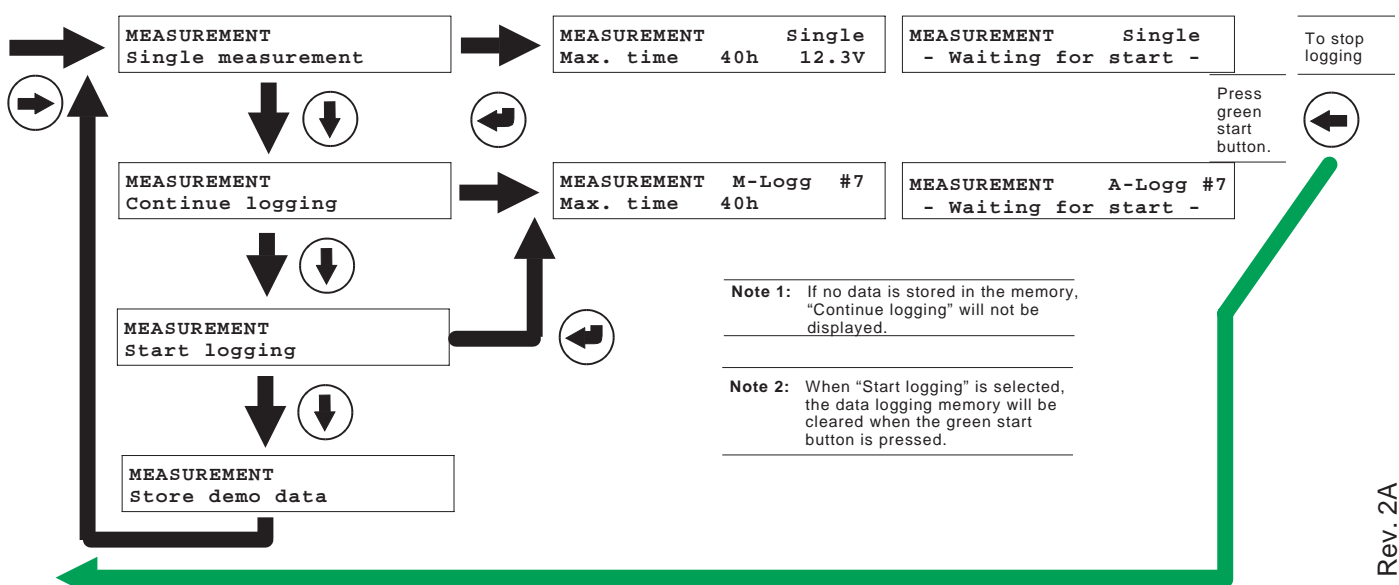


Fig. 3.4 Measurement Modes

3.3 Data Retrieve

The DATA RETRIEVE mode enables the results from data logging to be displayed.

Select DATA RETRIEVE as shown in Fig. 3.3, press the SELECT key to enter the mode. The following display is shown:

```
DATA RETRIEVE
Periods #a - b
```

where a = first period, and b = last period. The number of periods depends on how long data logging was used.

Press SELECT to display a summary result of each period, the first period is shown:

```
Period #1<
x      Bmean = .....
```

where

x = number of results in the periods
< = logging was interrupted.

The mean value from the results in the period is shown. The number of results in the period is set in the PARAMETERS mode, see Section 3.6. To see the mean results from the other periods, use the "SCROLL" key.

If the individual results from each period are required then these can be displayed. Select the desired period then press SELECT. The following display is shown:

```
Period #a      P - start
93.03.08  15:00:00
```

where

a = period number
p-start = time when the period started.

Use the SCROLL key to display the individual results:

```
Period #a      (b - d)
(b xxx)(c xxx )(d xxx)
```

where b-d = result number.

Each time SCROLL is pressed three individual results are displayed, press SCROLL again to display the next three etc. When all results have been displayed, the "P-start" display appears so that the results can be scrolled through again.

Use QUIT to return to a higher level.

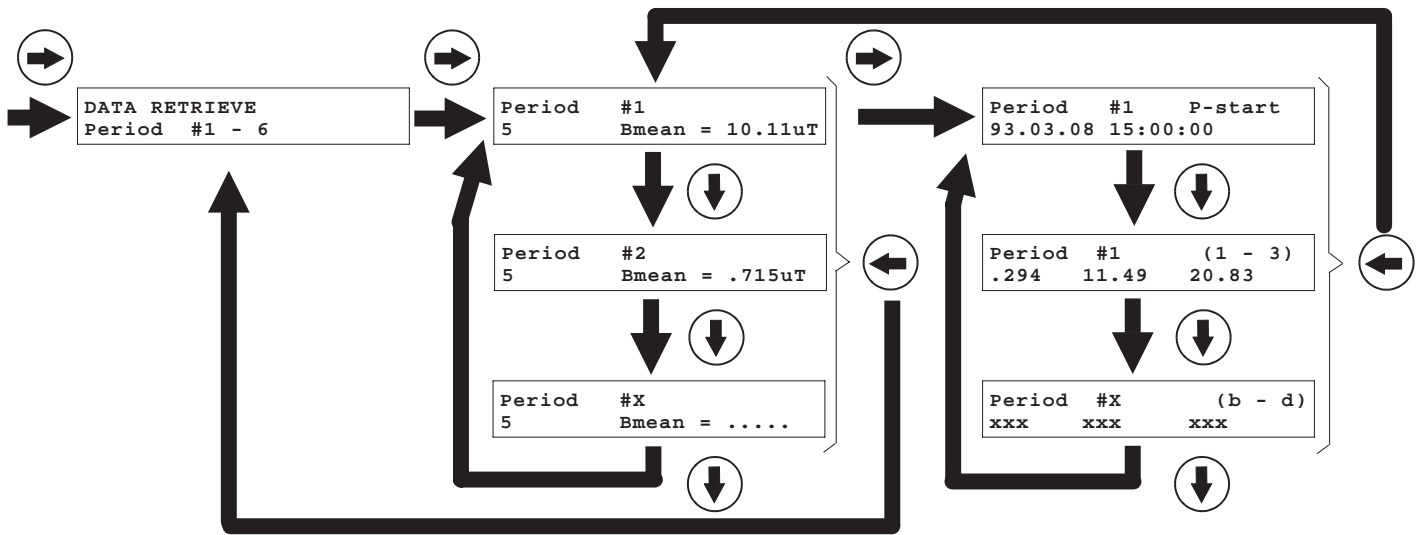


Fig. 3.5 Data Retrieve Mode

3.4 Print

The measurement data stored in the MFM10 can be printed out on a printer with an RS232 interface or sent to a PC (which has suitable software). Contact Combinova or your local representative for product information about Combinova’s specially designed PC software.

Connect the printer to the printer terminal on the MFM 10. Refer to Section 4 TECHNICAL DESCRIPTION, for details.

There are three print modes, see Fig. 3.6:

Reduced - A summary of results from each logging period, together with a protocol header (see Fig. 3.7).

Complete - An individual result from each logging period, together with a protocol header (see Fig. 3.8).

Last measure (printer or computer) - All waveform samples comprising the last measurement. Total 3 x 1024 per each measurement value.

Note: Each of the three print modes can output data either to be printed out or to be sent to a PC, see “TECHNICAL DESCRIPTION” Sec. 4.

Check that the parameters for printing, see PARAMETERS mode, Sec. 3.6, are correctly set for the printer. Press ENTER to start printing.

If a ‘P’ is shown in the bottom-right of the display, then this indicates that the data has already been printed out.

When transferring data to the printer the message ‘Printing’ is displayed, and when the last data of the selected sub-mode has been transferred ‘Print complete’ is displayed.

To stop the print at any time, press the QUIT key. Use QUIT to exit the print function.

