NHT-3D

Complex signal analyzer

User Manual

MICRORAD

INDEX

1   SAFETY INSTRUCTIONS

1.1 Foreword

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument.

Read the entire manual carefully before using the instrument.

Always keep a copy of the manual with the instrument, available to anyone who uses it, even if it is transferred to a third party.

1.2 Correct use

The NHT3D has been designed and built to provide the operator with an instrument for the measurement of electromagnetic fields. Use the instrument only for the purpose and under conditions for which it is designed.

In particular, follow the technical specifications of use, shown in paragraph 2.13, "NHT3D technical specifications".

Make sure that the instrument is used by qualified and adequately trained operators.

1.3 Improper use

The NHT3D is not an alarm device. Its purpose is not to alert the operator for the presence of a dangerous field by means of an audio or visual signal.

Remember that the NHT3D instrument is a measuring device and not an alarm device. The operator must be careful, continuously checking the field value indicated by the instrument, when it is in areas with an unknown field.

1.4 Dangers for electromagnetic fields

• *Pay attention to high fields*

Fields with particularly high values may be present near some sources. Do not cross barriers or safety warnings. Persons particularly at risk, as carriers of active implanted medical devices (eg pacemakers), must avoid dangerous electromagnetic field situations.

• *Check the operation of the probe*

Before starting the measurement, check that the probe connected to the instrument is working properly. This will prevent the operator from being in high field areas without the instrument having detected the level. Therefore carry out a preventive measure under known conditions.

• *Possible measurement errors*

Do not apply metal labels or other on the probe, since metal parts in contact with the part of the probe suitable for the measurement of the electromagnetic field can influence the value detected by the instrument.

• *High static magnetic fields*

In the presence of high static magnetic fields, pay attention to the effect of attraction caused by the field on the instrument itself.

1.5 Dangers for electric sources

• *DO NOT use the instrument near electric sources*

Since the instrument shell is made of metallic material, always keep the instrument away from electrical sources in order to avoid the risk of electric shock.

1.6 Dangers due to batteries

NHT-3D is powered by a rechargeable lithium ion battery pack. Batteries can break, burn or explode when they are handled incorrectly. Shorting a lithium battery can cause fires and explosions.

• *DO NOT access the battery compartment*

Operators must not remove the instrument covers and must not access the battery compartment. The battery supplied with the instrument must not be changed or replaced.

1.7 Dangers due to the battery charger

Electrical shock events may occur due to improper use of the battery charger.

• *Check the battery charger*

The battery charger, provided with the instrument, must be used to recharge the battery.

Do not use the charger if it is damaged.

Do not use the charger if it is moved from a cold to a warmer environment, as this may cause condensation on the device.

• *Conditions for recharging*

Recharge only indoor, with ambient temperature and humidity within the operating limits of the device. Keep away from flammable and explosive sources.

• *Verification of the AC line*

Check that the specifications of the electric network used for recharging are exactly those for the battery charger. If the mains voltage is different, it can cause damage to the charger.

1.8 Additional risks

• *DO NOT substitute parts or modify the instrument*

To avoid the danger of introducing additional hazards, do not open the NHT3D meter, do not install or substitute parts, or perform unauthorized modifications to the instrument. Return the instrument to *Microrad* Service Center for service and repair to ensure that safety features are maintained in operational condition.

2 GENERAL INFORMATION

2.1 Application

Human exposure to electromagnetic fields (not ionizing radiation) is nowadays a very critical subject almost all countries in the world are dealing with. Technical and normative bodies work alongside government institutions to enact new guidelines and decrees regarding maximum permitted exposure levels for populations and workers.

The measurement equipment for this type of analysis must suit the technical requirements from the guidelines and must provide the user with qualified physical parameters for compliance with legally required thresholds.

2.2 About the instrument

The NHT-3D is the new *Microrad* solution for the measurement and analysis of complex signals in the electromagnetic safety applications.

Besides being handy and compact, the instrument operates in selective mode in the frequency band DC÷400kHz, and in wide band mode up to 40GHz.

It is user-friendly and provides extremely reliable measurements; it also provides the operator with local temperature and GPS coordinates of the site being measured for inclusion in a final report.

2.3 Operating modes

The instrument performs measurements in two different modes, depending on the type of probe: selective frequency mode and wide band mode.

In both modes, acquisition and display of measurement data is continuous and real time.

It is also possible to store individual measuring points (snapshots) or continuous sequences (monitoring) that can then be downloaded to a PC / Tablet and analyzed using Waves application.

Waves application software also allows the device to be remotely controlled thus providing the operator with access to measured signal portions for in depth analysis both in the time domain and in the frequency domain.

2.3.1 Frequency selective mode

In frequency selective mode, the signal is sampled very quickly, allowing its exact reconstruction in the time domain, and a subsequent spectral analysis, its comparison with normative masks, and calculation of weighted indexes linked to frequency performance and exposure limits.

In this mode signals in the frequency band from DC to 400kHz are measured. The probes used in selective mode are the so-called low frequency probes (probes for the electric field and the magnetic induction field) and probes for the magnetostatic field.

2.3.2   Wide band mode

Wide band mode is typical of radio frequency probes for electric or magnetic field, that are capable of measuring signals from approximately 100kHz up to 40GHz and over. These types of probes sample the signal after it has been rectified within the probe. The probe provides the **r.m.s.** value (root mean square), and it is no longer possible to discriminate the frequency information. However, fast sampling allows tracing, with Waves application, a timeline of the r.m.s. value, capable of representing impulsive signals with a width of few microseconds.

2.3.3   Single EMF measurement

The main application of NHT-3D is to perform electromagnetic field measurements allowing the user to make evaluations in relation to established protective safeguards. The system uses a variety of probes to measure specific physical parameters (magnetic induction, magnetic field and electric field) according to the frequency band of interest.

On the instrument LCD display, are always displayed:

- Instantaneous isotropic value **ISO** of measured field.
- Instantaneous value on the three Cartesian axes **X, Y, Z**.
- Maximum value **MAX** of measured field.
- Moving average value r.m.s. in time domain **AVG.**
- Spatial average value **SPT**.
- **Filter** insertion status.
- **Frequency Span** on (*only in selective mode*).
- **Regulation limit** selected (*only in selective mode*).
- **WP** or **Ib** index (*only in selective mode*).
- Alarm threshold **ALM**.
- Measurement **unit**.
- **GPS** on/off.
- Temperature.
- Date and time clock.
- Battery charging level.

The instrument can be used in direct operating mode via the front keyboard panel and the measurements can be viewed on the LCD display. The instrument can also be remotely controlled by connecting it to a PC/Tablet via fiber-optic, and using the Waves software.

2.3.4   NHT-3D remote control using Waves software

This operation mode is recommended in order to avoid where possible the influence of the user's presence on the environment being measured (mainly for electric field analysis) or when there is a requirement to install the measurement system in a screened and controlled space (anechoic chamber for EMC testing). In such a situation it is strongly recommended that a wooden tripod with variable height (optional) is used.

NHT-3D can be remotely managed through a fiber optic connection to an external PC/Tablet. The Waves software allows the total remote control of the NHT-3D unit displaying measured values, indexes and masks relating to occupational or population regulations. Simultaneously it displays the graphic curves in the time domain and in the frequency domain, with high resolution diagrams.

Additionally, Waves software can perform in-depth analysis of the signal, computing additional evaluation indexes and allowing data and images to be exported for post-analysis, reporting, and recording.

The display of the normative limits mask and the diagram in the frequency domain is only possible in selective mode, using low frequency or magnetostatic probes.

2.3.5   Downloading data to PC / Tablet

All measured values, recorded both as single acquisition or continuous monitoring, can be downloaded to an external PC/Tablet through the fiber optic cable using an optical/USB adapter.

Once the values have been transferred, they can be viewed and analyzed within Waves software and saved on a hard disk or other mass storage units for later reference. Data export in tabular format (Excel compatible) and graphics, such as images, is also possible.

2.4 Measurement probes

Measurement probes available for use in conjunction with NHT-3D, are listed below, according to the type of probe and field being measured:

2.4.1   Low frequency electric field probes

- **11E :** for measurements of electric field (E) in the frequency range from 1Hz to400kHz; measurement range from 1V/m to 20kV/m.

2.4.2   Low frequency magnetic field probes

- **10B :** for measurements of magnetic induction (B) in the frequency range from 1Hz to 400kHz; measurement range from 100nT to 1mT.

- **20B :** for measurements of magnetic induction (B) in the frequency range from 1Hz to 20kHz; measurement range from 300nT to 16mT.

- **30B :** for measurements of magnetic induction (B) in the frequency range from 1Hz to 400kHz; measurement range from 300nT to 16mT.

2.4.3   Magnetostatic field probes

- **10H :** for measurements of magnetic induction (B), static field only; measurement range from 150nT to 2.5mT.

- **20H :** for measurements of magnetic induction (B) from static field up to 1kHz; measurement range from 1mT to 15T.

- **30H :** for measurements of magnetic induction (B) from static field up to 1kHz; measurement range from 200uT to 600mT.

2.4.4 Combined low frequency and magnetostatic probes

- **33P :** for measurements of electric field (33E) in the frequency range from 1Hz to 400kHz, measurement range from 1V/m to 20kV/m, of magnetic induction (33B) in the frequency range from 1Hz to 400kHz, measurement range from 300nT to 16mT, and of magnetic induction (33H), static field only, measurement range from 150nT to 2.5mT. The 3 measurements are combined in the same device, each of them can be selected through a manual selector.

2.4.5 Radio frequency electric field probes

- **01E :** for measurements of electric field (E) in the frequency range from 100kHz to 6.5GHz; measurement range from 0.2V/m to 350V/m.

- **02E :** for measurements of electric field (E) in the frequency range from 400kHz to 40MHz; measurement range from 2V/m to 1'200V/m.

- **03E :** for measurements of electric field (E) in the frequency range from 100kHz to 18GHz; measurement range from 0.8V/m to 650V/m.

- **04E :** for measurements of electric field (E) in the frequency range from 3MHz to 40GHz; measurement range from 0.5V/m to 350V/m.

2.4.6 Radio frequency magnetic field probes

- **02H :** for measurements of magnetic induction (B) in the frequency range from 300kHz to 30MHz; measurement range from 0.016A/m to 16A/m.

Each probe is automatically recognized by the NHT-3D when inserted.

Please refer to our website for additional technical details on probes and for availability of new products (www.microrad.it).

2.5 Exposure limits

The limit of the electric or magnetic field levels at a specific frequency value represents the r.m.s. value of a sinusoidal field tone at that frequency, beyond which health security is no longer guaranteed.

