ELECTRIC FIELD
METER 100
Operators Manual

The EFM 100 is a professional instrument to measure alternating electric 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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1. INTRODUCTION

1.1 Electric field measurements with EFM 100

Electric fields exist in a very wide range of amplitudes and frequencies. The EFM 100 is designed to handle low frequency electric fields.

- ELF frequency range (5-2,000 Hz) from 0.5-10,000 V/m (rms)

- VLF frequency range (2-400 kHz) from 0.05-1,000 V/m (rms)

Measurements are made using ground reference techniques to reflect the electric field from a source to a specific size of ground reference probe. The instrument is specifically designed to fully comply with the Swedish MPR II (1990:8) test methods for VDU's effective from 1 January 1991. All accessories needed for MPR II measurements is delivered with the standard instrument (details in section 2).

1.2 The instrument - EFM 100

Electric Field Meter 100 is a professional instrument to measure alternating electric fields. The instrument has a wide dynamic range with automatic gain settings. Two different frequency ranges are available; ELF (5-2,000 Hz) and VLF (2-400 kHz).   The instrument is operated from a built in chargeable battery. The built in communication interface (Fiber optical) can be used for remote control of the instrument from a computer or be used with the Combinova CMS package.

The electronics in the instrument consists of analog amplifiers, a microcomputer with communication peripherals and an alphanumerical LCD-display.

1.3 Using the EFM 100

Performing measurements:

The instrument is very straightforward to use, simply press **ON/OFF** to turn instrument on, scroll to the desired mode with the **MODE** button and press the **START** button to select.
When the instrument shows 'Waiting for start', press **START** to make a measurement. The result will be displayed within a few seconds.

To simplify measurement setups, the instrument remembers which mode that was used when the instrument was switched off. Simply press **START** directly after power on to restart the last measurement mode.

A nonalterable automatic turn-off delay shuts the instrument off to conserve battery life if the instrument is not used in more than 30 minutes.

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1.4 COMBINOVA AB - The company behind the product

The Electric Field Meter 100 has been developed by Combinova AB, who are also responsible for the manufacture, marketing and central after-sales service of the product. The EFM 100 is part of the range of Field Meters which have all been developed by Combinova AB.

Other related Combinova products are:

 * EFM 200   - Electric Field Meter, electrostatic and alternating electrical fields.
 * MFM 2000   - Magnetic Field Meterfor TCO measurements.
 * MFM 3000   - Magnetic Field Meter in the (5 Hz-400 kHz) range.
 * MFM 2020   - Automatic Systems for VDT magnetic field measurements.

In addition to the instrument product line Combinova AB also works as development partner for Swedish and international customers covering a broad area of technical development.

The principle areas of technical expertise are:

 - instrument development
 - measurement solutions and technical trouble shooting
 - design and production of special manufacturing equipment.

The depth and wide range of technical expertise in the company makes it possible to handle all stages of product development.

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S-19740 BRO
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Section 2

UNPACKING AND INSPECTION

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UNPACKING AND INSPECTION

The EFM 100 is delivered in a specially designed transportation case, which also contains all standard and optional accessories used with the instrument. Inspect the transportation case for any damage caused by transportation. If damage has occurred, please contact the shipping company that delivered your instrument.

- » EFM 100 standard version

- » EFM 100 instrument

- » Battery charger PS 10 (110 V or 220 V)

- » Ground reference cable (black 3 m with connection clip)

- » Fiber optical cable (10m)

- » Distance measurement tool

- » Operators manual

IMPORTANT!

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

Before switching on and using the instrument, read this manual!

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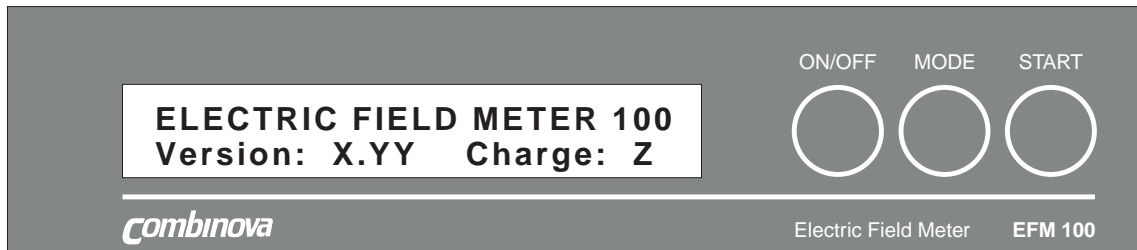
Section 3