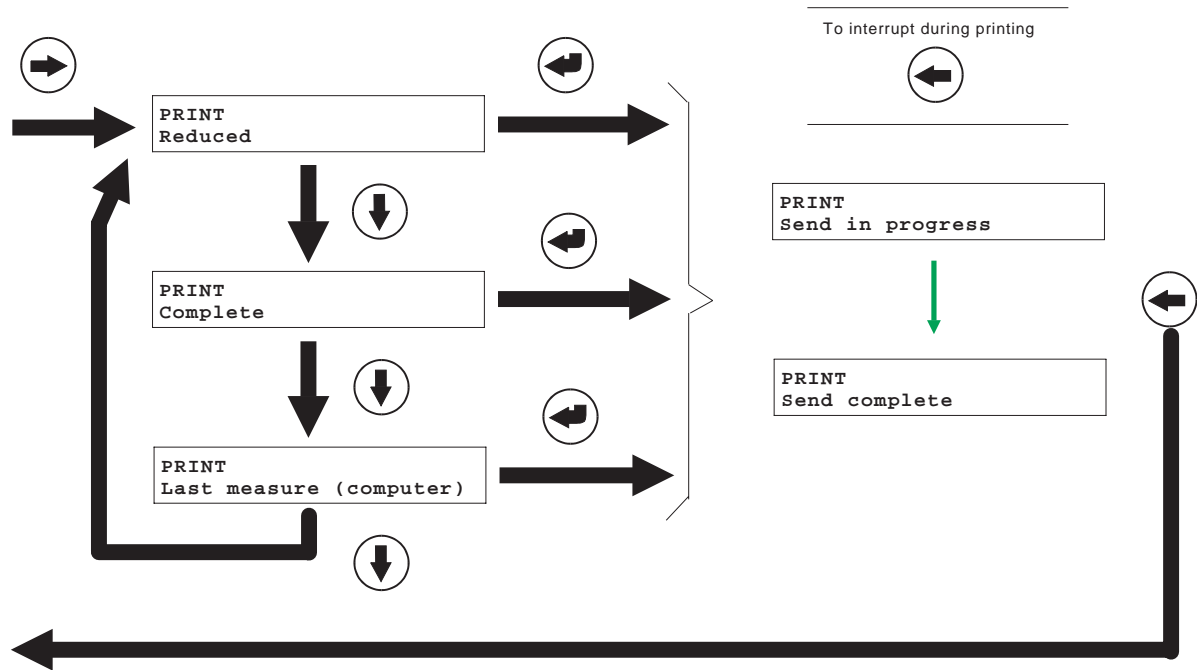


Fig. 3.6 Print Mode

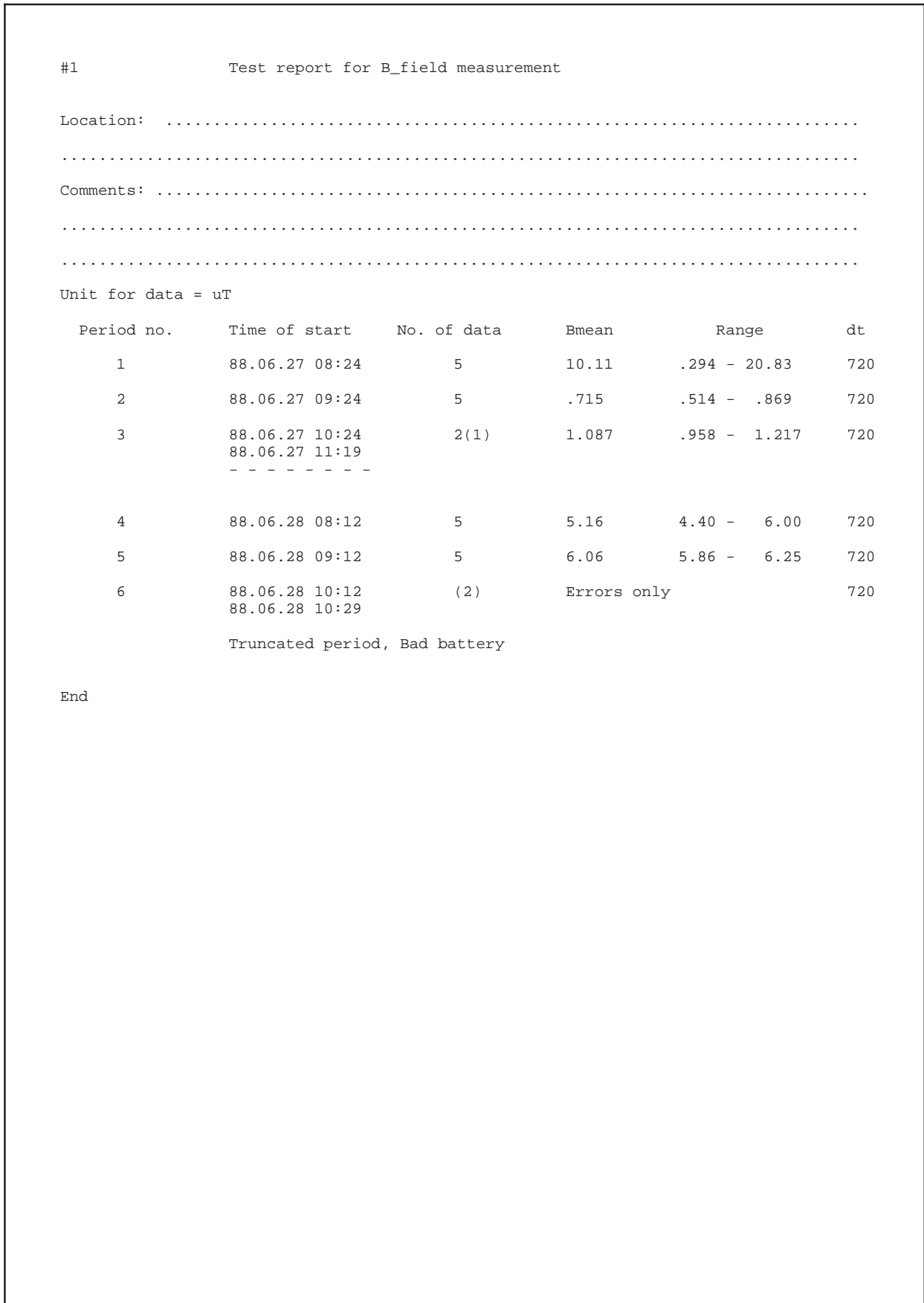


Fig. 3.7 Example of Reduced Print-out

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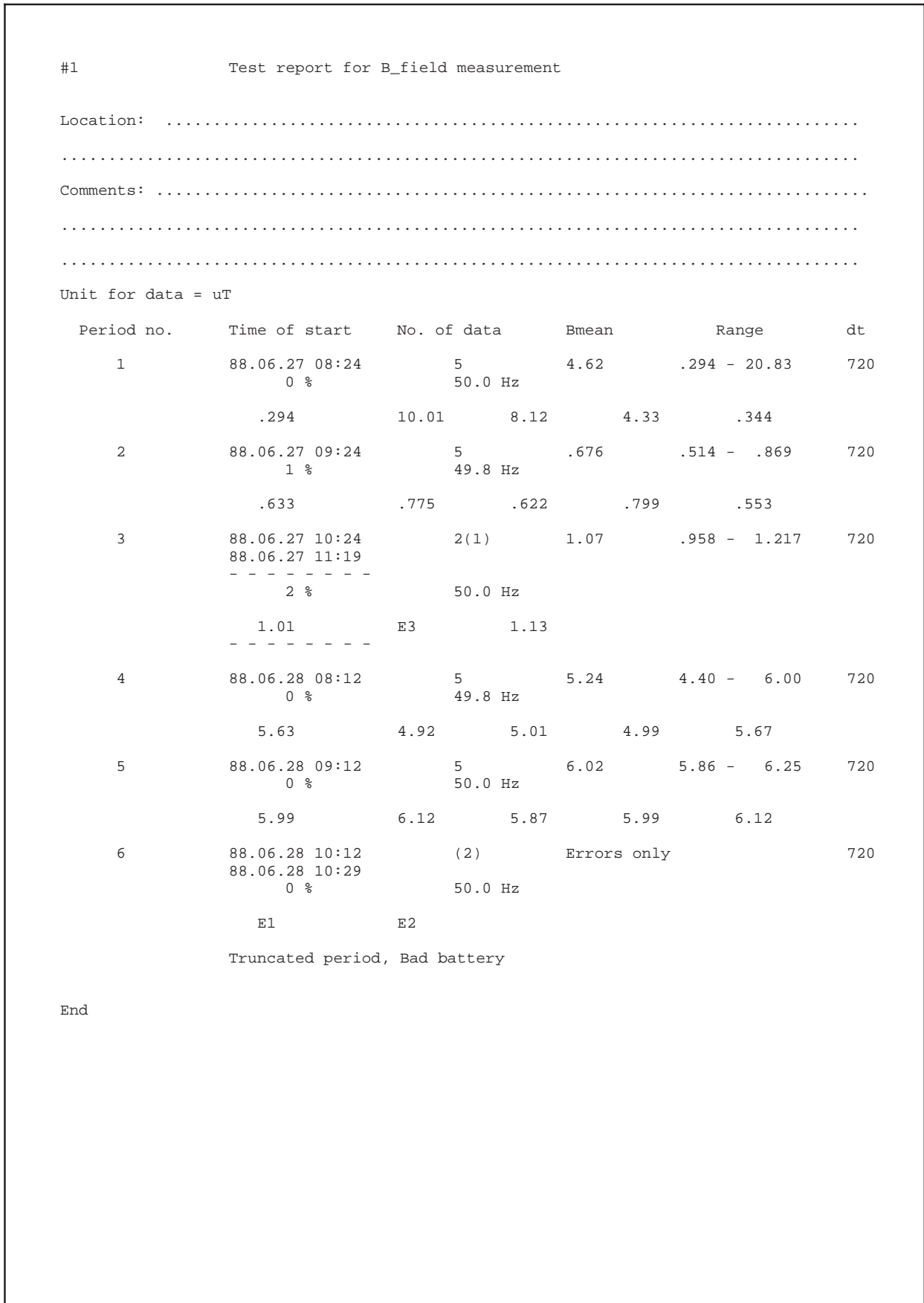