Different regulatory limits are implemented: population and working environments. The latter, as defined by law [4], is generally subdivided into lower, upper and localized levels, both for electric field and magnetic field; localized levels are defined only for magnetic fields.

The instrument performs an automatic analysis of compliance with exposure limits only when it is working in selective frequency mode, even in the presence of complex signals with bands up to 400kHz, using low frequency and magnetostatic probes.

Exposure limits are in fact considered by the instrument in the calculation of **WP** and **Ib** weighted indexes; these dimensionless indexes ensure that limits are not exceeded when they have a value below 1.

Additionally, Waves software graphically represents the selected mask for the limits within the signal diagram in the frequency domain, and uses them in the calculation of the **II98** and **IRSS** indexes.

2.5.1 Exposure limits for the population

For the population exposure mask, the reference levels contained in document [1] paragraph 1.14 are adopted. The tables below show exposure limits for the electric field and magnetic induction, up to 400kHz.

Frequency	E (V/m)
< 25 Hz	10'000
0.025 – 3 kHz	250/f
3 – 400 kHz	87

Tab. 2.1 – Electrical field limits for the population

Frequency	B (uT)
< 1 Hz	40'000
1 – 8 Hz	$40'000/f^2$
8 – 800 Hz	5'000/f
0.8 – 150 kHz	6.25
150 – 400 kHz	920/f

Tab. 2.2 – Magnetic field limits for the population

2.5.2 Occupational exposure lower limits

For the workplace mask, lower levels, the exposure limits are defined in document [2] paragraph 1.14 and in document [4] Annex II paragraph B. The tables below show the exposure limits for the electric field and magnetic induction, up to 400kHz.

Frequency	E (V/m)
< 25 Hz	20'000
0.025 – 3 kHz	500/f
3 – 400 kHz	170

Tab. 2.3 – Electrical field limits for professional environments, lower levels

Frequency	B (uT)
< 1 Hz	200'000
1 – 8 Hz	$200'000/f^2$
8 – 25 Hz	25'000/f
25 – 300 Hz	1'000
0.3 – 3 kHz	300/f
3 – 400 kHz	100

Tab. 2.4 – Magnetic field limits for professional environments, lower levels

2.5.3   Occupational exposure upper limits

For the workplace mask, upper levels, the exposure limits are defined in document [4] Annex II paragraph B. The tables below show the exposure limits for the electric field and magnetic induction, up to 400kHz.

Frequency	E (V/m)
< 50 Hz	20'000
0.050 – 1.64 kHz	1000/f
1.64 – 400 kHz	610

Tab. 2.5 – Electrical field limits for professional environments, upper levels

Frequency	B (uT)
< 1 Hz	300'000
0.001 – 3 kHz	300/f
3 – 400 kHz	100

Tab. 2.6 – Magnetic field limits for professional environments, upper levels

2.5.4   Occupational exposure localized limits

For the workplace mask, localized levels, the exposure limits are defined in document [4] Annex II paragraph B. The tables below show the exposure limits for the magnetic induction, up to 400kHz. Localized levels are not defined for the electric field.

Frequency	B (uT)
< 1 Hz	900'000
0.001 – 3 kHz	900/f
3 – 400 kHz	300

Tab. 2.7 – Magnetic field limits for professional environments, localized levels

2.6 Values and measurement indexes description

2.6.1   Indexes displayed on the instrument

The NHT-3D device calculates and displays on its screen the following values and measurement indexes:

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- **ISO**: instantaneous isotropic value of the field, and corresponds to the value displayed in large digits on the instrument screen; even if it is called instantaneous, in reality it is an r.m.s. average value. The average is calculated on a moving window. The time window width depends on the selected span: with 400K span the window is 8.2ms, with 20K span it's 163.8ms, with1K span it's 3.3s. For wide-band probes, where the span cannot be selected, the window is 163.8ms.

- **MAX**: is equal to the maximum ISO value; it displays the maximum value measured from insertion of the probe or from last reset. This value is updated only when a new higher amplitude value is reached. A reset from the keyboard can be performed when required. The value is also reset every time a snapshot is captured, either from the keyboard or remotely with the Waves application.

- **X, Y, Z**: are the 3 Cartesian components of ISO value.

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- **AVG**: long-term r.m.s. value; the average is calculated on a moving window. The time window width is configurable via Waves application from a minimum of 1s up to a maximum of 192 minutes; a reset from the keyboard can be performed. The AVG value is evaluated only after a period of time equal to the length of the moving window has been completed (starting from power on, from insertion of the probe or from the average reset).

- **SPT**: represents the r.m.s. value of points acquired through single acquisitions. This function can be useful to quickly obtain an average value in space when capturing two or more values in different locations from which spatial average name is derived. A reset from the keyboard can be performed if/ when required. The SPT value is also reset when the instrument is switched on or when the probe is changed.

- **WP**: weighted peak index, is implemented according to the indications in document [2] appendix. The weighted peak index allows the operator, even in the presence of complex signals, to quickly evaluate whether regulatory limits have been exceeded; in fact, the index is a dimensionless number, and ensures that exposure limits are not exceeded when its value is less than 1. It is calculated from the instrument using a weighted digital filter, whose parameters vary according to the type of probe (electrical or magnetic) and to selected exposure limits (population, lower, higher, and localized occupational) for a total of 7 different configurations (localized is defined only for magnetic probes). The WP index is equal to the output peak value of the digital weighted filter. The index is available only in selective mode,

with low frequency probes, and it is calculated in the bandwidth between 1 Hz and 400 kHz. Span selections or notch filters activation do not affect the calculation and result of the index.

- **Ib**: weighted index implemented as defined in [3] "time domain evaluation" section, with characteristics similar to those of the weighted peak. The definition band is the same and the main difference is that the index is not equal to the peak but it's the r.m.s. value of the signal at the weighted digital filter output. The Ib index is available only in frequency selective operation mode with low frequency probes and the span selections or the activation of notch filters will not affect the processing.

2.6.2   Indexes displayed through Waves software

The Waves software can display all individual samples (real instantaneous values, non-mediated) in a diagram in the time domain; furthermore, if the instrument is in selective mode, the application, when performing the FFT operation, is also able to represent in detail the information regarding to the frequency domain of the acquired signal.

All this enables the processing and display on PC / Tablet of the following values / measurement indexes:

- **RMS**: r.m.s. isotropic value of samples acquired within the window and represented in the time diagram, consisting of 65'536 instantaneous consecutive field values.

- **Peak**: the maximum isotropic value of the samples acquired within the window and represented in the time diagram.

- **WP** and **Ib**: are the weighted indexes calculated by the instrument and transferred to the application that returns them to screen without any additional processing. They do not depend on the selected span.

- **II98**: Index calculated according to the following formula [1]:

$$\text{II98} = \sum_j \left(F_j \,/\, L_j \right)$$

F_j = field component (r.m.s. value) at frequency j;
L_j = exposure limit at frequency j;
 j = frequency included in the range from 1Hz to the upper limit for the selected span (1, 20 or 400kHz).

II98 value is therefore influenced by the selected span, since it defines the upper limit where the summation stops.
The index is a non-dimensional number and it ensures that limits are not exceeded when its value is less than 1. II98 index is available only in frequency selective mode.

- **IRSS**: index calculated according to the following formula:

$$\text{IRSS} = \sqrt{\sum_j \left(F_j / L_j \right)^2}$$

F_j = field component (r.m.s. value) at frequency j;
L_j = exposure limit at frequency j;
j = frequency included in the range from 1Hz to the upper limit for the selected span (1, 20 or 400kHz).

IRSS value is therefore influenced by the selected span, since it define the upper limit where the summation stops. The index is a non-dimensional number and it ensures that limits are not exceeded when its value is less than 1. IRSS index is available only in frequency selective mode.

- **Fmax**: represents the frequency, within the selected span, where the spectral component of the signal has the highest intensity. This indicator is available only in selective frequency mode.

- **Irms**: index calculated according to the following formula:

$$\text{Irms} = \text{RMS} / L_{Fmax}$$

RMS = wide band field r.m.s. value;
L_{Fmax} = exposure limit at the frequency Fmax of greatest contribution.

In practice, this index is calculated assuming all the power of the signal is concentrated at Fmax frequency. The index is a non-dimensional number and it ensures that limits are not exceeded when its value is less than 1. IRMS index is available only in frequency selective mode.

2.7 Filters

The NHT-3D instrument is internally equipped with selectable **digital filters,** that can facilitate measurement by cutting off negligible bandwidths or selecting the frequencies that originate the captured signal.

The available filters are those related to the frequency span selection (1K, 20K 400K) and those for the suppression / rejection of the 50Hz or DC components of the signal.

The filters can be activated via keyboard or remotely, and for each probe, according to the type, it is possible to enable a specific set of filters.

2.7.1   1K span

The **1K span** is selectable for all types of low frequency probe or for magnetostatic probes.

The filter function is to cut all spectral components above 1kHz, leaving undisturbed those up to 1kHz (low pass filter). Specifically, above 2.5kHz an attenuation of more than 100dB is achieved.

When 1K span is selected, the instrument works at a sampling rate of 5ksps, corresponding to an interval of 200us between one sample and the next.

2.7.2   20K span

The 20K span is selectable for all types of probes excluding magnetostatic. Also radio frequency probes typically use the 20K span.

The filter function is to cut all spectral components above 20kHz, leaving undisturbed those up to 20kHz (low pass filter). Specifically, above 50kHz an attenuation of more than 100dB is achieved.

When 20K span is selected, the instrument works at a sampling rate of 100ksps, corresponding to an interval of 10us between one sample and the next.

Note that in order to maximize rejection due to out-of-band disturbances, this filter remains inserted even when working with the 1K span.

2.7.3   400K span

The 400K span is selectable for all types of low frequency probes capable of working at over 20kHz.

The function of this filter is to cut all spectral components above 400kHz, leaving undisturbed those up to 400kHz (low pass filter). Specifically, above 500kHz an attenuation of more than 100dB is achieved.

When 400K span is selected, the instrument works at a sampling rate of 2Msps, corresponding to an interval of 500ns between one sample and the next.

Note that in order to maximize rejection due to out-of-band disturbances, this filter remains inserted even when working with 20K and 1K span.

2.7.4   50 Hz notch filter

The **50 Hz** notch filter is available for low frequency probes, electrical and magnetic (not for magnetostatic probes).

The function of this filter is to suppress the spectral components generated from the 50Hz mains supply. The filter is characterized by a 50Hz component attenuation greater than 40dB, and a stop bandwidth (-3dB) smaller than 0.5Hz.

The filter can be activated only when the 1kHz frequency span is selected.

2.7.5   50 Hz interference notch filter

The 50 Hz interference notch filter is defined only for radio frequency probes.