OPERATING INSTRUCTIONS

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3 OPERATING INSTRUCTIONS

3.1 General operation

The instrument is turned on using the **ON/OFF** button. First a number of tests are performed and if no errors are found the display response is:

```
ON/OFF    MODE    START

ELECTRIC FIELD METER 100
Version: X.YY    Charge: Z          ( )   ( )   ( )

Combinova              Electric Field Meter    EFM 100
```

X.YY indicates which software version the instrument is equipped with.

Z indicates the result of last battery charging.

See section 3.5 for a description of the charging codes.

The **ON/OFF** button is used to switch the instrument on and off.

The **MODE** key is used to switch the instruments between the seven possible instrument functions:

> Single ELF measurements
> Single VLF measurements
> Single ELF+VLF measurements
> Check (see section 3.3)
> Remote control (see section 3.4)
> Beeper (see section 3.5)
> Measure power off delay (see section 3.6)

The **START** button on the instrument is used to start single and repetitive measurements (details in section 3.2).
It is also used as SELECT when choosing mode or using CHECK.

The instrument remembers the last measurement mode used, simply press the **START** button directly after power on to restart.

3.2 - MEASUREMENT

To start measurement turn on the instrument with **ON/OFF**.

IMPORTANT!

Always connect the ground pin on the EFM 100 to the field source ground (most often the mains ground) reference as the illustration shows.
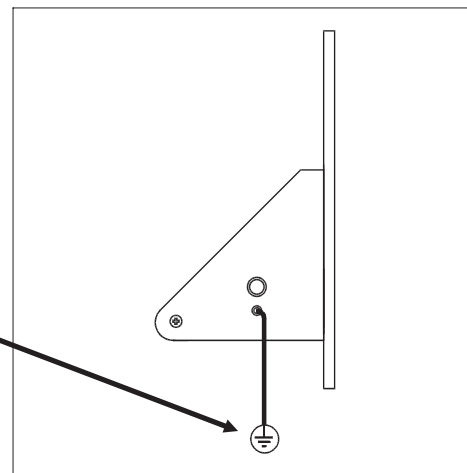
Use the **MODE** button to select the desired measurement mode.
By pressing the **START** button the instrument will perform a measurement.

The measurement result will be displayed after a few seconds.

For repeating measurements keep the **START** button depressed during the first single measurement. The instrument will make 200 measurements and then stop. Return to single measurement by using the **START** button again. See the Charging mode parameter in section 3.7 for information about setting a true continuous mode.

A check of background field levels in the laboratory is needed to make accurate measurements related to a specific field source.

During measurements the instrument should be disconnected from the battery charger to avoid interferences.

MEASUREMENT RESULTS

ELF measurement
- alternating ELF electric field measurements. In addition to the result, the fundamental frequency of the signal is displayed.

VLF measurement
- alternating VLF electric field measurements.
In addition to the result, the crest factor (= peak value divided by rms value) is displayed.

ELF+VLF measurement
- alternating ELF and VLF electric field measurements.
Only the results will be displayed, there is no frequency of the ELF signal or crest factor of the VLF signal.

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3.3 - CHECK

Use the **MODE** key to scroll to the CHECK section.
Check mode includes a number of tests to verify different instrument functions.
Use the **MODE** key to scroll through the different choices.

Check: Battery

Press **START** and the display will indicate current battery voltage.

The instrument will work properly if battery voltage is above 11.0 V.

IMPORTANT!

The instrument should be recharged if the if the battery voltage is below 11.5 V.
If the instrument is not to be used for a longer period (several months), make sure that the battery is fully charged.