Fig. 3.8 Example of Complete Print-out

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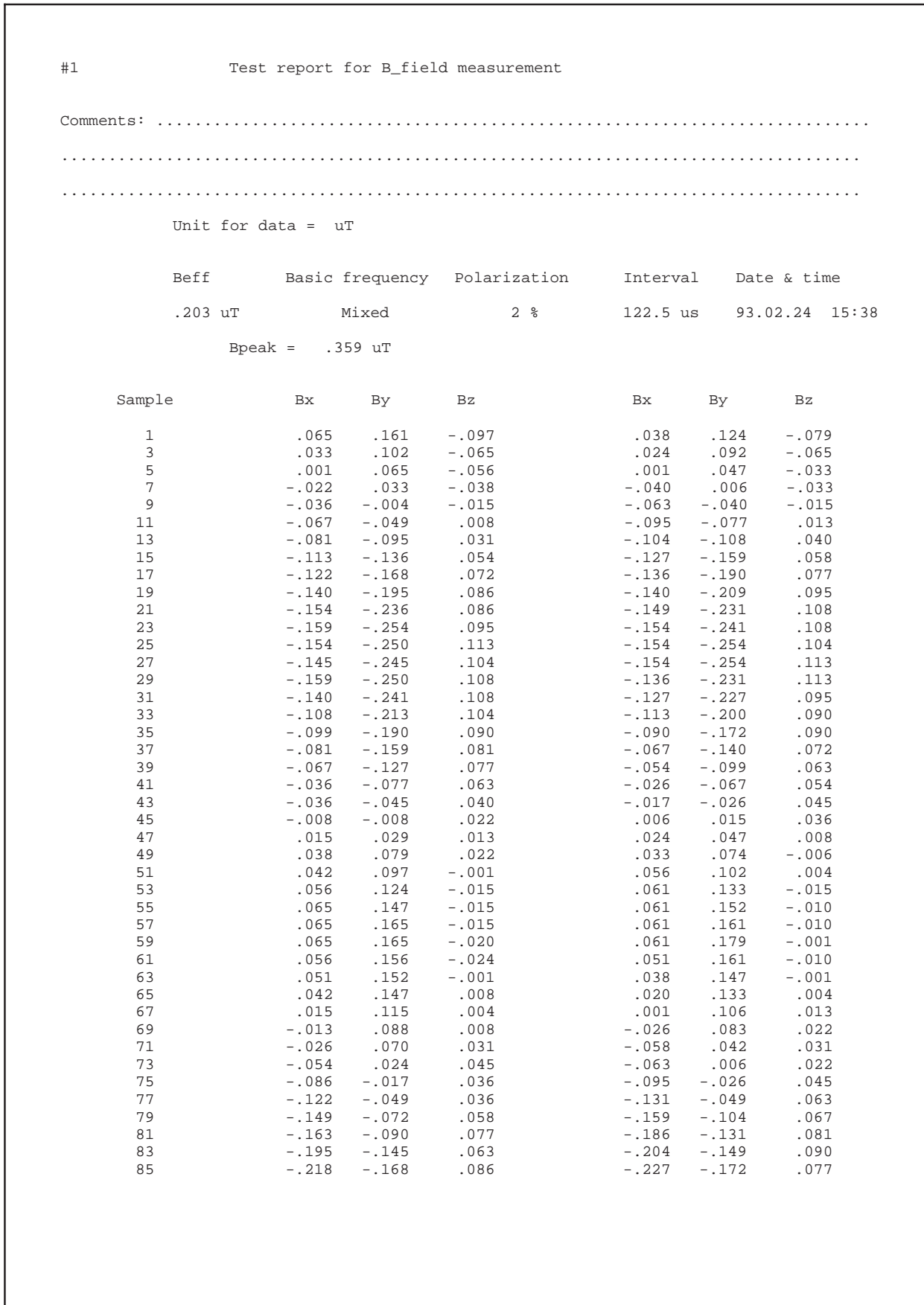


Fig. 3.9 Example of Last Measurement (Printer) Print-out

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```

        .203 uT      Mixed      2 %      122.5 us      93.02.24  15:38

                                Bpeak =   .359 uT

1;.065,.161,-.097;.038,.124,-.079
3;.033,.102,-.065;.024,.092,-.065
5;.001,.065,-.056;.001,.047,-.033
7;-.022,.033,-.038;-.040,.006,-.033
9;-.036,-.004,-.015;-.063,-.040,-.015
11;-.067,-.049,.008;-.095,-.077,.013
13;-.081,-.095,.031;-.104,-.108,.040
15;-.113,-.136,.054;-.127,-.159,.058
17;-.122,-.168,.072;-.136,-.190,.077
19;-.140,-.195,.086;-.140,-.209,.095
21;-.154,-.236,.086;-.149,-.231,.108
23;-.159,-.254,.095;-.154,-.241,.108
25;-.154,-.250,.113;-.154,-.254,.104
27;-.145,-.245,.104;-.154,-.254,.113
29;-.159,-.250,.108;-.136,-.231,.113
31;-.140,-.241,.108;-.127,-.227,.095
33;-.108,-.213,.104;-.113,-.200,.090
35;-.099,-.190,.090;-.090,-.172,.090
37;-.081,-.159,.081;-.067,-.140,.072
39;-.067,-.127,.077;-.054,-.099,.063
41;-.036,-.077,.063;-.026,-.067,.054
43;-.036,-.045,.040;-.017,-.026,.045
45;-.008,-.008,.022;.006,.015,.036
47;.015,.029,.013;.024,.047,.008
49;.038,.079,.022;.033,.074,-.006
51;.042,.097,-.001;.056,.102,.004
53;.056,.124,-.015;.061,.133,-.015
55;.065,.147,-.015;.061,.152,-.010
57;.065,.165,-.015;.061,.161,-.010
59;.065,.165,-.020;.061,.179,-.001
61;.056,.156,-.024;.051,.161,-.010
63;.051,.152,-.001;.038,.147,-.001
65;.042,.147,.008;.020,.133,.004
67;.015,.115,.004;.001,.106,.013
69;-.013,.088,.008;-.026,.083,.022
71;-.026,.070,.031;-.058,.042,.031
73;-.054,.024,.045;-.063,.006,.022
75;-.086,-.017,.036;-.095,-.026,.045
77;-.122,-.049,.036;-.131,-.049,.063
79;-.149,-.072,.058;-.159,-.104,.067
81;-.163,-.090,.077;-.186,-.131,.081
83;-.195,-.145,.063;-.204,-.149,.090
85;-.218,-.168,.086;-.227,-.172,.077
87;-.231,-.177,.090;-.259,-.195,.077
89;-.245,-.186,.090;-.250,-.195,.081
91;-.254,-.195,.067;-.254,-.186,.081
93;-.263,-.190,.067;-.254,-.177,.063
95;-.259,-.177,.058;-.263,-.168,.049
97;-.236,-.154,.040;-.250,-.140,.031
99;-.245,-.127,.008;-.209,-.104,.017
101;-.241,-.095,-.001;-.213,-.077,-.001
103;-.195,-.049,.004;-.195,-.040,-.020
105;-.168,.001,-.029;-.168,.015,-.038
107;-.154,.042,-.042;-.127,.056,-.051
109;-.118,.079,-.056;-.108,.092,-.070
111;-.090,.133,-.061;-.072,.138,-.079
113;-.058,.165,-.079;-.049,.193,-.079
115;-.045,.193,-.106;-.013,.234,-.092
117;-.040,.238,-.106;.001,.252,-.111
119;.020,.270,-.106;.029,.266,-.120
121;.042,.279,-.111;.047,.284,-.115
123;.047,.288,-.120;.070,.302,-.111
    
```

Fig. 3.10 Example of Last Measurement (Computer) Print-out

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3.5 Check Mode

A number of checks are available to check the operation of the MFM 10.

Each check is selected using the SCROLL key and initiated by pressing the SELECT key. The following checks are available:

Battery

The display will show:

```

CHECK
Battery           X.XV
    
```

where X.X is the battery voltage.

The instrument will only operate properly if the voltage is greater than 11.0V. Be sure to keep the battery in good condition by regular charging.

IMPORTANT! The instrument should be recharged if the battery voltage is below 11.5V or if the instrument is not to be used for a long period of time.

Transmit

When this function is selected the text string 'TRANSMIT' is sent out to the printer or PC to check the communication link. The text string is transmitted when the ENTER key is pressed. Ensure that 'TRANSMIT' is printed out.

```

CHECK
Transmit
    
```

Receive

This function is used to check characters received from the communication interface. The mode is initiated by pressing SELECT, and the first received character is displayed. Following characters can be displayed using the SCROLL key.

```

CHECK
Receive
    
```

```

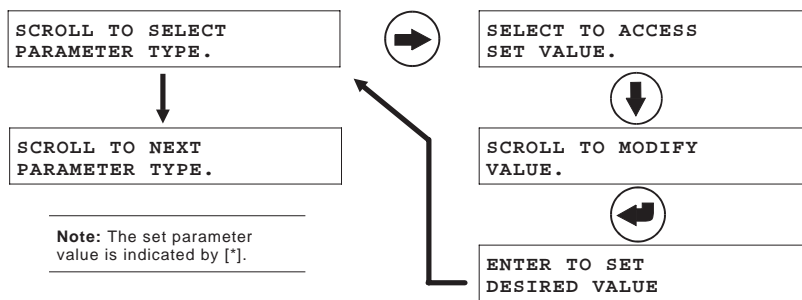
CHECK   'A'           01(22)
Receive.... 41H
    