The filter suppresses the 50Hz disturbances induced by high electrical fields, such proximity to electricity grid or to powered devices.

In fact, although the radio frequency probes have an intrinsic rejection of the 50Hz field, since typically the sensitivity band starts from tens or hundreds of kHz, the presence of very strong components may disturb the measurement results.

The filter introduces an attenuation of the 50Hz component greater than 50dB and a stop bandwidth (-3dB) smaller than 8Hz.

2.7.6   DC filter

The DC component filter is used only with magnetostatic probes (except 10H, 33H probes), since they are the only ones capable of measuring the continuous components of the field.

It is a high-pass filter of the first order that completely eliminates the continuous component of the signal and leaves all the AC components.

The -3dB cut-off frequency is less than 0.1Hz.

2.8 Acoustic alarm

The instrument is equipped with an **acoustic alarm** that, when activated, alerts the operator when an isotropic value being measured has exceeded a predefined field threshold.

The alarm can be switched on and off using the instrument keyboard, while the thresholds are configurable using the Waves software.

In particular, three different thresholds can be set: a threshold is used in conjunction with low frequency electric probes, another with low frequency or magnetostatic magnetic probes, the last with radio frequency probes.

Moreover, with low frequency probes it is possible to activate the alarm on the overcoming of the WP and Ib indices.

2.9 GPS module

NHT-3D integrates a **GPS module** to acquire geographic coordinates as reference to the area in which the measurements were carried out.

In case of outdoor activities, it is always recommended to add the GPS data related to the measurement site in order to mention them in the final report. GPS associates not only geographic information but also the exact time (UTC time).

No other external device is required to perform these operations as the NHT-3D performs the measurement and automatically provides field values together with GPS coordinates of the site. The Waves software can directly show it on **Google Maps™**.

2.10 Temperature Sensor

In addition NHT-3D integrates a **temperature sensor** acquiring the temperature value during measurement activity.

Since the sensor is integrated into the front of the instrument, it is necessary to consider that, as the meter shell is a good thermal conductor, the measurement may be influenced by the operator's hand temperature. In order to have exact temperature values, the instrument must be used with a tripod support.

2.11 Clock

NHT-3D integrates a **RTC** (Real Time Clock) device that can perform clock and calendar functions. The date and time can be synchronized to those of the PC through the Waves software.

The RTC device is equipped with a battery to keep the time information even when the instrument is switched off. The battery life is limited to a number of years. When the battery is exhausted or low the following message is displayed : "RTC ERROR" during the instrument power-on phase at which point the date and time are no longer stored in memory.

Replacement of the internal battery can only be performed by qualified personnel, sending the instrument to the mother company for maintenance.

2.12 Equipment configuration

The basic unit NHT-3D is delivered in the standard configuration including:

- ▪ NHT-3D basic unit for measuring, storing and display field data
- ▪ Fiber optic cable (10 meters length)
- ▪ Fiber-USB adapter to link fiber optic to PC
- ▪ USB A/B adapter cable
- ▪ Battery charger
- ▪ Waves software and user manual (available on website www.microrad.it)
- ▪ ISO 9001:2008 calibration certificates

In order to proper work the NHT-3D meter must be connected to a measurement probe to be chosen among the available ones.

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2.13 NHT-3D Technical Specifications

PROBE TYPES	
Frequency range	Selective mode: DC – 400 kHz Wide band mode: 100 kHz – 40GHz
DISPLAY	
Type	Transflective LCD monochrome
Size	2,8" , 128x64 dots
Backlight	LED switchable 10s/continuous
SAMPLING	
Rate	Up to 2 Msps
MEASUREMENT FUNCTIONS	
Measurement units	V/m, A/m, W/m^2, mW/cm^2, uT, mT (depending on the probe)
Display range	from 0,00001 to 999'999
Result types	Instantaneous ISO (short term r.m.s.) and Cartesian components; MAX of ISO instantaneous value
Time Average	AVG: r.m.s. value in moving window selectable from 1s to 192min 24H moving average available for monitoring using software
Space Average	SPT: single storing average value
Normative mask weighted indexes	WP, Ib
Indexes on sw Waves	RMS, Peak, WP, Ib, II98, IRSS, IRMS, Fmax
Max Hold	Selectable on instrument and/or software
STORAGE MEMORY	
Single acquisition	1'024 non-volatile values
Monitoring	29 non-volatile sequences, until the 245'760 measures are available in memory; the sampling step is selectable from 1 to 30 seconds.
Sampling buffer	65'536 RAM memory points used as buffer when working remotely through software
INTERFACES	
Optical interface	Serial, full duplex, 10Mbps
Probe interface	Plug-and-play auto detection, LEMO™ connector
GPS	
Receiver	Sensitivity -163dBm, 48 channels, L1 C/A code, update rate 4Hz
Time to first position (TTFF)	Typical < 60 seconds
GENERAL SPECIFICATIONS	
Recommended calibration interval	24 months
Battery	Li-ion rechargeable
Operation time	> 24 hours (backlight and GPS off)
Charging time	3 hours
Battery level display	Graphic bar
Operative Temperature range	-10 °C to +50 °C
Storage Temperature range	-20 °C to +70°C
Humidity	5 to 95%, non-condensing
Size (h x w x d)	160 x 98 x 46 mm (without probe)
Weight	Approx. 600 g (including batteries without probe)
Accessories (included)	AC charger, fiber optic cable (10mt), USB-Optical Converter, User manual, Waves software, probes calibration certificate

Tab. 2.8 – Technical specifications

Note: technical specifications are subject to change without any prior notice.

2.14 Normative references

[1] ICNIRP, Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 Ghz) – Health Physics Vol 74 Nr 4 pp 494-522 April 1998.

[2] ICNIRP, Guidelines for limiting exposure to time-varying electric, magnetic fields (1 Hz to 100 kHz) – Health Physics Vol 99 Nr 6 pp 818-836, December 2010.

[3] CEI-CENELEC EN 62233, Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure, 2008.

[4] DIRETTIVA 2013/35/UE del Parlamento europeo e del Consiglio, sulle disposizioni minime di sicurezza e di salute relative all'esposizione dei lavoratori ai rischi derivanti dagli agenti fisici (campi elettromagnetici), del 26 giugno 2013.

2.15 Standard compliance

ESD e EMC	Electrical equipment for measurement, control and laboratory use. EMC requirements: radiating emission, radiating immunity in radio frequency, electrostatic discharge.	**CEI EN 61326**
SAFETY	Safety requirements for electrical equipment for measurement, control and laboratory use – General requirements.	**CEI EN 61010**
CE MARK	European Union	**OK**
	Country of origin	**ITALY**

Tab. 2.9 – Standard compliance

3 CERTIFICATION AND WARRANTY

3.1 Certification

Microrad certifies that this product met its published specifications at the time of shipment from the factory. *Microrad* also certifies that each probe for the NHT-3D instrument has been calibrated according to DIN EN ISO 9001: 2008. On request, SIT certification is available, covering magnetic and electric field strength and high frequency electromagnetic power density, and OKD certification for magnetic induction intensity and low frequency electric field.

3.2 Warranty

This *Microrad* product is warranted against defects in material and workmanship for a period of 24 months. Accessories are warranted for a period of 6 months. During the warranty period, *Microrad* will, at its option, either repair or replace products that prove to be defective.

For warranty service or repair, this product must be returned to *Microrad*.

Microrad warrants that its software and firmware, designated by *Microrad* for use with an instrument, will execute its programming instruction when properly installed on that instrument.

3.3 Limitation of warranty

The foregoing warranty shall not apply to defects resulting from: improper use or inadequate maintenance by User, User-supplied software or interfacing, unauthorized modification or misuse, operation outside the environmental specifications for the product, or improper site preparation or maintenance.

4 UNIT DESCRIPTION

4.1 Front panel legend

The following table refers to Figure 4.1 which shows the keyboard and the main parts on the NHT-3D base unit front panel.

Some keys have a second function, indicated in orange, which can be enabled by pushing the middle button **SHIFT** in advance**.**
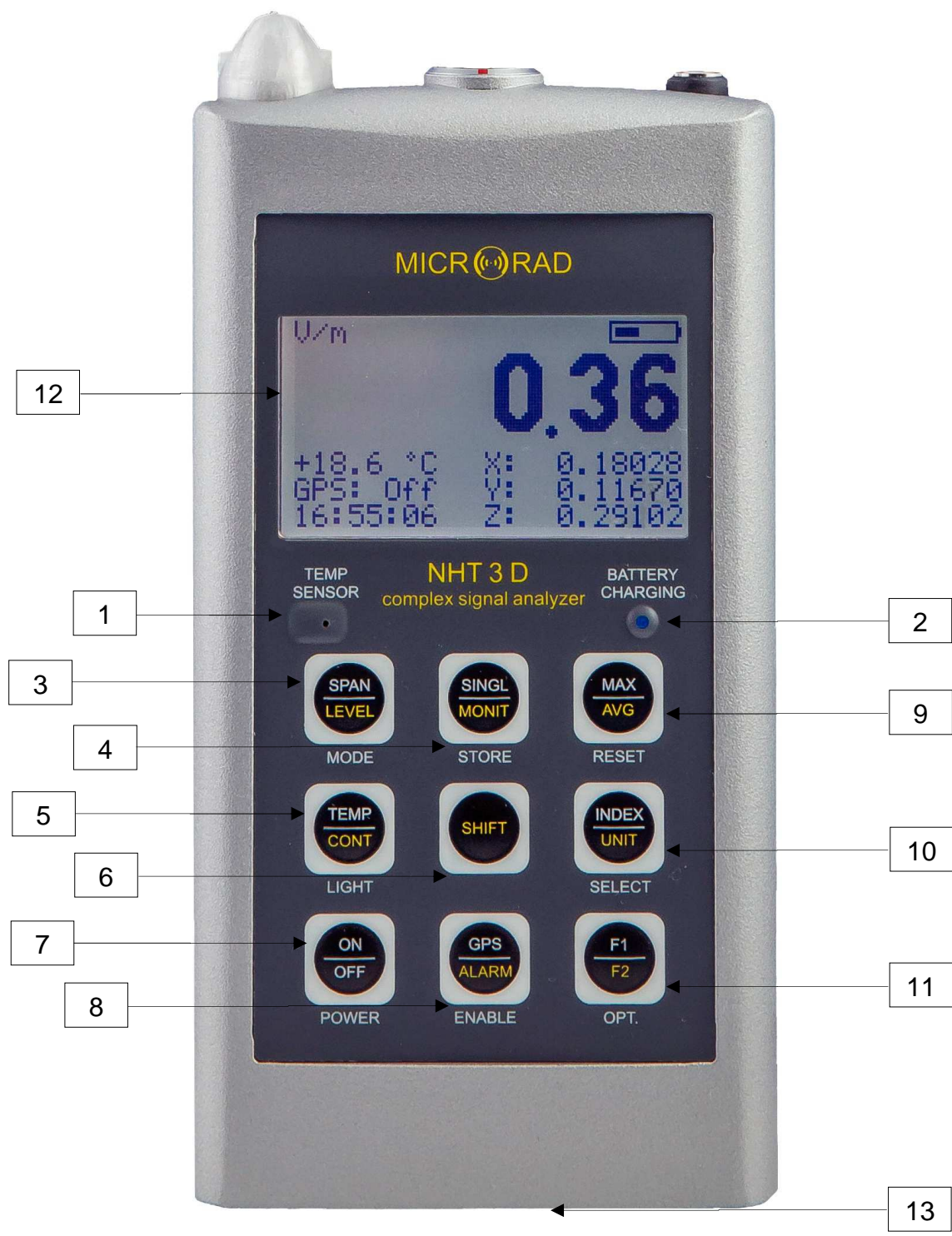