Check: Transmit
Each time the **START** key is pressed, the string 'TRANSMIT' is transmitted
on the fiber communication port.
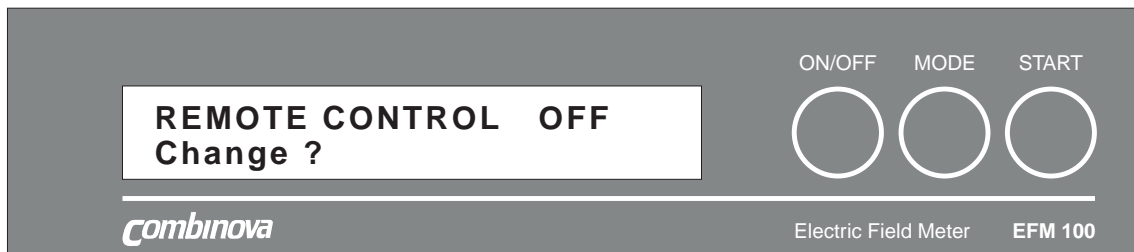
Check: Receive
This function displays characters received on the communication port.
Enable this check by pressing **START**.
The last received character will be displayed on the bottom row of the display.
Use the START key to scroll through all received characters.

To quit any of the CHECK modes, press **MODE**.

3.4 EFM 100 REMOTE CONTROL

Remote control ON/OFF:

Press **MODE** to scroll to the Remote control ON/OFF menu:

```
                                        ON/OFF    MODE    START

    REMOTE CONTROL   OFF                   ◯        ◯       ◯
    Change ?

    Combinova                         Electric Field Meter   EFM 100
```

Press **START** to select either ON or OFF and then press **MODE** to enter.
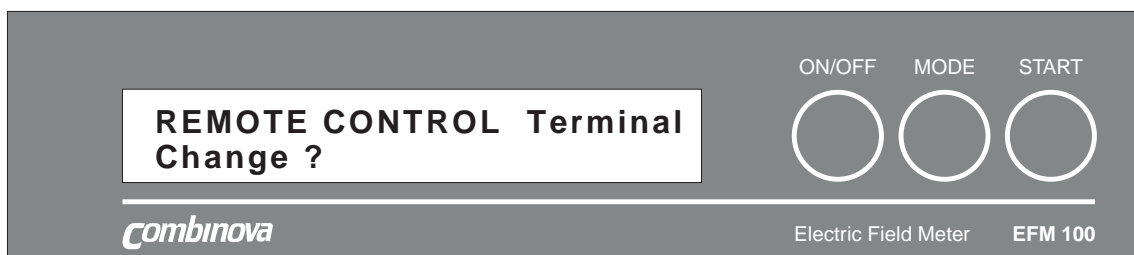
In this mode, measurements can be started via the fiber communication.
The keys are still operable.
Each measurement results will be shown on the display.

The **START** button may be used together with the Combinova CMS remote control
software package to start a measurement sequence.

When remote control is set to ON, the instrument will automatically go into
measurement mode after power on.

Remote control Terminal/Computer

Press **MODE** to get to the Remote control Terminal/Computer display:

```
                                        ON/OFF    MODE    START

    REMOTE CONTROL  Terminal               ◯        ◯       ◯
    Change ?

    Combinova                         Electric Field Meter   EFM 100
```

Use **START** key to select either Terminal or Computer and then press **MODE**.

Selecting **Terminal** will make all control characters (such as ACK, acknowledge)
to be sent in readable ASCII strings, suitable for reception by a simple text terminal.

Selecting **Computer** will make the opposite, all control characters will be the actual
binary code (like ACK which has the code 06H) suitable for reception by a computer.

For details about remote control and technical information about the fiber
communication,see chapter 4, 'TECHNICAL DESCRIPTION'.

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3.5 - Beeper

This function is used to turn the instrument beeper on or off. Use the START key to select ON or OFF.

```
                                                       ON/OFF    MODE    START
    ┌─────────────────────────────────────┐
    │  Beeper                ON           │            ◯         ◯        ◯
    │  Change ?                           │
    └─────────────────────────────────────┘

       combinova                                    Electric Field Meter   EFM 100
```
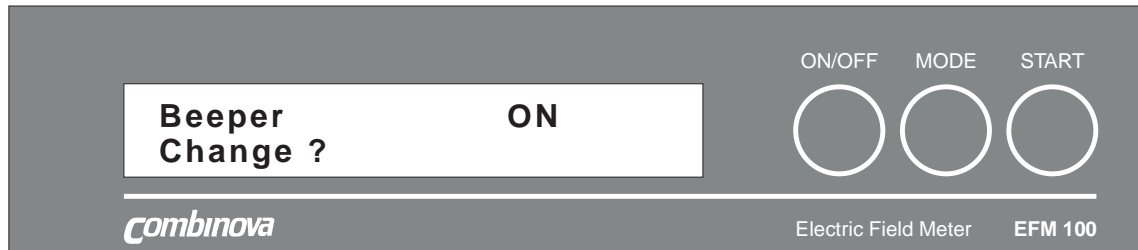
3.6 - Measurement speed