```

- where: A = received character
- 41 = HEX-code for the received character
- 01 = character position in the character string
- (22) = number of received characters.

3.6 Parameters

The Parameters mode allows the user to set up the MFM 10 for a wide range of measurement and communication possibilities. The parameter functions are shown in Fig. 3.12, which also shows examples of changing parameters. A full list of the parameter values for each parameter function is given in this section.

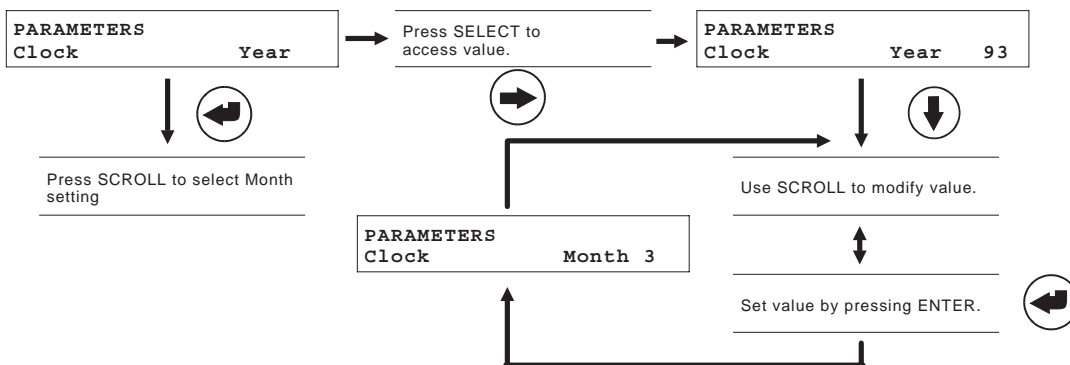
A comprehensive description of setting a parameter, date and time is given below, while the other parameters are listed. The principle of parameter setting is the same for all parameters.



Clock

Set the correct date and time.

Select “clock” and press the SELECT key. The following will appear on the display:



When the modified value has been set, press ENTER to get to the month setting. Set each date and time value, to the correct date and time.

When setting date and time all values must be selected, otherwise the newly entered value will not be set. If a value is correct then simply press ENTER, without modifying the value.

Data Logging

The frequency of measurements for automatic data logging depends on the set values of the “Period” and “Sample Rate” parameters. For example if the period is set to 120 seconds and the sample rate to 5 the five measurements are made every 120 seconds, which is a measurement every 24 seconds. These parameters should be set according to the requirements of what is to be measured. The higher the measurement rate then the shorter the time that data logging can be used. When data logging mode is selected the time available is shown on the display.

When the period parameter is set to manual, then measurements are initiated manually, by pressing the green start button. A measurement cycle in this case is a number of measurements, determined by the "Sample Rate" parameter, being taken in a "burst". The "burst" of measurements is taken at the instrument's fastest possible rate, and the results are logged, as for automatic data logging.

Period

This parameter defines the length of each logging period, and if manual or automatic logging is to be used. The values that can be selected are shown below. Each period is time stamped on the print-out.

Values = Manual, 180, 360, 900, 1800 or 3600 seconds.
Default = 3600.

If "Manual" is selected then measurement is initiated by pressing the green start button, and a "burst" of measurements is taken. The number of measurements depends on the "Sample Rate" parameter setting.

Sample Rate

This parameter defines the number of samples to be taken in each logging period.

Values = 2, 5, 10, 20 or 30 samples/period.
Default = 5.

Off Delay

If the MFM 10 is left alone for some time then it will switch itself off to conserve the batteries. The delay from the last operation to when the MFM 10 switches itself off can be set by this parameter. The instrument is switched off if the low battery or memory full warnings have been displayed. When automatic data logging and recharging the instrument the 'off delay' is disabled, as the instrument must remain on during data logging and charging. If manual data logging is selected then the off delay is set to 1 hour.

Values = 1, 2, 5 or 10 minutes.
Default = 2.

Backlight Time

To assist in viewing the MFM 10 display panel in poor lighting conditions a backlight can be used. Each time a key is pressed then the backlight is lit for a time. This parameter defines whether to switch on the backlight and the time it will remain lit.

If it is too dark to see the display and the backlight parameter is selected off the backlight can be switched on by holding down the ON/OFF switch for 3 seconds when switching on the instrument. The backlight will then remain lit so that this parameter can be set to switch the backlight on.

Values = OFF, 1, 2, 5, 10, 20 or 30 seconds.
Default = OFF.

When "OFF" is selected then the backlight is not used so that running time is prolonged.

Page Size

This parameter is used to set the page size, in number of lines, of the printer connected to the MFM 10. The value entered depends on the printer used (see Section 4, TECHNICAL DESCRIPTION for a detailed description). If a PC is connected to the MFM 10 then the 'computer' value should be entered, because this removes the header data and extra line feed commands from the measurement data sent out from the MFM 10.

Values = Computer, 46, 66, 70 or 72 lines/page
Default = 72.

Baudrate

This parameter sets the baudrate for the communication between the MFM 10 and printer (or PC).

Values = 300, 600, 1200, 2400 or 4800 bits/second.
Default = 4800.

Language

The language in which the display messages are presented can be selected by this parameter.

Values = Svenska, English, Deutsch, American.
Default = English.

Instrument No.

Where several MFM 10's are being used together, they can be given a number so that their results can be identified after they have been printed out.

Values = 1,2,3,4,5,6,7,8,9,10.
Default = 1.

Flux Unit

The units in which the measurement results are presented, can be selected by this parameter. See Section 6 TECHNICAL DESCRIPTION for further details.

Values = B in μ T, B in mG (0.1 μ T is equal to 1mG)
H in A/m (where H = magnetic field strength)
Default = B in μ .T.

Beeper

A beeper can be enabled to indicate end of measures, errors etc.

Values = Enabled, disabled.
Default = Enabled.

Fiber Optic Function

If the fiber option is installed then the following parameters are additionally available:

Commport

Select the communication port type to be used for the option. When RS232 is selected the fiber option is disabled and the instrument uses the normal (electrical) RS232 interface for printing. Remote control cannot be used in this option. This mode does not result in increased current consumption.

When **FIBER** is selected the RS232 port is disabled, and one-way communication through the fiber transmitters is possible. Remote control cannot be used in this option. However when the transmitter is on, the receiver is also on so that handshake characters can be responded to. A small increase in current consumption occurs when printing (compared to RS232).

When **FIBER 2-WAY** is selected the RS232 port is disabled and full two-way communication is possible. Remote control can be used with this mode. The receiver is active as long as the instrument is switched on, resulting in increased current consumption.

Values = RS232, Fiber, Fiber 2 way, Fiber System.
Default = RS232.

Comm Mode

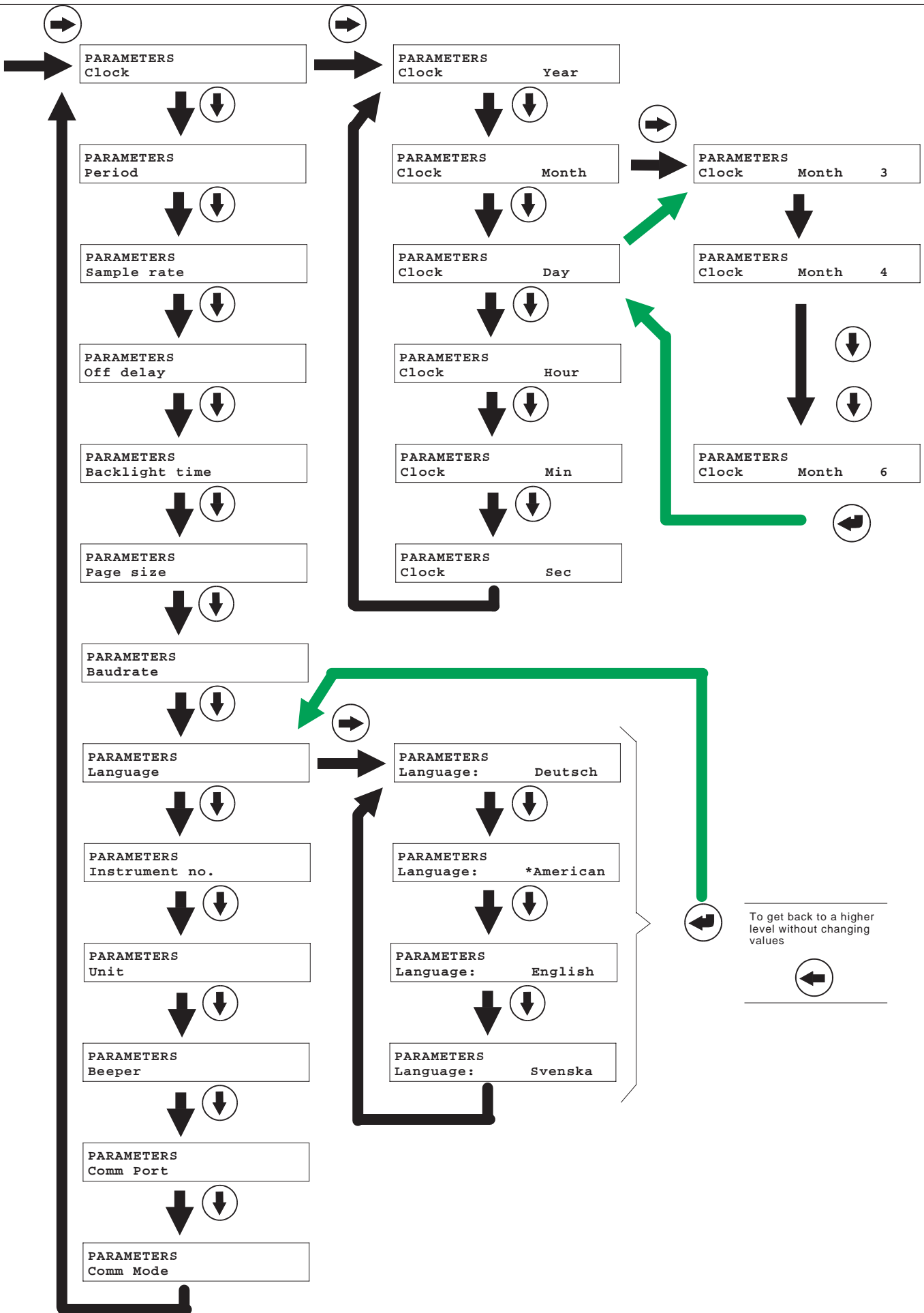
These parameters are only used for remote control.

When **TERMINAL** is selected, all control characters are converted into readable ASCII strings.

COMPUTER mode is used when the instrument is controlled by a computer. All control characters are ASCII control codes.

See Section 5 "TECHNICAL DESCRIPTION" for further details of the fiber option.

Values = Terminal, computer.
Default = Terminal.



3.7 Battery Charging

The MFM 10 instrument incorporates a rechargeable battery which normally provides at least 100 hours of operation between chargings. Be sure to keep the battery in good condition by regular charging.

Charging Code

When the instrument is switched on a code is given in the bottom right of the display panel. This code indicates the state of the last charging of the instrument.