Fig. 4.1 – Base unit front view

Item		Function
1	TEMP SENSOR	Temperature sensor
2	BATTERY CHARGING	Blue LED indicating battery charging status. ▪ Led on (bright light): battery recharge. ▪ Led on (weak light): battery in maintenance charge (battery level> 90%). ▪ Led off: charger unplugged or charging timeout (about 9 hours). ▪ Led blinking: battery failure.
3	SPAN LEVEL MODE	**MODE key** **SPAN**: sequentially selects the frequency span (400kHz, 20kHz, 1kHz, 1kHz+DC filter o 50Hz). Selectable values depend on the type of inserted probe. Pressing the button for 10s it is possible to change the temperature unit from ℃ to ℉ and vice versa. **LEVEL**: select the application environment by Occupational (inf, sup, loc) in Population (pop) and vice versa. It works with probes suitable for working in selective mode (with low frequency and magnetostatic probes, for the magnetostatic the population is not selectable). For 10H and 33H probes it is not foreseen.
4	SINGL MONIT STORE	**STORE key** **SINGL**: storing a single measuring value (snapshot). If pressed for more than 2 seconds, initiates a countdown sequence before starting the store. **MONIT**: start a monitoring sequence. If pressed for more than 2 s, it starts a monitoring sequence lasting 6 minutes.
5	TEMP CONT LIGHT	**LIGHT key** **TEMP**: temporary backlight of 10s. **CONT**: continuous backlight.
6	SHIFT	**SHIFT key** **SHIFT**: enables all orange defined functions.

7		**POWER key** **ON/OFF**: switching the device on / off.
8		**ENABLE key** **GPS**: enables / disables the GPS receiver. **ALARM**: enables / disables the acoustic alarm. When enabled, even if the ALM field is not displayed, it appears for few seconds at the right bottom to remember the value of the default value, when disabled, the message "ALM: Off" appears. If a low-frequency probe is connected to the instrument, it is also possible to select the function linked to the overcoming of the indices alarm. In this case the words "ALM: WP> 1" and "ALM: Ib> 1" appear.
9		**RESET key** **MAX**: reset of maximum instantaneous value (MAX); if pressed for more than 10 seconds performs a reset of the instrument, reinitializing all parameters and deleting all stored data. **AVG**: reset of the value of the moving average (AVG) or spatial average (SPT) depending on which of the two indexes is displayed on the screen.
10		**SELECT key** **INDEX**: sequentially selects the values displayed in the 3 lines at the right bottom of the screen; with low frequency and magnetostatic probes the sequence is:

SELECT key

INDEX: sequentially selects the values displayed in the 3 lines at the right bottom of the screen; with low frequency and magnetostatic probes the sequence is:

$$\rightarrow \begin{matrix} MAX \\ AVG \\ WP \end{matrix} \rightarrow \begin{matrix} MAX \\ SPT \\ WP \end{matrix} \rightarrow \begin{matrix} MAX \\ SPT \\ Ib \end{matrix} \rightarrow \begin{matrix} MAX \\ AVG \\ Ib \end{matrix} \rightarrow \begin{matrix} X \\ Y \\ Z \end{matrix} \rightarrow$$

With radio frequency probes:

$$\rightarrow \begin{matrix} MAX \\ AVG \\ ALM \end{matrix} \rightarrow \begin{matrix} MAX \\ SPT \\ ALM \end{matrix} \rightarrow \begin{matrix} X \\ Y \\ Z \end{matrix} \rightarrow$$

If pressed for more than 2 seconds, the Max Hold function is switched on / off for WP and Ib indexes, indicated by the **H** symbol that appears next to them.

UNIT: changes the measurement unit according to the following sequences, for the different types of probe:
- Radio frequency probe: V/m, A/m, W/m^2, mW/cm^2
- low frequency magnetic probe: uT, A/m
- low frequency electrical probe: V/m
- magnetostatic probe: mT

21

11		**OPT key** **F1** : enables the display of the percentage bar of the field and of the distribution on the Cartesian axes. display of X,Y,Z field polarity (only for 10H and 33H). For the 10H and 33H probes, keeping the button pressed, displays the field direction (+/- sign of the X, Y, Z axes). **F2** : future additional function.

Tab. 4.1 – Keyboard legend

The backlit screen (12) and the ¼-inch threaded hole for tripods or brackets mounts (13) are also indicated in the figure.

4.2 Connectors and interfaces legend

The tables below refer to connectors and interfaces available on the back and at the top of the base unit.

Fig. 4.2 – Base unit rear view

Item	Name	Function
14	**FIBER**	Fiber optic cable interface for connection to a remote PC/Tablet

Tab. 4.2 – Rear interfaces

Fig. 4.3 – Base unit top view

Item	*Name*	*Function*
15	**LEMO**	Probes Input connector
16	**BARREL JACK**	Battery charge input
17	**GPS**	GPS Antenna

Tab. 4.3 – Top interfaces

5 PREPARATION FOR USE

5.1 Unpacking

As soon as the instrument arrives at destination, please carefully check the packages to verify possible damages caused by shipment. If any damage is found, inform *Microrad* immediately. It is recommended to keep the original packages for a future shipment due to, for instance, repairing or setting.

5.2 Storage

After the material contained in the packages has been inspected and it has been verified for damages, it shall be stored in its original packing until the time of use. The storage deposit must be well protected and free from humidity.

If the instrument should be kept in storage for a long time, it is advisable to insert hygroscopic substances (such as silicon gel salts) in the package.

5.3 Connecting the probes

The probe is equipped with a LEMO "Push/Pull" connector. To connect it to the NHT-3D unit, push the probe plug straight down into the probe socket until it clicks into place (the red mark on the probe plug must point towards the red mark on the unit socket).

To disconnect the probe, slide the sleeve on the probe plug upwards and pull the probe upwards to remove it.

PROBE PLUG

MICR⊙RAD

U/m

0.36

Fig. 5.1 – Probe connection

> **WARNING: TO REMOVE DO NOT TURN THE PROBE !**
> **SLIDE THE SLEEVE ON THE PROBE PLUG UPWARDS AND PULL THE PROBE**
> **UPWARDS TO REMOVE IT.**

5.4 Power supply and autonomy

NHT-3D operates with Lithium-ion rechargeable batteries.

The batteries are usually delivered pre-charged, but could need a complete charge before the first use. The full recharging time, very close to 100%, is about 3 hours after which the charger operates in a standby mode with a small charge current.

During the battery recharge cycle the instrument cannot be switched on and, if the instrument is already operating, the reliability of the measurement is not guaranteed.

Turning on the instrument when it is charging, an indication of the charge level is displayed, and within a few seconds the NHT-3D automatically switches off and continues the battery charge.

In order to further extend the autonomy of the instrument, it is possible to use an external charge source (power bank). If this is connected to the instrument already switched on and running, the NHT-3D continues to operate. The recommended characteristics for a possible power bank are:

> Voltage 5 Vdc
> Current> 2 A
> Capacity> 10 Ah

However, when the instrument is used with an external power supply the technical specifications of the probe are not guaranteed. The measurement performed is not fully reliable, since all measurements should be performed with the instrument disconnected from any power source.

During the batteries charging cycle, the blue LED (figure 4.1, item 2) lights up with the following meanings:

- Led on (bright light): battery recharge.

- Led on (weak light): battery in maintenance charge (battery level> 90%).

- Led off: charger unplugged or charging timeout (about 9 hours).

- Led blinking: battery failure.

The battery discharge time is longer than 24 hours of continuous operation (with backlight turned off and no active GPS).

During normal operation, the battery charge status is always displayed at the top right of the screen (figure 6.6, item 35), represented by the symbol of a battery that is filled proportionally to the available charge.

6 OPERATION

6.1 Base unit switching on

Press POWER ON KEY (item 7, fig. 4.1).

The instrument starts an auto test tool, emits a beep sound three times and simultaneously displays instrument information (identification data, configuration parameters, memory used).

Fig. 6.1 shows the first screen displayed at power up and reports the identification data of the instrument for a few seconds.
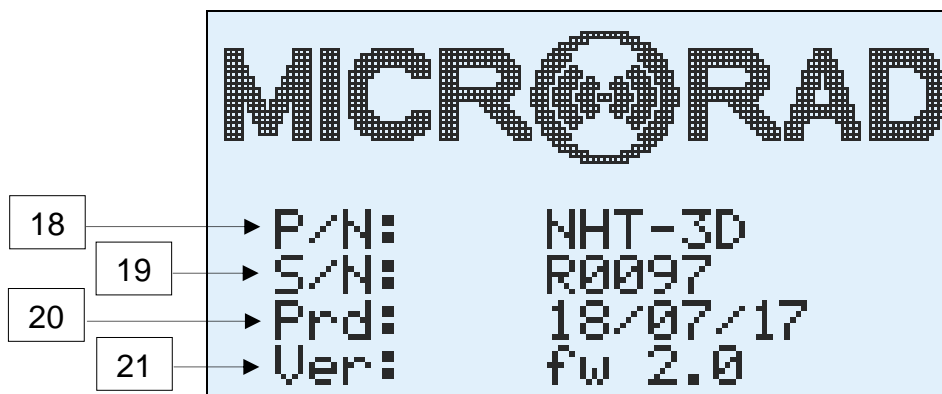

Fig. 6.1 – Power up screen

18 – P/N: instrument identification code.

19 – S/N: instrument serial number.

20 – Prd: instrument production date.

21 – Ver: instrument firmware version.