This function is used to speed up measurements in remote mode by keeping power to the measurement electronics on for a longer time and making certain optimations in the measurement procedures.

Making measurements not to wait for a power up sequence before doing the actual measurement is the biggest time saver. In addition, ELF measurement times are shortened by making a check of the necessity for a change in measurement range as opposed to the normal procedure where a complete range optimization is done for each measurement.

Frequency measurement in ELF is also optimized. In normal mode, a complete frequency analysis procedure is done for each measurement. This is quite time consuming so to shorten the time, the complete frequency analysis is only done:

- at the first measurement after instrument power up.
- at the first measurement after the measurement power off delay of 10 min. has expired.
- when changing measurement range.

The frequency result is then saved and used in all following measurements until the condition described above for making a new frequency measurement is satisfied. This means that the measurement signal source frequency should be stable during measurements that does not change range. The only way to force a new frequency measurement without turning the instrument off or waiting for the delay timeout is to make the instrument change measurement range by applying or removing a signal source.

Select measurement speed with the START key. The available choices (in remote-only) are:

Normal, Fast

Normal selects standard remote mode with a measurement electronics power off delay of 30 seconds. Complete frequency analysis is made.

Fast selects the increased measurement speed mode. This may result in shortened operation time before recharging due to the 10 min. measurement electronics power off delay.
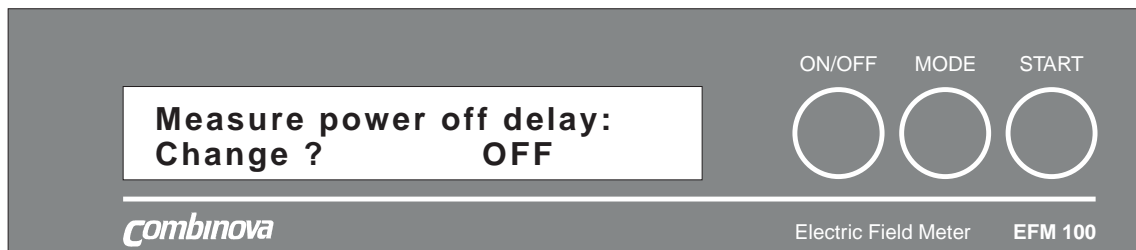
3.7   - Charging mode

This function is used to switch between normal charging, as described in section 3.8, auto charging and continuous charging mode.

This parameter is available in Remote-On only.

When **Auto** is selected and the charger is connected, charging will automatically start if the battery voltage is less than 12,5V and no measurements have been made during the last 10 minutes.

The charging will continue for eight hours if the instrument is left in idle. Any attempt to use the instrument such as:

- A remote command
- A key press
- A manual power off

will immediately stop the charging process.

This automatic charging function is most useful in a system application where the instrument is stationary and remote operated. No manual charging operations are needed, if the charger is connected the instrument will manage the battery maintenace automatically.

Continuous charging mode will cause the repeating measurement function described in section 3.2 to run forever without interruption until the START key is pressed again or the instrument is turned off. During a repeating measurement, the battery is continuously monitored and charged if necessary. This function is most useful in a system application where the instrument is stationary and manually operated/supervised. The instrument can measure continuously while managing the battery maintenance automatically. **NOTE!** The Continuous mode is lost at power off and Charging mode will be reset to Auto.

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IMPORTANT:
To minimize the measurement result influence from the charger, the charger and its cable should be located as far away from the probe as possible.

3.8   - BATTERY CHARGING

Charging is automatically controlled by the built in microcomputer.

Make sure that the EFM 100 is switched off and connect the charger to the EFM 100.
Before connecting the charger to the mains supply, ensure that the charger is the correct type for the local mains supply.
Turn instrument power on.