```
MAGNETIC FIELD METER 10
92.02.01 12:34:56      1
```

The codes which can be displayed are:

- 0 = Charging completed after more than 30 min. of charge
- 1 = Charging completed within 30 min.
- 2 = Charging interrupted
- 3 = Charging failure. Voltage rise too fast
- 5 = Charging failure. Voltage rise too slow

Charging codes "0" or "1" indicate a successfully charged battery. If codes "3" or "5" are displayed, this indicates a bad battery or a charging circuit failure. If any code is displayed other than "0" or "1" (charging completed) then check the battery voltage. Refer to Section 3.5 for details of checking the battery voltage. If the voltage is below 11.5V then the instrument should be recharged.

When the battery voltage reaches the minimum operational level a message is displayed and the instrument automatically stops any measurements to avoid erroneous results.

```
MEASUREMENT Single
Charge battery
```

```
MEASUREMENT M-logg      #1
Truncated, bad battery
```

Before using the instrument for data logging over a long period of time, the battery should be charged.

Recharging Procedure

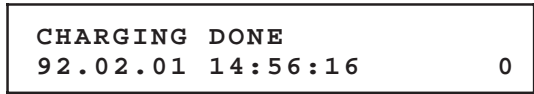
Connect the battery charger (standard accessory) as shown in Fig. 3.13. Before connecting the power supply ensure that the charger is the correct type for the local mains supply.

Switch on the MFM 10 and charging will start. The instrument must be left on during charging, as the microprocessor controls the charging process. The following message is displayed:

```
CHARGING BATTERY
92.02.01 10:02:00
```

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If the battery voltage is below the minimum operational level then recharging will take approx. 10 hours. 'CHARGING DONE' will appear on the display when recharging is complete, and the instrument will switch itself off after the set delay (see Section 3.6).



Disconnect the charger. Switch on the instrument to check that the battery charging code is either "0" or "1". Otherwise check the battery voltage, which should be approximately 12.5V for a fully charged battery.

IMPORTANT!

Always charge the battery:

- » If the voltage is below 11.5V.
- » If the instrument is not being used for a long period of time.
- » If the instrument is to be used for a long data logging period.

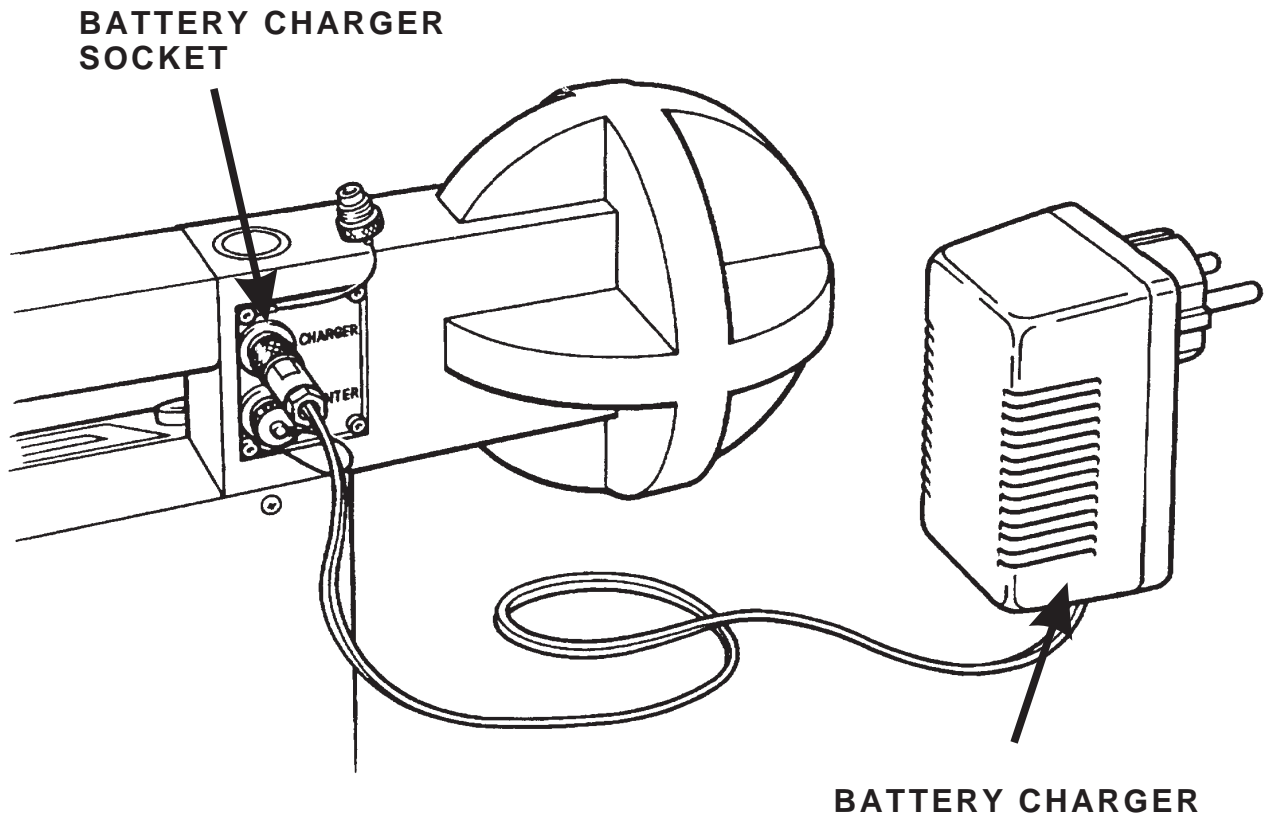


Fig. 3.14 Battery Recharging

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Section 4

TECHNICAL DESCRIPTION

	Page
4.1 Antenna	4.2
4.2 Electronics	4.3
4.3 Measurement Principle	4.5
4.4 Printing with the MFM 10	4.6
4.5 Fiber Optic Remote Operation	4.8
4.6 Fiber Adapter 10	4.11

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4.1 Antenna

The antenna is shown in simplified form in Fig. 4.1 and consists of three perpendicularly aligned windings with a common center. Each winding consists of 400 turns of insulated wire with a winding area of 0.01m². The spacing between the turns and screen has been selected so that self-capacity effects do not give rise to resonance peaks near to or at the frequency range of the instrument. There is also a separate electrostatic screen around each of the windings.

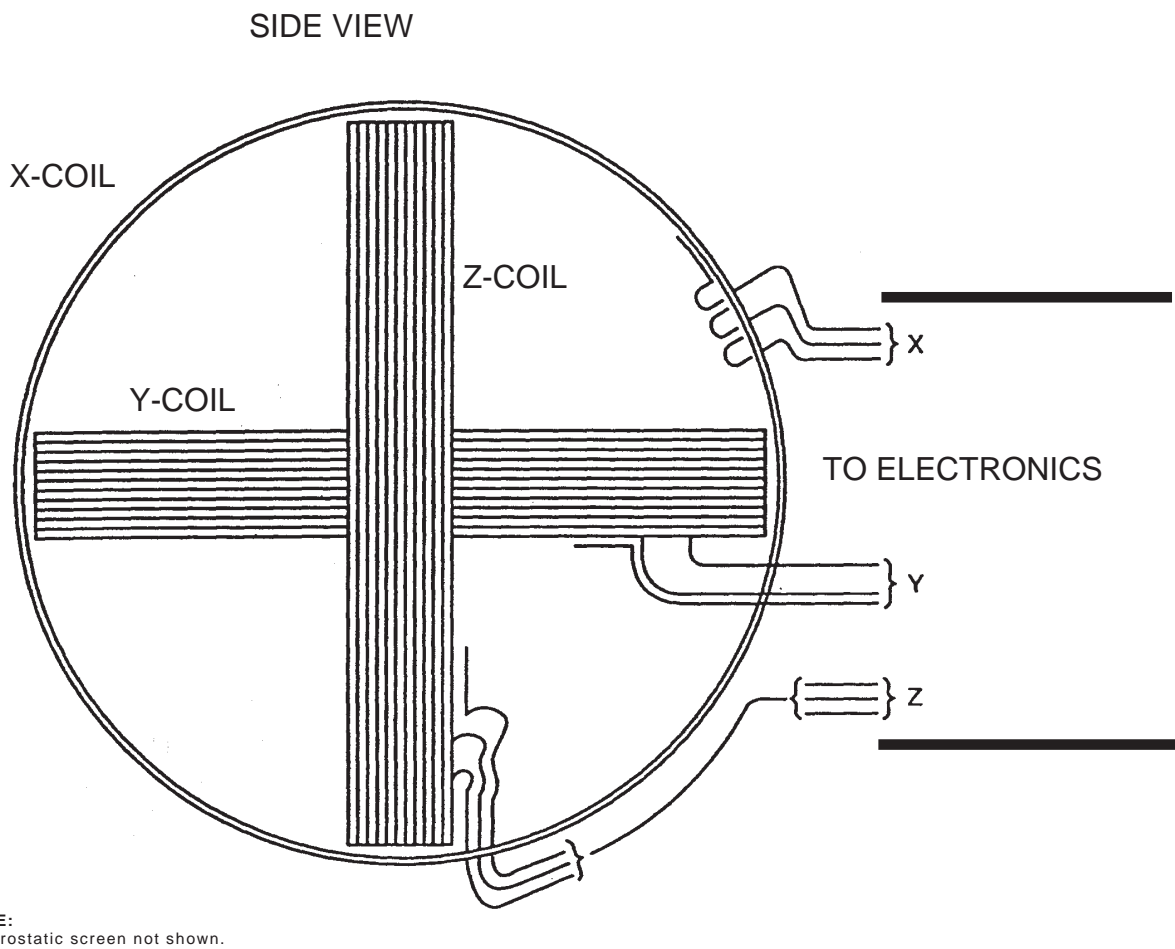


Fig. 4.1 Antenna

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4.2 Electronics

The electronics of the MFM10 can be divided into analogue and digital parts. The analogue parts carry out the measurements while the digital parts carry out the overall control of instrument function, power supply monitoring, display and communication control. Figure 4.2 is a simplified block diagram of the analogue part.

The analogue parts of the MFM 10 have the following main functions:

- Integrator stages with selectable time constants.
- Two-pole low-pass filters with a cut-off frequency of 2000Hz.
- Four-pole high-pass filters with a cut-off frequency of 5Hz.
- Amplifier stages with automatic amplification selection.
- Track and hold" circuits to allow the synchronous sampling of the instantaneous value of flux.
- An analogue multiplexer followed by a 12-bit A/D converter.

The digital parts of the MFM 10 have the following main functions.

- Battery voltage monitor and recharging control.
- Micro computer with peripheral circuits (EPROM, RAM) to control data acquisition, result calculation, data logging, and overall instrument control.
- EEPROM memory to store user defined instrument parameters. RAM memory to store results data. Up to 4,000 results can be stored.
- A 2 x 24 character, alphanumeric display for presentation of magnetic flux δ (in μT or mG), magnetic field strength (A/m), dominant frequency (Hz) and polarization (%).
- Operator control panel and its interface.
- Serial communication port (RS232C) for communication with a printer for hard-copy print of measurement results, or to a PC for measurement result evaluation.

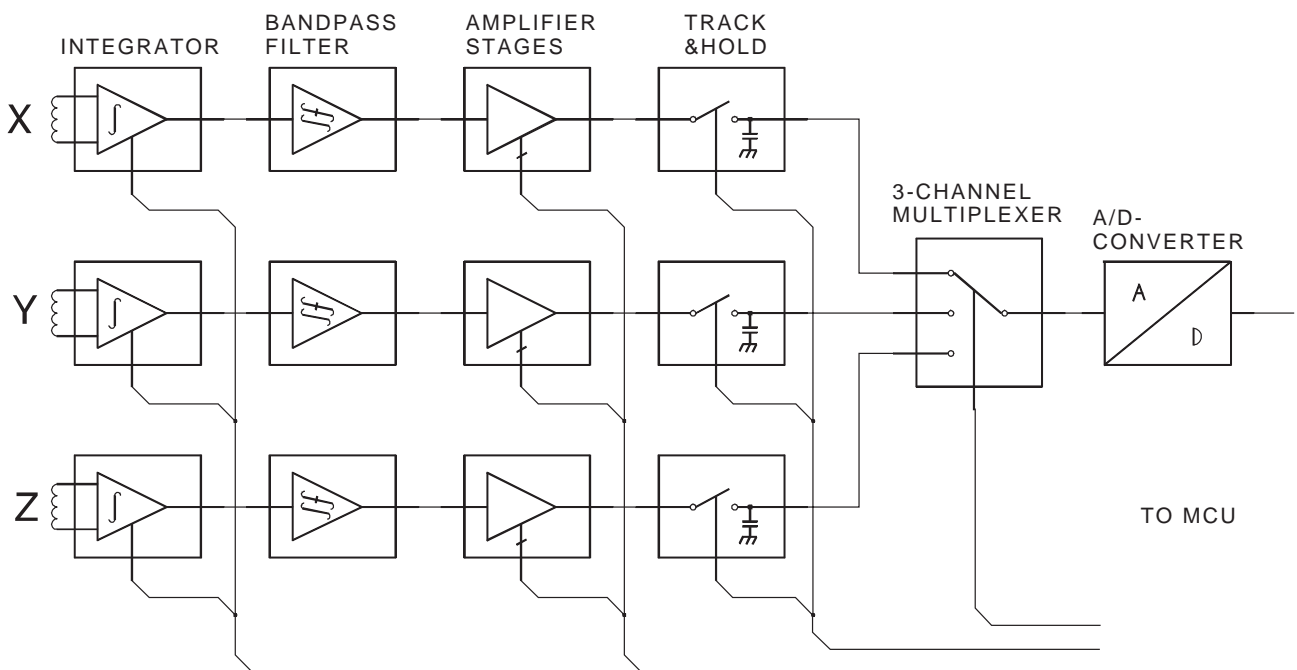


Fig. 4.2 Analogue Circuit Simplified Block Diagram

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4.3 Measurement Principle

A combination of analogue and digital measurement techniques are used to measure the flux density at the antenna location. The signal from each sensing coil is integrated, filtered and amplified using analogue amplification techniques. Figure 4.2 is a block diagram of the analogue circuit for one measurement coil. These signals are obtained from the three coils at an initial sampling rate of 10k/ (s)ample. The frequency of the largest coil signal from the three coils is determined by auto-correlation. This technique calculates the signal frequency by taking one complete period, then adding a delay to a copy of that period. When the two periods are correlated to each other the added delay (Δt) is used to determine the frequency. The calculated frequency is then used to set a sampling interval so that complete waveforms can be measured. At this time the gain of the amplifier stages is set, depending on the amplitude of the strongest signal, so that the optimum measurement resolution is maintained.

For each measurement, three values are obtained which correspond to the instantaneous values of flux density from the triaxially aligned sensing coils. The three digital results are squared and added. The appropriate results: flux, frequency and polarisation, are presented on the LCD display. The flux RMS value is calculated by measuring a complete period once the sampling interval has been determined. This is done by taking 2^{10} (1024) samples over an integer number of periods, enabling a true RMS value to be extracted.

The presented total value is calculated from:

$$B_{rms} = \sqrt{\sum_{n=1}^N \frac{(B_{xn}^2 + B_{yn}^2 + B_{zn}^2)}{N}}$$

where $N = 1024$ and B_{xn} , B_{yn} , B_{zn} are the flux density for all three directions in the instant n .

The polarization degree is then calculated as:

$$\text{Polarisation in \% } s = 100 * \sqrt{\frac{B_{min}^2}{B_{max}^2}}$$

where

$$B_{max}^2 = \text{Max.} \left[\sum_{n=1}^N (B_{xn}^2 + B_{yn}^2 + B_{zn}^2) \right]$$

$$B_{min}^2 = \text{Min.} \left[\sum_{n=1}^N (B_{xn}^2 + B_{yn}^2 + B_{zn}^2) \right]$$

For a single phase source giving a magnetic field in only one direction, the polarisation result will be 0% since B_{min}^2 is equal to zero.

For a three phase system with equally spaced phase angle difference and equal distance between the conductors (triangle form), the resulting field in the geometrical center will be a circular polar wave with constant amplitude. In this case, B_{\min}^2 will be equal to B_{\max}^2 , thus giving 100% polarization.

In practical cases with three phase power lines with other geometrical forms, the resulting polarisation will be less than 100%.

In cases with several single phase sources with different phase angles, the resulting polarisation will be more than 0% and less than 100%.

The polarisation value can thus be used as a measure of the complexity of the magnetic field, whether it is a single source or several sources contributing to the measured value

4.4 Printing with the MFM 10

Result data measured and stored by the MFM 10 can be transferred, via a serial communication port (RS232) to a printer or PC. Figure 4.3 shows the location of the serial communication port.

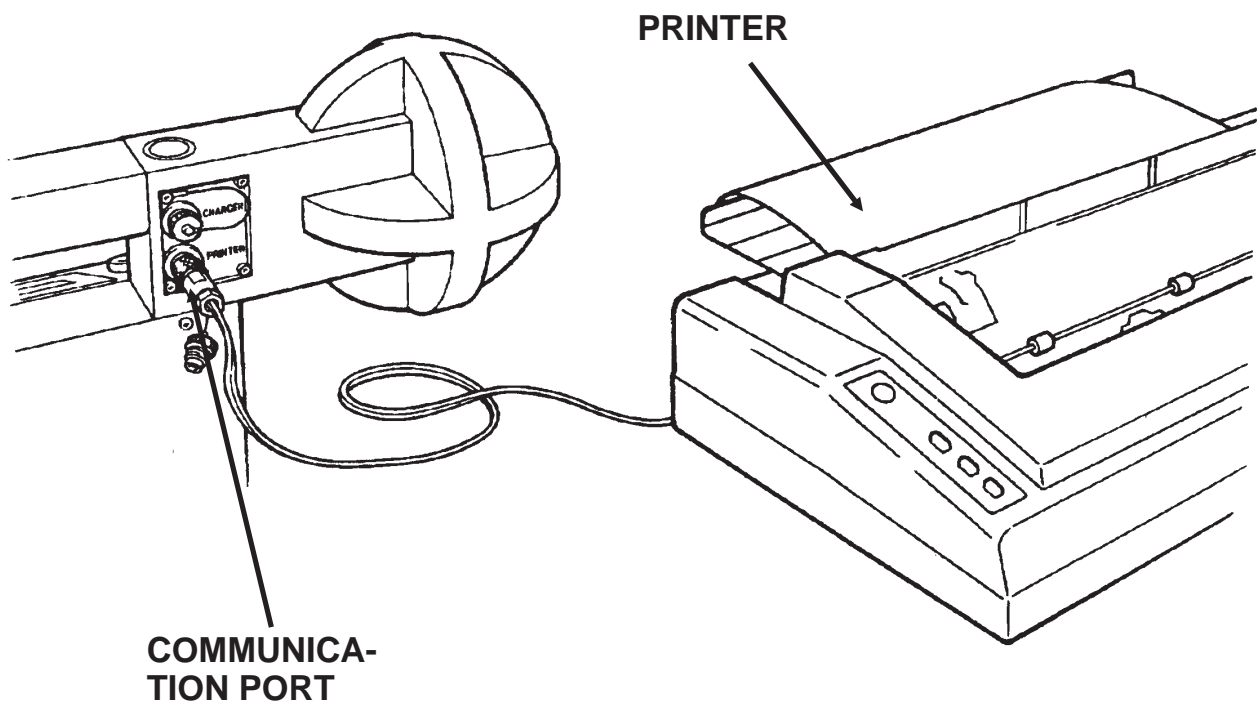


Fig. 4.3 Serial Communication Port

There are two cables supplied with the instrument, one with a 25-pin female D-SUB connector and one with a 25-pin male D-SUB. The cable with the female connector is used when the data from the MFM 10 is sent to a computer and the cable with the male D-SUB should be used when sending the data to a printer.

The cables are wired as show in Fig. 4.4(a-b)

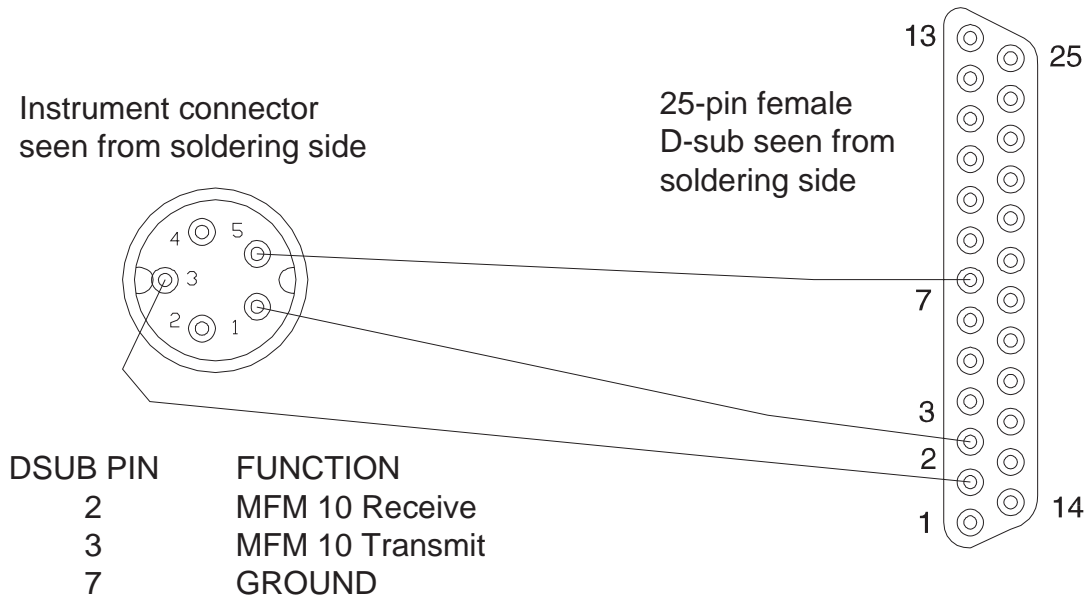


Fig. 4.4(a) Computer Cable

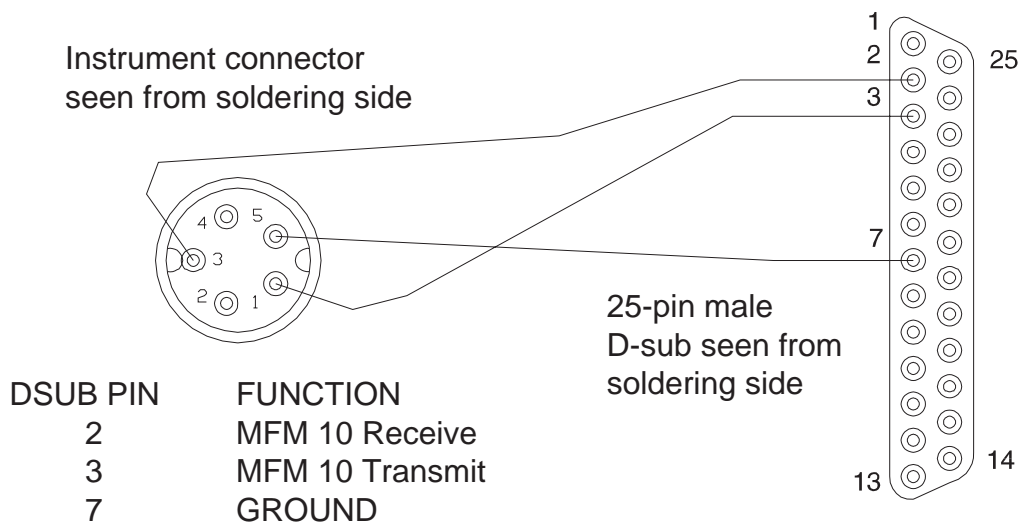


Fig. 4.4(b) Printer Cable

Note that no electrical handshaking is used. Electrical levels are standard RS232 and the data flow is controlled by sending XON and XOFF characters to the instrument.

- » Sending XOFF (ASCII 013H) to the MFM 10 disables transmission.
- » Sending XON (ASCII 011H) to the MFM 10 enables transmission.

All printouts start with the SOH (ASCII 001H) character and ends with the EOT (ASCII 004H) character.