Fig. 6.2 shows the second screen displayed after the power up, reporting memory status information and the setting of some parameters.
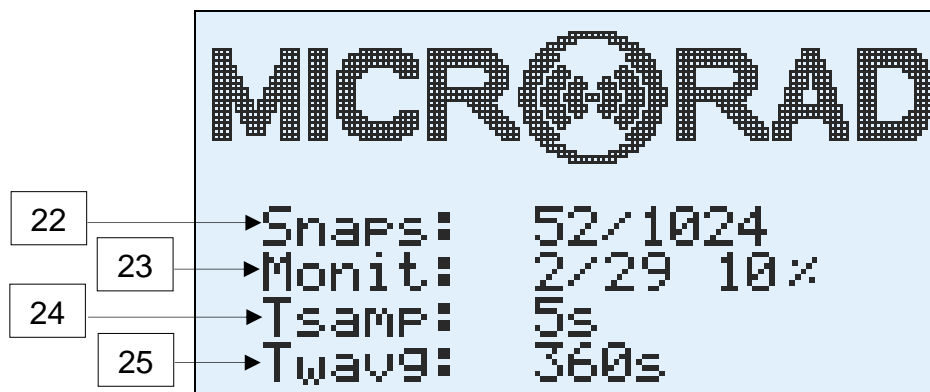
Fig. 6.2 – Second screen after power up

22 – Snaps: number of single measurements stored in the NHT-3D memory.

23 – Monit: number of monitoring sequences stored in the memory and indication of total memory occupation.

24 – Tsamp: sampling interval used during monitoring.

25 – Twavg: time window width for moving average (AVG).

After the power up information sequence, if a probe is already connected to the instrument, the following information are displayed (see fig 6.3).
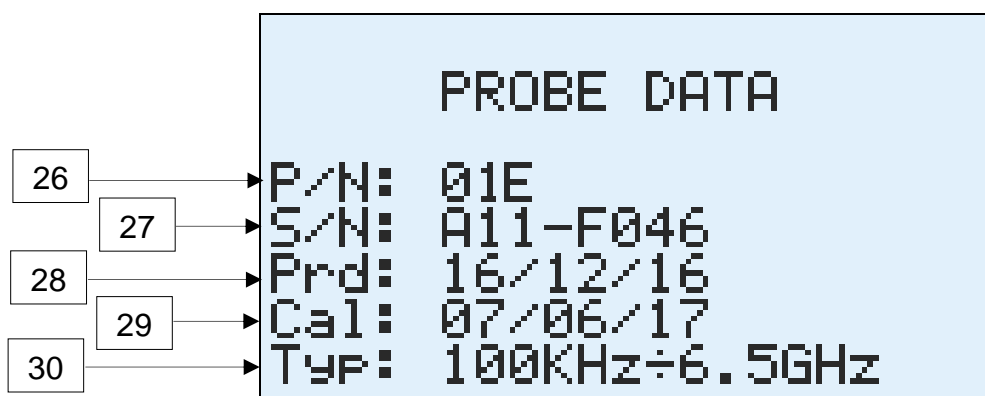

Fig. 6.3 – Probe data after recognition

26 – P/N: probe identification code.

27 – S/N: probe serial number.

28 – Prd: probe production date.

29 – Cal. Probe calibration date.

30 – Typ. Probe frequency range.

The same information is also displayed whenever a probe is inserted in the instrument. The information is displayed for a few seconds.

The insertion of a probe is also signalled by a double acoustic beep.

When a probe is connected to the instrument, the NHT-3D recognizes it automatically; then it starts a specific test and calibration session for the type of probe just identified. During this phase the measurement is not valid and in fact all values and indices on the screen are kept at zero (fig. 6.4).

The instantaneous ISO isotropic value (large characters on display) also appears in a blinking mode, and always with a null value. The test and calibration session ends when the ISO value stops blinking.
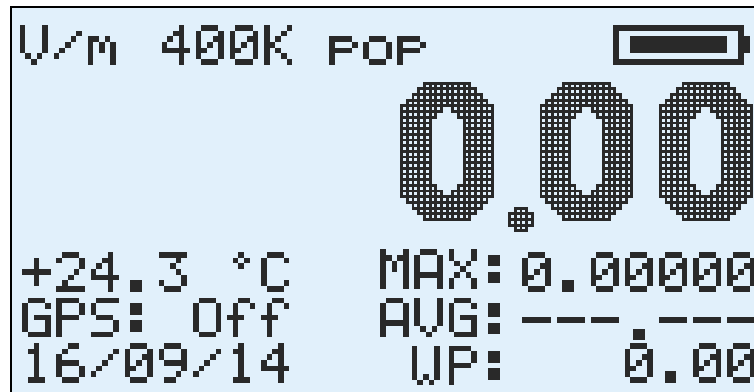
Fig. 6.4 – Typical screen during calibration

If the calibration session is not completed successfully, or if the probe is not recognized by the instrument, the message "PROBE ERROR" appears for a few seconds together with an acoustic signal.

If this type of problem systematically or frequently occurs, then it is necessary to send the probe and / or the instrument for repair to *Microrad*.

If no probe is connected to the instrument, then the screen in Figure 6.5 will appear with the text "NO PROBE" blinking and all indexes and indicators for the measurement in an indefinite state.
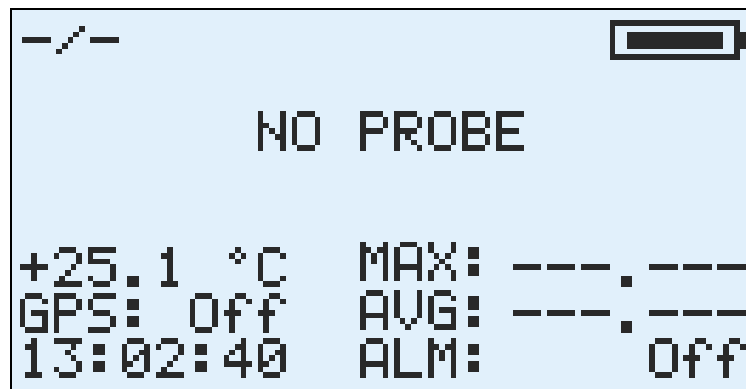
Fig. 6.5 – Typical screen in case of probe absence

The same screen is also displayed as soon as a probe is disconnected from the measuring instrument.

6.2 Main measuring screen

After the power on operation and probe detection and calibration is completed, the main measure screen appears together with all the other report elements which are also highlighted as shown in figure 6.6.
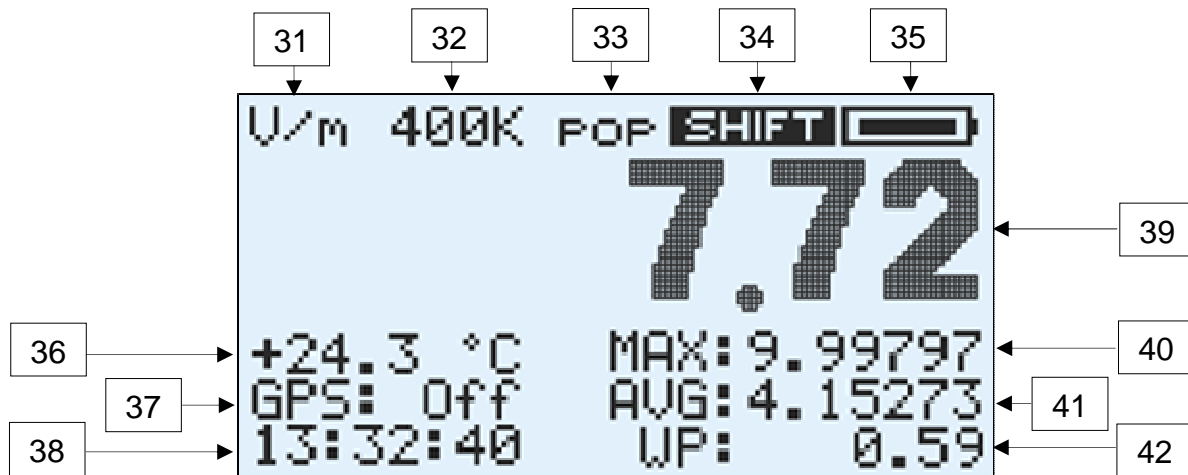
28

Fig. 6.6 – Main measurement screen

31 – Measurement unit; depending on the probe used and on selection made it can assume one of the following values: **V/m**, **A/m**, **W/m^2**, **mW/cm^2**, **uT**, **mT**. Refer to item 10 of table 4.1 for more details.

32 – Span / frequency filter information; depending on the probe used and on selection made it can assume one of the following values: **400K**, **20K**, **1K**, ~~**50**~~ **1K**, ~~**50**~~, ~~**DC**~~ or remain un-valued in case of radio frequency probes. Refer to item 3 of table 4.1 for more details.

33 – Active exposure limits (selective mode only): **pop** for population-related levels, **inf** for lower occupational levels, **sup** for upper occupational levels, and finally **loc** for localized ones; the selection is made using the LEVEL key (fig. 4.1, item 3).

34 – **SHIFT** state indicator: for the ability to activate a yellow function on the keyboard; it is activated or deactivated via the SHIFT key (fig. 4.1 item 6).

35 – Battery charge level. The residual autonomy is proportional to the battery icon fill. When the battery is running low, the battery icon blinks.

36 – Environmental temperature measured by the integrated sensor on the front part of the unit. The temperature value shown is surely reliable when the unit is working on a tripod and not in the user's hand.

37 – Localization information from the built-in GPS sensor. If the GPS sensor is off, the message "GPS: Off" is displayed; activating the GPS sensor, the message "GPS: On" starts to blink; at this point, if the tool is outdoor, within a couple of minutes, geographic location coordinates are displayed.

Longitude and latitude coordinates, in the format defined in the NMEA standard, alternate in displaying:

Latitude / Longitude = DDMM.FFC

Where the 2 digits *DD* are used for degrees (digits can be 3 for longitude), the 2 digits *MM* for minutes, and the 2 digits *FF* for cents of minute. *C* is the cardinal direction: N (North) or S (South) for latitude, E (East) or W (West) for longitude.

38 – Date and clock alternates on the display.

39 – Instantaneous isotropic measured field value (ISO). In presence of a field below the sensitivity of the probe connected to the instrument, the value 0 is displayed.

40 – Display the MAX value or the X axis instantaneous value according to the selection made. Please refer to item 10 of table 4.1 for further details.

41 – Display the AVG, SPT or Y axis values according to the selection made. Please refer to item 10 of table 4.1 for further details.

42 – Display WP index, Ib index, Z axis value, or ALM threshold according to the selection made and to the operating mode (in selective mode all data are available except ALM threshold which only appears temporarily at the ALARM key pressure; in broadband mode, with radio frequency probes, WP and Ib indices are unavailable while ALM threshold is displayed). Please refer to item 10 of table 4.1 for further details.