The display will show that the charging has started:

During charging, the battery voltage is constantly checked against different limits by the microprocessor to decide if the charging is working properly.

The microcomputer expects a MAXIMUM voltage rise over a period of time.
If the voltage rise is too fast, the battery has too high internal resistance and is considered faulty.
The instrument will indicate this error on the display with charging code 3.

The microcomputer also expects a MINIMUM voltage RISE over a period of time.
If the voltage rise is too slow, the battery is not accepting charge and is considered faulty.
The instrument will indicate this error on the display with charging code 5.

If errors 3 or 5 occurs, there is a hardware error that needs repair.

When charging is completed,the instrument will show **CHARGING DONE** on the display and then shut itself off after the power-off delay.

IMPORTANT!

-       Always charge battery when battery voltage is below 11.5V.

-       If the instrument is not to be used for a longer period (1 month or longer), always make sure that the battery is fully charged.

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Charging codes

The charging codes are listed below:

     0 = Charging completed in more than 30 minutes.
     1 = Charging completed within 30 minutes.
     2 = Charging interrupted.
     3 = Voltage rise too fast (bad battery or hardware error).
     4 = Not used.
     5 = Voltage rise too slow (bad battery or hardware error).

Section 4

TECHNICAL DESCRIPTION

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4   TECHNICAL DESCRIPTION

4.1 General

Electrical Field Meter 100 (EFM 100) is a combined instrument for measurement of ELF and VLF alternating electric fields. A block diagram for the complete instrument is shown on the next page.

The instrument is powered by a sealed lead-acid 12 V battery and individual circuit blocks are switched off automatically when not used to reduce power consumption. The circuit for charging of the battery is controlled by the built-in microcomputer .

Display of data and operating modes are done on a LCD display. The operator keys allowing instrument settings is connected to the microcomputer.

The instrument measurement principles are based on digital sampling of measurement signals by sample and hold circuits followed by a 12 bit A/D-converter. Data is fed into the microcomputer where the instrument software takes care of result calculations and digital signal processing.

There are no adjustable analog components for calibration purposes, all calibration is carried out on a software basis with the different calibration factors stored in a non volatile memory.

4.2 Field measurement principle

For measurement of alternating electric fields the EFM 100 uses a special ground reference probe (defined in the MPR rules). The probe has a diameter of 300 mm and in the center a circular measurement area with a radius of 50 mm.

By using separate amplifier stages a simultaneous measurement can be performed for the two frequency ranges specified in the MPR rules (ELF 5-2,000 Hz and VLF 2-400 kHz).

The measurements are done with true RMS sampling technique using a combination of analog and digital signal processing. For the VLF frequency range an electronic rms converter is used. To ensure that correct gain is used independent of signal wave shape, a separate peak detector is used.