The parameter **page size** is used to control the printout format. Page length can be selected between **46, 66, 70** or **72** lines per page. The formfeed character (ASCII 00CH) is not used to advance to the next page. Instead, carriage return, line feed (ASCII 00DH and ASCII 00AH) codes are used to advance to the next form.

There is also the selection **Computer** under Page size. Selecting **Computer** will disable the form feed function as described above and send the data without page formatting, suitable for reception by a computer.

4.5 Fiber Optic Remote Operation

The fiber option card is mounted inside the instrument and two holes at the rear of the MFM 10 are used to access the fiber connectors. The fiber option for the MFM 10 contains:

- » MFM 10 fiber option card (placed inside the MFM 10)
- » 10 meter's of plastic fiber, ready to use
- » Software for the instrument to support fiber option.
- » One Combinova Fiber Adapter 10 (separate order)

The Combinova Fiber Adapter 10 is designed to use the MFM 10 charger as the power supply. The power connector at the rear of the Fiber Adapter 10 is the same type as the charger connector on the MFM 10.

Remote Controlling the MFM 10

To enable the remote control of the MFM 10 select **Fiber 2 way** in PARAMETERS COMM PORT (see Sec. 3.6). If the instrument is set to **FIBER 2 WAY**, it will automatically go into MEASUREMENT mode when the instrument is turned on. This is to make sure that the instrument can be talked to immediately. Leaving MEASUREMENT mode will cause the instrument to respond with NAK (Command not accepted). The only way to re-establish remote control is to return to MEASUREMENT mode.

Remote control of the MFM 10 is carried out by sending a valid command character to the instrument and wait for the reply.

- 1: Transmit the command character to the instrument (A, B or C).
- 2: The instrument will immediately reply with 'ACK' if the command was accepted or a 'NAK' if it was not.
- 3: After the command has been executed the result will be sent by the instrument.

Result Description

The result string is divided into result fields. The fields are separated with one or more spaces (ASCII 020H).

Ex: '2.45 μ T 100Hz'
 ↑ ↑
 Field 1 Field 2

The ' μ T' and 'Hz' can be ignored since the result is always in microtesla and hertz. The results of command A also contain the frequency of the ELF signal. If the frequency cannot be determined, the result is 'Mixed' or 'Noise'.

Ex: '.1234 μ T Mixed'

If the frequency is below 10Hz, the result is '<10Hz'.

Ex: '.1234 μ T <10Hz'

If the frequency is over 1000Hz, the result is '>1kHz'.

Ex: '.1234 μ T >1kHz'

Always wait for the result before sending any more characters to the instrument, otherwise the behavior of the instrument may be unpredictable.

Command Descriptions

There are three commands available in the remote mode. These are:

Command A

ASCII character 'A' (Hex 41):

This command starts a measurement in the MFM 10.

It performs a single measurement and sends the result to the computer. The result consists of the measured field and frequency.

Ex: SOH, .1234 μ T 50.1Hz, EOT
 ↑ ↑
 Total Frequency

Command B

ASCII character 'B*' (Hex 42):

This command starts a measurement in the MFM 10. This is basically the same as command 'A', the difference being in the result format. The result is extended and the measured field is separated over three axes.

Ex: SOH, '.1234 μ T .056 μ T .101 μ T .043 μ T 50.1Hz', EOT

↑	↑	↑	↑	↑
Total	X	Y	Z	Frequency

Command C

ASCII character 'C' (Hex 43):

This command orders the instrument to return its battery voltage, estimated remaining operating time and identification characters.

Ex: SOH, 12.5V 50H 10', EOT

↑	↑	↑
Voltage	Time	ID

The first digit in the ID section is '1'. This informs the controller that the responding instrument is an MFM 10. The second digit '0' is the mode character. This character is always set to '0'.

Selecting 'COMPUTER' under COMM MODE [see Section 3.6)

The result transmission starts with the 'SOH' character followed by the string which is ended by an 'EOT' character. The special ASCII control characters 'ACK', 'NAK', 'SOH' and 'EOT' have the following codes:

- » ASCII character 'ACK' has the hex code 006H
- » ASCII character 'NAK' has the hex code 015H
- » ASCII character 'SOH' has the hex code 001H
- » ASCII character 'EOT' has the hex code 004H

Selecting 'TERMINAL' under COMM MODE

The control characters 'ACK' and 'NAK' will be replaced with the ASCII string 'ACK' or 'NAK'. All messages are terminated with carriage return, linefeed (ASCII 00DH, 00AH). The control codes 'SOH' and 'EOT' are not used.

4.6 Fiber Adapter 10

The Combinova Fiber Adapter 10 is used to establish RS 232 communication via fiber optic cable for improved transmission range and noise immunity.

The Fiber Adapter 10 has a 25-pin DSUB female connector for direct connection to a standard PC RS 232 serial communication port.

The fiber optic is of low cost plastic type with simple single action connections, giving an effective range depending on the selected data speed of up to 100 meters.

The fiber connections are colour coded with a grey connector being the transmitter and a blue connector being the receiver.

The adapter is normally powered by the MFM 10 battery charger. However, the adapter is able to operate with voltages between 18 and 36 volts DC.

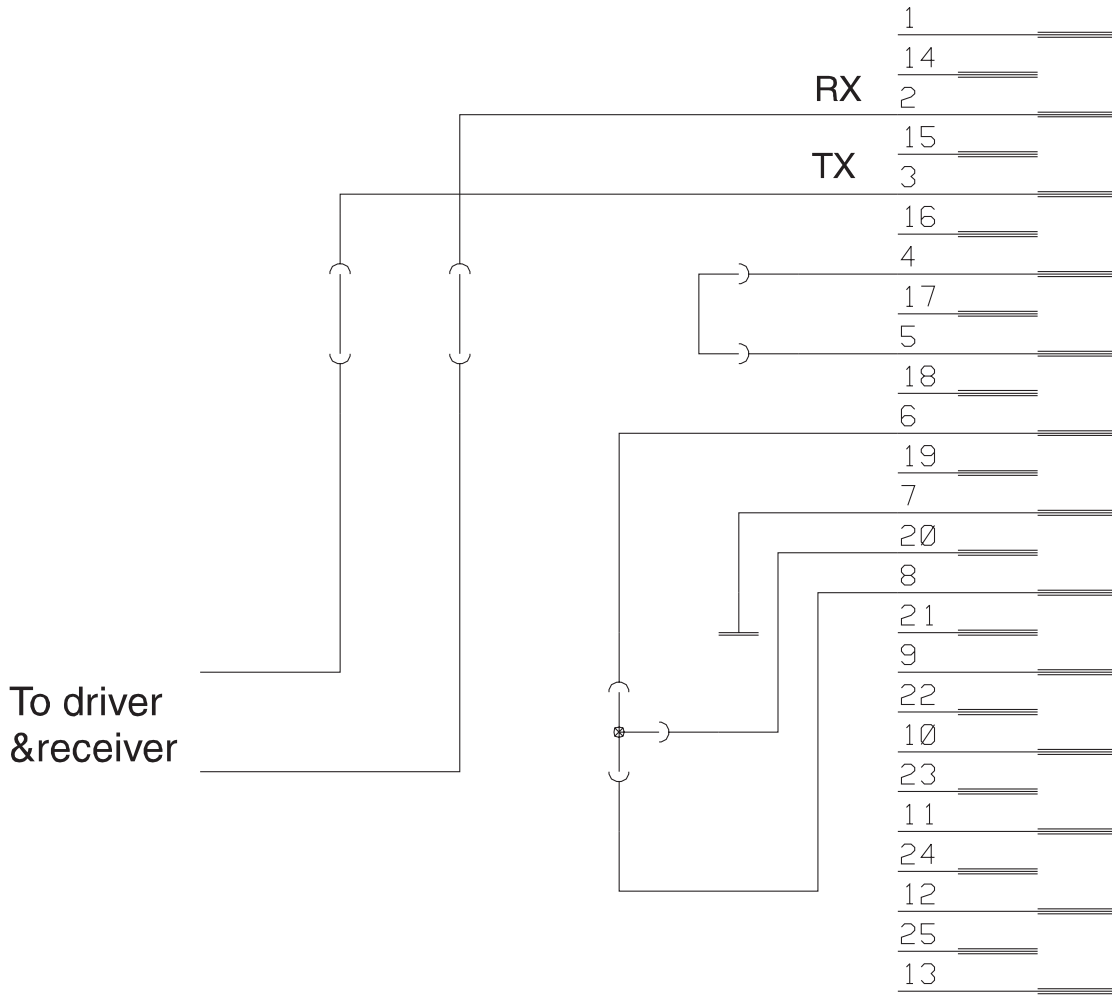
The unit is a small and slim metal box, making it possible to connect it to the computer without using extension cords.



Fig. 4.5 Fiber Adapter 10

Connections

The 25-pin D-SUB connector has the following pin-out:

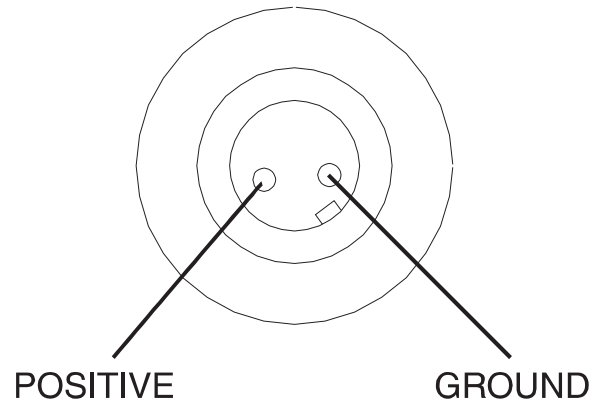


Pin	Function
2	Adapter Receiver (Rx)
3	Adapter Transmitter (Tx)
4	PC Request To Send (RTS)
5	PC Clear To Send (CTS)
6	PC Data Set Ready (DSR)
7	Ground
8	PC Carrier Detect (DCD)
20	PC Data Terminal Ready (DTR)

Fig. 4.6 Fiber Adapter 10 Pin-out

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The power connector has the following pin-out:



Pin	Function
1	Positive (18-36 Volts DC)
2	Ground

Fig. 4.7 Power Connector Pin-out

Section 5

SPECIFICATIONS

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Individual data given in the technical data are subject to change without prior written notice. Specifications are given at the temperature $T_{amb}=23\pm 5^{\circ}$ centigrade.

Measurement

Measurement range: 0.01 - 10000 μ T Automatic range selection (in four ranges)

Display resolution: Better than 0.5% of reading or 0.001 μ T

Accuracy: Better than $\pm 2\%$ of reading or $\pm 0.005\mu$ T.
Typical $\pm 1\%$ of reading or 0.003 μ T

Frequency response: 5 to 2000Hz - 3dB points of amplifier range (Digital output range 10 to 1000Hz)

Polarization : 0 to 100% (B(min)/B(max))

Display

Type: 2 x 24-digit, alphanumeric liquid crystal display, incorporating backlight display.

Memory

Parameter: EEPROM, instrument parameters are defined by the user and stored in the non-volatile memory. Settings are retained, even if the battery pack is changed.

Results data: Up to 4000 results together with time and date identification.

General

Battery: Rechargeable 12V, 2Ah sealed lead-acid battery, with max. operating time of 100 hours in normal use.

Communication: RS232C serial port. Optional fiber optic port

Dimensions: Length: 380mm
Width: 115mm
Height: 250mm
Weight: 3.0kg

Operating temp.: -10 $^{\circ}$ C to +50 $^{\circ}$ C

Environmental: Water resistant.

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Section 6

ERROR CODES

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6.2 Measurement Errors	6.3
6.3 Data Retrieve Errors	6.3
6.4 Print Errors	6.3

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6.1 Instrument Errors