Figure 6.7 shows a screen where the display of the 3 orthogonal components of the ISO field has been selected. Figure 6.7 shows a screen display of the 3 orthogonal components of the ISO field which has been selected.

If a 10H or 33H probe is connected to the instrument, holding the OPT F1 key the + or - sign (field direction), in front of the value of each individual axis, is also displayed.
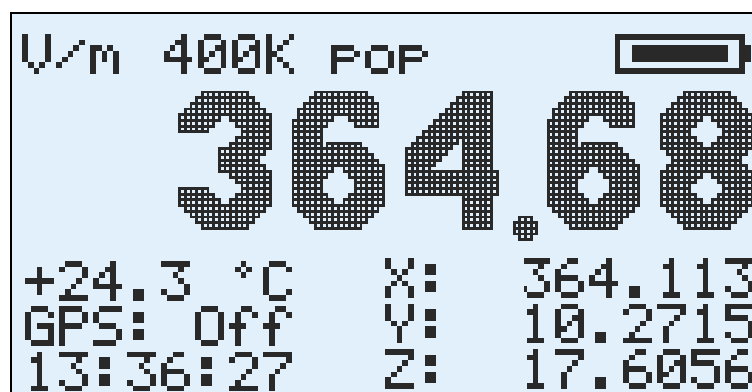

Fig. 6.7 – Display of the 3 spatial components of the field.

Pressing the OPT F1 key (table 4.1, item 11) enables the display of the bar indicating the percentage with respect to the threshold value set for the acoustic alarm (ALM) is enabled together with the distribution of the field according to the axes X, Y and Z.
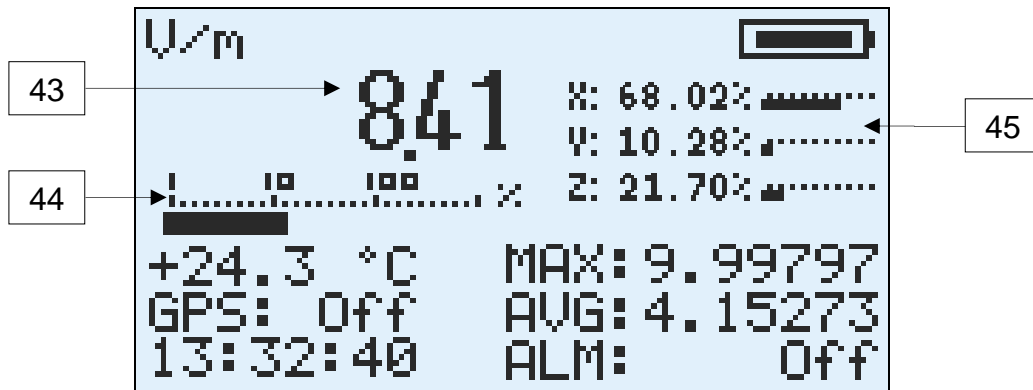

Fig. 6.8 – Display of the percentage bar graph.

43 – Isotropic instantaneous value of the measured field (ISO). In presence of a field below the level of sensitivity of the probe connected to the instrument, it displays the value 0.

44 – Bar graph representing the percentage of the ISO field measured, with respect to the value sets as acoustic alarm (ALM) threshold. The reference for the percentage reported in the upper part of the bar is on a logarithmic scale: from 1 to 10 it uses steps of 1 percentage point, from 10 to 100 steps of 10 percentage points, over 100 steps of 100 percentage points.

45 – Bar graphs representing the percentage contributions of the individual X, Y and Z axes to the value of the ISO field. For each axis the value is calculated according to its quadratic contribution, e.g. $x^2 / (ISO)^2$ for the x axis ..

6.3 Recording measured values

The user can record the measured values using two different methods:

- Manual storing of the single measured value (single storing)

- Automatic storing of a measurement sequence (monitoring).

The instrument reserves two different memory spaces for the two recording modes.

6.3.1   Single storing

Each time the user makes preliminary measurements or he wants to store data displayed on the screen, he has to simply press the SINGLE key (Fig. 4.1, item 4).

This action allows the storing of a set of values that includes:

- instantaneous isotropic value of the field (ISO);

- maximum value (MAX) and its date and time;

- the value of the 3 orthogonal components of the field (X, Y, Z);

- r.m.s. moving average value (AVG) and time window width;

- spatial average value (SPT) and number of samples considered in its calculation;

- date and time;

- temperature;

- WP or Ib weighted index value;

- connected probe data;

- GPS coordinates and absolute time when GPS sensor is active.

Note that for WP and Ib weighted indexes only the one displayed on the screen during capture is stored in memory; if neither of the two indexes is displayed (eg in the case of selecting the 3 orthogonal components of the field) then no index is saved.

A delay can be introduced when storing data: depress the SINGLE key for at least 2 seconds before releasing it and the countdown starts. This feature is useful in order to allow the operator to move away from the device and avoid disturbing the electromagnetic field before storing takes place. The delay can be set via the Waves software and is the same parameter that sets the delay for monitoring.

During data storing the display shows the message as in Fig. 6.8; it informs about number of stored values vs total available (1'024 single stores).

Fig. 6.9 –Single storing

When the memory is full, the message "MEMORY FULL" will be displayed and it will no longer be possible to store data until the memory is erased using the Waves software or with a factory reset.

6.3.2 Monitoring

The instrument is able to carry out continuous tracking activity over time: practically it performs a sequence of single stores, all spaced from the same time delay.

The time interval between a sample storing and the next (sampling step) is by default 5 seconds but it can be reconfigured by the user using the Waves software, from a minimum of 1 second to a maximum of 30 seconds.

The instrument can store in up to 29 different data acquisition sequences for electromagnetic fields long-term monitoring.

The sequences can contain up to 245,760 samples.

Each sample consists of the following information:

- instantaneous isotropic value of the field (ISO);
- the value of the 3 orthogonal components of the field (X, Y, Z);
- r.m.s. moving average value (AVG) and time window width;
- date and time;
- temperature;
- WP or Ib weighted index value;
- connected probe data;
- GPS coordinates and absolute time when GPS sensor is active.

Even in this case, as in single storing, only the WP or Ib weighted index selected and displayed before the monitoring start is acquired.

In addition, the present GPS information stored relates only to the moment in which the monitoring activity commences, as the instrument is supposed to remain in the same position and the GPS sensor is switched off to increase the autonomy. The backlight is also turned off for the same reason.

The probe information is also saved only once, since it is not possible to change the probe during the monitoring; in fact the probe disconnection would cause an immediate stop.

The operator can start the monitoring sequence by simply pressing the MONIT key (fig. 4.1 item 4) or remotely by using the Waves software. The instrument will start a countdown of 15 seconds (it's a default value that can be reconfigured using the Waves software) before the acquisitions start, to allow the user to move away from the instrument installed on a tripod and thus avoid any possible disturbance of the measurement.

During countdown (Fig. 6.9), the current tracking number, from 1 to 29, is displayed.

During countdown the sequence can be aborted simply by pressing any key.
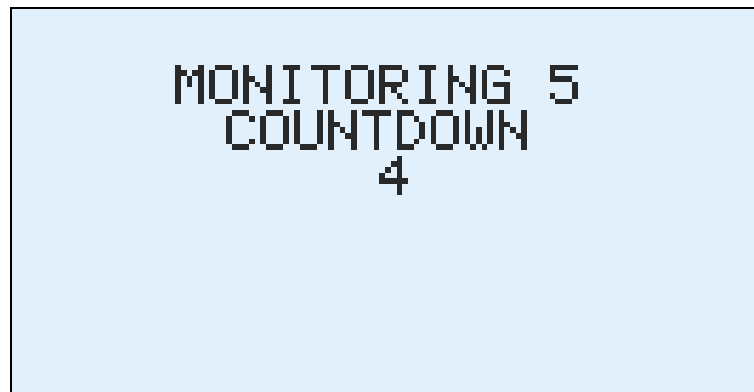
Fig. 6.10 – Countdown

A typical screen displayed by the instrument during the monitoring phase is shown below.
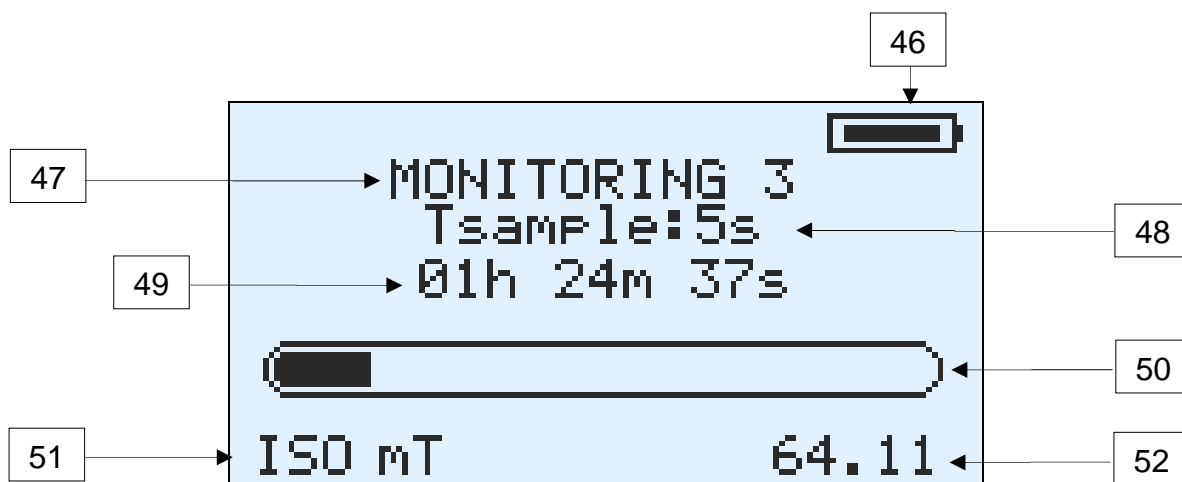
Fig. 6.11 – Monitoring screen

46 – battery life.

47 – monitoring number from 1 to 29.

48 – sampling rate for storing.

49 – time since the monitoring start.

50 – memory fill bar for monitoring.

51 – measurement unit for the displayed ISO value.

52 – instantaneous isotropic value of the field (ISO).

In progress monitoring may extend until the total memory space available for the 29 monitors (245,760 measures) is filled, indicated by the "MEMORY FULL" message, or until the user wants to stop it by pressing any key on the instrument

A 6-minute monitoring can be started by keeping the MONIT button pressed for more than 2 seconds. When the monitoring starts, "6 min MONITORING" is displayed. The sequence will automatically stop after 6 minutes from its start.