For the two frequency ranges the instrument has 4 different independent automatic gain ranges, which are factory calibrated to achieve high accuracy and a wide dynamic range.
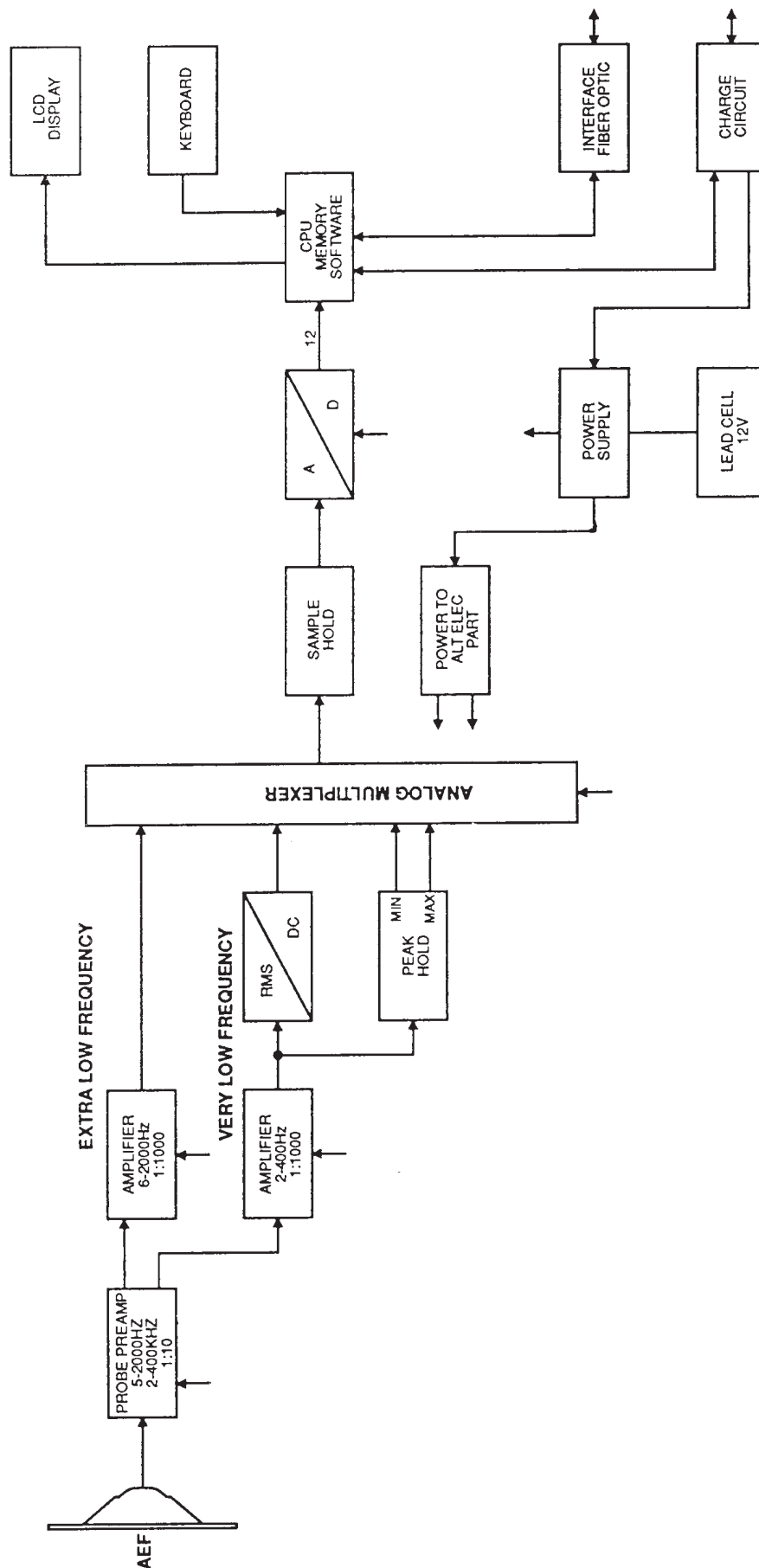
4 . 1 EFM 100 Block diagram

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4.3 Fiber optic remote operation

The fiber communication port is located inside the instrument and two holes in the cover below the panel of the EFM 100 are used to access the fiber connectors.

The fibercommunication in the standard version of EFM 100 is intended to be used with the Combinova CMS software package.
For users that wish to create their own remote control setup, the FiberAdapter 10 is available to convert the optical signals to electrical RS232.

FiberAdapter 10 is not delivered with the instrument.
Please contact your local Combinova dealer for more information.

Communication formats and remote controlling the EFM 100.

Remote controlling of the EFM 100 is done by sending a valid command character to the instrument and wait for the reply.

1: Transmit the command character to the instrument (only the command character, no carriage return or/and line feed).

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 send by the instrument.

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.

Note: see section 3, **EFM 100 Remote control** about remote control setups

General description of result section:

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

EX: ' 2.34 V/m 100 Hz   3.123 V/m 1.4'

      Field 1   Field 2   Field 3   Field 4

The 'V/m' and 'Hz' can be ignored since the result is always in volts/meter and hertz.

The measurement error messages are replaced with E codes as follows:

      ERROR MESSAGE TYPE OF ERROR

      E1   Fading signal
      E2   Overrange
      E3   Not used
      E4   Not used
      E5   Not used
      E6   Offset too large
      E7   Not used
      E8   Charge battery

Ex: SOH,'E5',EOT

IMPORTANT!

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 four commands available in the remote mode. These are:

Command A

> ASCII character 'A' (Hex 41):

This command starts an ELF and VLF measurement in the EFM 100.