```
MAGNETIC FIELD METER 10
93.03.09 15:00:00 1
```

Start-up checks complete, instrument OK.

```
MAGNETIC FIELD METER 10
Logged data lost
```

Message displayed if battery has been disconnected.

The message can be canceled by selecting "Start logging"

```
ROM-Error
Call Service
```



```
RAM-Error
Call service
```



```
MAGNETIC FIELD METER 10
EEPROM error
```



Use the SCROLL key to cancel the error message.

Calibration and parameter settings are lost. Default values will be used.

Measurement accuracy $< \pm 10\%$. Call for service.



```
MAGNETIC FIELD METER 10
Program error #xx
```

Program execution has stopped for some reason. Use the SCROLL key to cancel the error message.

Report the fault to Combinova AB.

NOTE: If program error #26 occurs then this indicates a Watchdog timeout. This could appear due to an external disturbance such as:

- A cable is connected during measurements
- A strong external discharge

Acknowledge this code by pressing SCROLL or SELECT to recover normal operation.

Normally there is no problem with the instrument if this code would appear, but stored data may be lost, because of this fault.

6.2 Measurement Errors

Measurement E1	Fading signal
Measurement E2	Overrange
Measurement E6	Offset too large
Measurement E8	Charge battery
Measurement E9	Measurement mode error

6.3 Data Retrieve Errors

Data retrieve - - - No data - - -	This message will be the result of a loss of logged data
--------------------------------------	---

6.4 Print Errors

Print - - - No data - - -	This message will be the result of a loss of logged data
------------------------------	---