The NHT-3D memory can hold up to 245,760 acquisition points. Once this limit has been reached or after performing 29 monitoring sequences, data must be downloaded and delete from the device before performing a new storage. The limitation is displayed at the instrument switching on (section 6.1 item 23).

Monitoring start and stop can be also set from remote through Waves software, by setting start time and duration of recording.

To this end, it is important that the instrument clock is synchronized, which can be performed through the Waves application.

When a monitoring activity has been set, the * symbol blinks on instantaneous value left as shown in the figure. Once the start date and time is reached, the symbol disappears and the monitoring starts automatically for the expected duration.

6.4 Measurement download and display

All measured values, stored in NHT-3D memory, can be downloaded to an external PC/Tablet via fiber optic connection and USB adapter, This data can then be viewed, processed and analyzed using the Waves software.

6.5 Alert levels

The NHT-3D features a function which alerts the user by means of an acoustic signal which indicates that the measured field exceeds a user configurable

threshold inserted via the Waves application; this function is enabled by pressing the **ALARM** key.

As well as having this user configurable function, the instrument however alerts the operator when the maximum field value measured by the probe has been exceeded by 95%. This warning is provided by the letter **E** which appears beside the ISO field (Fig. 6.10) accompanied by an acoustic signal. The letter **E** appears near the isotropic value and near axis which has surpassed this threshold, as long as the display of the single components has been selected.
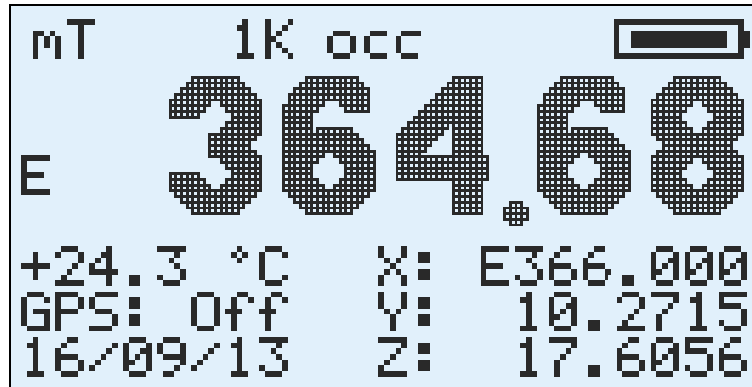
Fig. 6.12 – Warning of approaching the measuring range

In the case where the field is so strong that it surpassed the probe range, then the message **OVER-RANGE** (Fig. 6.10) appears on the screen in place of the isotropic value; the message is always coupled whit an acoustic signal.
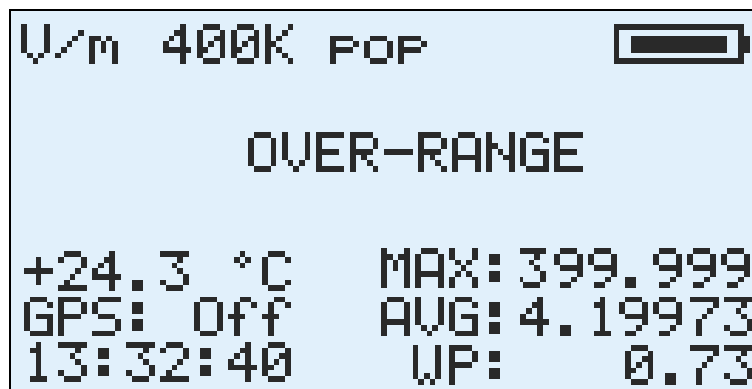
Fig. 6.13 – Surpassing the probe range

6.6 Factory reset

To perform a reset on NHT-3D unit, press the **[RESET]** key and hold it for 10 seconds. The system restarts by performing a general reset.

This action will erase all measurement data and will restore all NHT-3D parameters to factory default.

7   WAVES SOFTWARE

7.1 Introduction

Waves is a PC/Tablet based software package which allows the user to interact with the NHT-3D device. By launching the Waves application with the NHT-3D instrument switched on and connected to the PC, the real-time signal acquisition is already active, in continuous mode.

The application displays a graphic window which, depending on the type of probe in use, is configured with the following characteristics:

- with probes operating in selective mode, ie low-frequency and magnetostatic probes, it displays the samples acquired in the time domain in the upper window, and simultaneously reports the spectral content of the signal in the frequency domain, shown in the lower window. The representations in the time and frequency domains are foreseen for the following probe models: 11E, 10B, 20B, 30B, 20H, 30H, 33E and 33B (the last two contained in the 33P combined probe).

- with probes operating in wide band mode, ie radiofrequency probes for which the frequency information is not discriminated, displays only the time window. The probe models for which the sole representation in the time domain is foreseen are: 01E, 02E, 03E, 04E and 02H.

- with the static probes 10H and the 33H, contained in the 33P combined probe, for the measurement of static magnetic fields, the display of the time and frequency diagrams is not foreseen. The values of the field can be viewed on the instrument display.
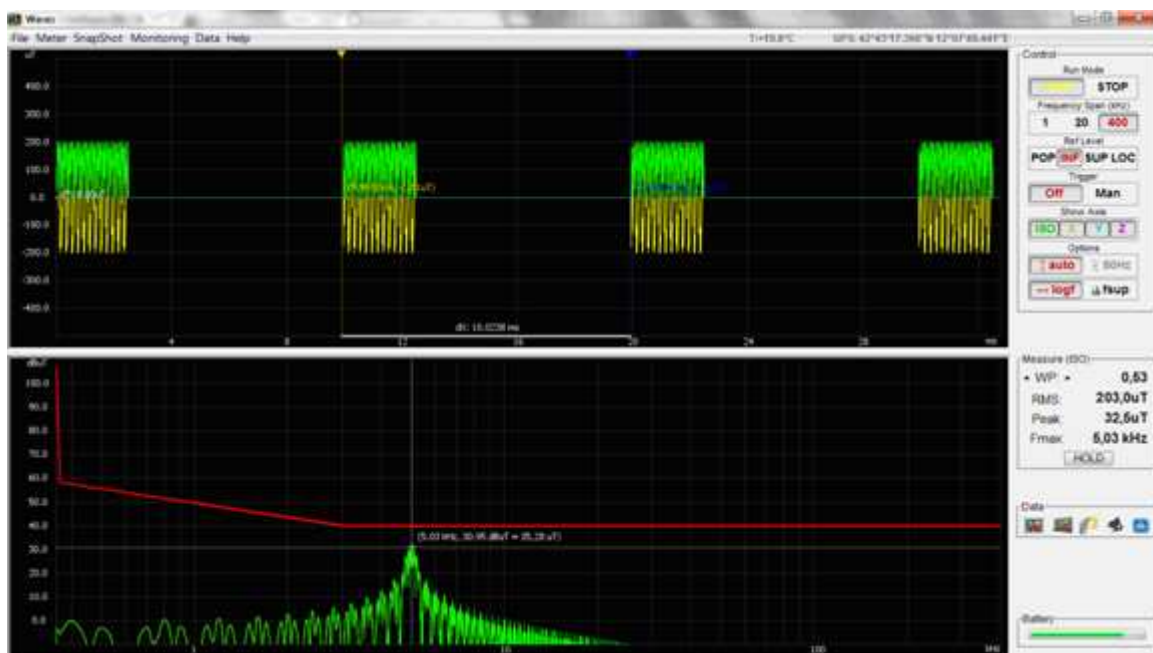

Fig. 7.1 –Waves software

The acquisition controls, the measurement values and indexes and the battery status are shown on the right hand side of the display. On the upper toolbar there are additional configuration menus, as well as the indicators for temperature and GPS position as detected by the instrument. The display is continually updated.

Real time acquisition works in two different modes, depending on the span selected: with 1K span, the instrument seamless scans and transfers all samples to the software; while with 20K or 400K span, the instrument transfers data windows made up of 65'536 samples; data sampled by the instrument during the window transfer through the fiber optic, which lasts about 0.6 seconds, are lost.

7.2 Software installation

Waves software is compatible with Windows XP, Vista, 7, 8, 10 operating systems, both 32 and 64 bits. The installation file can be downloaded from the *Microrad* website (www.microrad.it) within the software download page.

Together with the application, the Optical / USB adapter driver is also installed, enabling automatic adapter recognition each time it is connected to the PC.

7.3   Upper toolbar description

- **File** Menu

	Open Waveform – Opens a waveform previously saved in the PC. The time and frequency diagrams, marker position, status of controls, index values, temperature, and GPS sensor information are reloaded. It is possible to perform pan and zoom operations, move the marker, export data like image or tabular format.
	Save Waveform – Saves a new waveform on a PC's mass unit. The time and frequency diagram, marker position, status of controls, index values, temperature, and GPS sensor information are saved. Data can be reloaded and analyzed at a later time, without connection to the instrument.
	Exit – Exit from programme

- **Meter** Menu

	Meter Info – Contains information (Part Number, Serial Number, manufacturing date, firmware version) regarding the NHT-3D instrument connected to the PC and the inserted probe (Part Number, Serial Number, manufacturing date, calibration date, probe type and frequency band).

	Set Avg Window – Allows the user to set the width of the moving window that NHT-3D uses for moving r.m.s. calculation (AVG).

	Set Monitoring – Setting monitoring parameters: sampling step, start delay, start and stop time programming.

	Set Alarm Thresholds – Allows the user to set the threshold for acoustic alarms on the NHT 3D. It is possible to set a threshold for radio frequency probes, one for low frequency magnetic probes, and one for low frequency electric probes.

	Sync Clock – Synchronises information, data and time, between the PC and NHT-3D.

	Firmware Update – Updates the Firmware of the device.

▪ **Snapshot** Menu

	Download Snapshots – Transfers single snapshot taken by the NHT-3D device to the PC for further analysis and post processing; in particular, acquisitions can be stored on a PC's mass unit and visualized on the snapshot display panel.

	Take Snapshot – Remote command sent to the NHT-3D instrument to store each snapshot reading. It is equivalent to the SINGLE button on the instrument.

	Clear Snapshots – Erases all the acquisitions data from the device's memory (up to 1'024).

	Load Snapshots – Loads data from previously saved single snapshot files and opens the snapshot display panel.

▪ **Monitoring** Menu

Download Monitorings – Transfers all data of the monitoring sequences taken by the NHT-3D device to the PC for further analysis and post processing; in particular, acquisitions can be stored on a PC's mass unit and visualized on the snapshot display panel.

Start/Stop Monitoring – Remote monitoring command sent to the NHT-3D instrument. It is equivalent to pressing the MONIT key on the instrument.