This is the alternating electric field measurement. The result consists of ELF field and frequency, VLF field and crest factor.

EX:

> SOH,' 1.23 V/m 50.1 Hz 2.34 V/m 1.4',EOT

>> ELF total, ELF Frequency, VLF total, VLF Crest factor'

The results of command A contains the fundamental frequency of the ELF signal. If the frequency cannot be determined the result is 'Mixed' or 'Noise'.

Ex: '2.34 V/m Mixed 3.12 V/m 1.4'

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

Ex: '2.34 V/m < 10 Hz 3.12 V/m 1.4'

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

Ex: '2.34 V/m > 1 kHz 3.12 V/m 1.4'

Command C

> ASCII character 'C' (Hex 43):

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

EX:

> SOH,'12.5 V 50 h 31',EOT

>> Voltage , Time , ID

The first digit in the ID section is '3'. This informs the controller that the responding instrument is an EFM 100. The second digit '1' is the measurement mode character and will always read '1'.

Command K

ASCII character 'K' (Hex 4B):

This command starts an ELF measurement in the EFM 100.

This is the alternating electric field measurement. The result consists of ELF field and frequency.

EX:

SOH,' 1.23 V/m 50.1 Hz',EOT

ELF total, ELF Frequency

The results of command K contains the fundamental frequency of the ELF signal. If the frequency cannot be determined the result is 'Mixed' or 'Noise'.

Ex: '2.34 V/m Mixed'

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

Ex: '2.34 V/m < 10 Hz'

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

Ex: '2.34 V/m > 1 kHz'

Command L

ASCII character 'L' (Hex 4C):

This command starts a VLF measurement in the EFM 100.

This is the alternating electric field measurement. The result consists of VLF field and crest factor.

EX:

SOH,'2.34 V/m 1.4',EOT

VLF total, VLF Crest factor'

Section 5

SPECIFICATIONS

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5 SPECIFICATIONS

Individual data given in the technical specification are subject to change without prior written notice. Specifications are given at the temperature Tamb=23 ±5° centigrade.

1. Alternating electric fields ELF.

Frequency range: 5-2000 Hz (-3dB)

Filter attenuation: 80 dB/decade below 5Hz and
                               40 dB/decade above 2kHz.

Measurement range: 0.5 - 10,000 V/m rms, automatic range selection.

Accuracy: ±(3% of reading or 0.2 V/m).

Display resolution: Better than 0.5% of reading or 0.01 V/m.

2. Alternating electric fields VLF.

Frequency range: 2-400 kHz (-3 dB)

Filter attenuation: 80 dB/decade below 2 kHz and
                               40 dB/decade above 400 kHz.

Measurement range: 0.05 - 1000 V/m rms, automatic range selection.

Accuracy: ±(3% of reading or 0.03 V/m).

Display resolution: Better than 0.5% of reading or 0.001 V/m.

Display

24 characters * 2 lines, liquid crystal display.

Parameter storage

Instrument parameters and calibration constants are stored in a
non-volatile memory (EEPROM).

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Power

Rechargeable battery. Operating capacity exceeding 30 hours.

Communication

Fiberoptic communication as standard equipment.

Weight

Instrument weight 2.5 kg.

Size

300 mm x 155 mm (diameter x depth)

Environment

-10° ↔ +50° Centigrade.

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Section 6

ERROR CODES

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6 - ERROR CODES

The error messages that can occur during measurement are:

E1   The signal is fading during measurement

E2   Overrange

E3   Not used

E4   Not used

E5   Not used

E6   Instrument offset outside limits (transient signal)

Other types of errors can occur during start up tests of the instrument and the error is displayed.
Some of these errors mean that the instrument has a hardware problem and needs service.

A special type of errors are program errors which are indicated by the text "program error ##". If this type of error occurs please contact the local Combinova dealer for advice.

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WARRANTY for EFM 100

The warranty periods is 2 years.The warranty includes material and labor cost for service and repair. If new program versions become available during the warranty period a free update is also included.

If service is required the instrument should be sent to :

COMBINOVA   AB
Domkraftsvägen
S-19740   BRO
SWEDEN

Costs for freight, customs duty etc. is not included in the warranty and will be invoiced separately.

COMBINOVA AB