Clear Monitorings – Clears all monitoring data in the instrument (up to 10 monitoring sequences).

Load Monitoring – Loads data from previously saved monitoring sequence files and opens the monitoring display panel.

▪ **Data** Menu

Clear Markers – It performs the reset of the markers that had been previously selected, allowing the subsequent use of new markers.

Export Tabular – Exports in tabular format (Excel compatible) all the acquisition data contained in the screen displayed by the application (time and frequency diagram, date, time, GPS, temperature, controls status, indexes values, instrument and connected probe data).

Export Image – Exports in image, bitmap or jpeg selectable format all the acquisition data contained in the screen. Three pictures are exported: the time diagram, the frequency diagram and an overall picture containing the entire Waves user interface and then, in particular, indexes value, temperature, GPS, and controls status.

Print – Prints the acquisition data displayed on the screen. Three graphics are printed: the time diagram, the frequency diagram and an overall picture containing the entire Waves user interface and then, more specifically, indexes value, temperature, GPS, and controls status.

Change Units – Modify the measurement units that are used to represent the field values within the Waves software.
Note that the measurement unit selected in the remote software is not synchronized with the unit in the NHT-3D instrument, For example, it is possible to use different units simultaneously on the instrument and on the software.
Selectable units depend on the probe used and follow the same criteria as the units selectable for the instrument.

▪ **Help** Menu

Content – Link to the user's manual via Internet

About – Information regarding the software version installed

7.4 Description of side panel controls
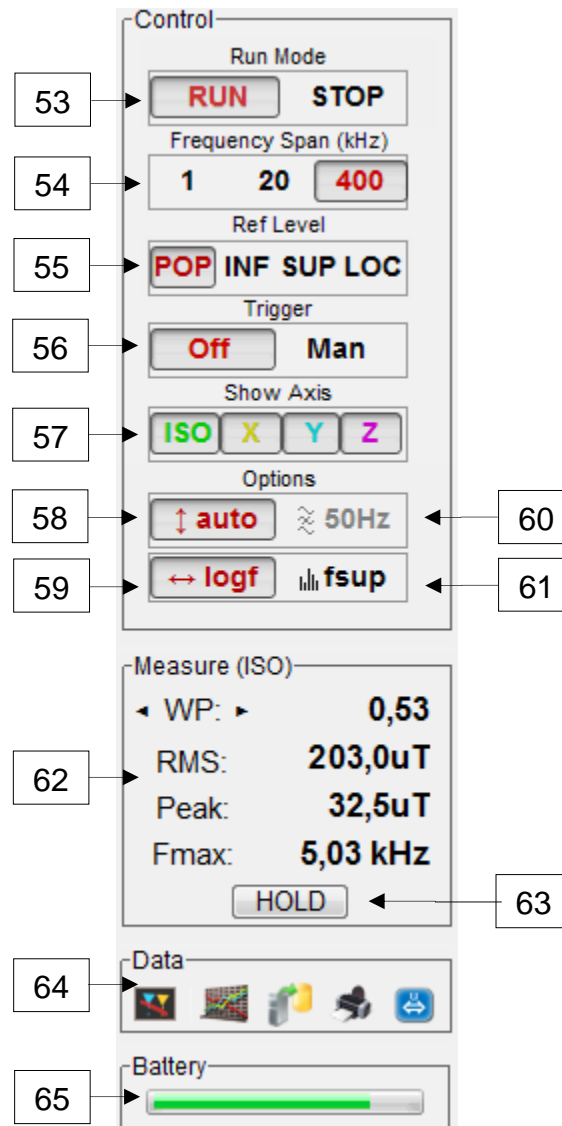
Fig. 7.2 – Side panel controls

53 – It starts and stops the transfer of real-time acquisition of the NHT-3D instrument. The STOP key blocks the screen at the last acquisition performed.

54 – Selection of the frequency span, only possible with probes that allow the instrument to work in selective mode (static and low frequency probes, radio frequency probes typically work with 20K span characteristics but frequency domain information is not present). Table 7.1 shows some acquisition characteristics based on span selection.

Span	Window length (ms)	Time resolution (us)	Frequency resolution (Hz)	Acquisition note
400K	32,768	0,5 us	30,52 Hz	continuous
20K	655,36	10 us	1,53 Hz	window
1K	13'107,2	200 us	0,076 Hz	window

Tab. 7.1 – Acquisition characteristics based on span selection

55 – Selection of the normative references regarding operators (lower, upper or localized) or population. The mask is graphically displayed in the frequency domain diagram. This control is only active in selective frequency mode.

56 – Trigger enable (only 20K, 400K span or radio frequency probes); the trigger is very useful for capturing impulse signals or signals above a certain intensity (ISO) but not stationary. A green horizontal line appears in the upper half of the time diagram, indicating the level that the isotropic signal of the field must surpass in order to start the acquisition, otherwise crystallized at the last one. The vertical position of the trigger can be changed by dragging the triangle to the right of the green line with the mouse left key depressed. The horizontal position of the trigger is fixed, in the middle of the acquisition window (so if, for example, a pulse is captured, it will always be in the center of the window). On the upper right of the panel, the "Trigger Time" is also displayed, it is the time between one acquisition and the next. For the 1K span, the trigger is not available since in this mode all the signal is continuously transferred and displayed, without loss.

57 – This key enables and disables the ISO and the single measurement axes (X, Y, Z) display.

58 – Vertical Autoscale: when this function is activated, the vertical scale of the time domain diagram is automatically adjusted to the peak signal value within the window.

59 – Linear or logarithmic horizontal scale selection for signal frequency domain diagram.

60 – Enable / disable the 50Hz notch filter with low frequency probes, the 50Hz interference notch filter with radio frequency probes and DC filter with magnetostatic probes.

61 – This key provides the user with the possibility to filter spectral content in the frequency domain. It is possible to eliminate that content which has a value of less than 10% of the selected mask value or that content which has a value of less than 3% of the maximum value. This function is available only in selective mode and modifying the spectral diagram it impacts also on the calculation of the indexes II98, IRSS, Irms, Fmax. The WP and Ib indexes

remain unchanged since they are processed by the NHT-3D instrument and transferred to the application without any variation.

62 – Measured values and indices, related to the isotropic signal window and displayed in time and frequency domain diagrams. The first is a selectable index between WP, II98, Ib, IRSS, Irms. Other values, such as RMS, Peak, Fmax, are always displayed. If a radio frequency probe is used (wide band mode) only the RMS and Peak values are displayed. Refer to paragraph 1.6 for the indexes description.

63 – MaxHold function: if enabled, each of the WP, II98, Ib, IRSS, Irms, RMS, Peak, Fmax indexes displayed in the "Measure (ISO)" panel is updated only when it has a higher value than the one displayed. Specifically Fmax frequency value is updated when a spectral component with a higher value than the last one is acquired.

64 – This toolbar contains the same functions present in the Data menu that are described in the previous paragraph.

65 – This function shows the battery charge level.

7.5 Chart diagram operation

7.5.1   Diagrams zoom and pan

The user can, via the mouse, select a rectangular area within time or frequency domain by holding down the left key and moving the cursor across the diagram; by releasing the left key, the selected area is enlarged to occupy the entire available screen window.

Once zoomed, the operator can pan across the screen by dragging the mouse holding down the left key.

By pressing the right button, user can return to the original view, without zoom.

7.5.2   Diagrams pointers

When the mouse is moved or positioned above the time or frequency domain diagram, the pointer is made up of two white dotted orthogonal lines. The coordinates (field and time values or field and frequency values) are displayed at the point where the lines intersect. If the operator wishes to export an image while leaving the pointer inside a diagram in order to highlight a value, all he/she has to do is use the keyboard command $CTRL + I$.
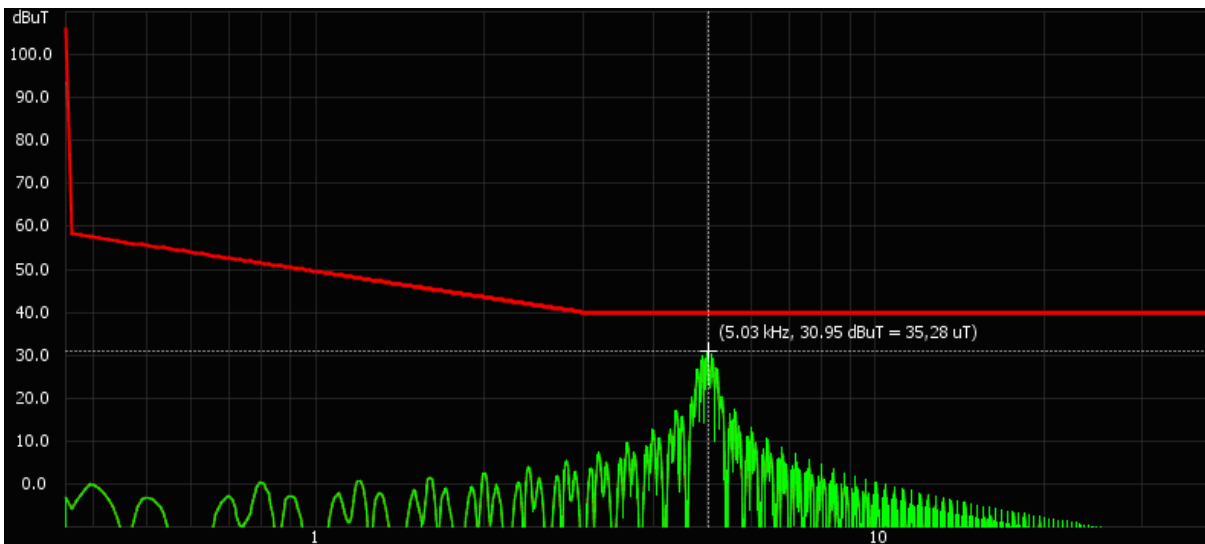
Fig. 7.3 – Pointer

7.5.3   Diagrams Markers

Each diagram, both in time domain and frequency domain, has 2 markers (displayed as 2 small triangles, one yellow and the other blue, in the upper left corner of the diagrams) that can be placed above points of interest.

To place a marker, select a triangle and drag it with the mouse left key depressed. The horizontal shift is free, while the vertical one, unlike the pointer, automatically follows the value of the field.

Once a marker is placed, the field and time (or frequency) values are displayed with the same colour of the marker. If the operator places both markers, the relative differences are also displayed, for the amplitude on the vertical axis and for the time (or frequency) on the horizontal axis.
The value of the field indicated by the marker relates to the first of the active axes in the display controls window, according to the ISO, X, Y, Z priority order. For example, if axes X and Z are displayed, the marker will refer to the X axis values.
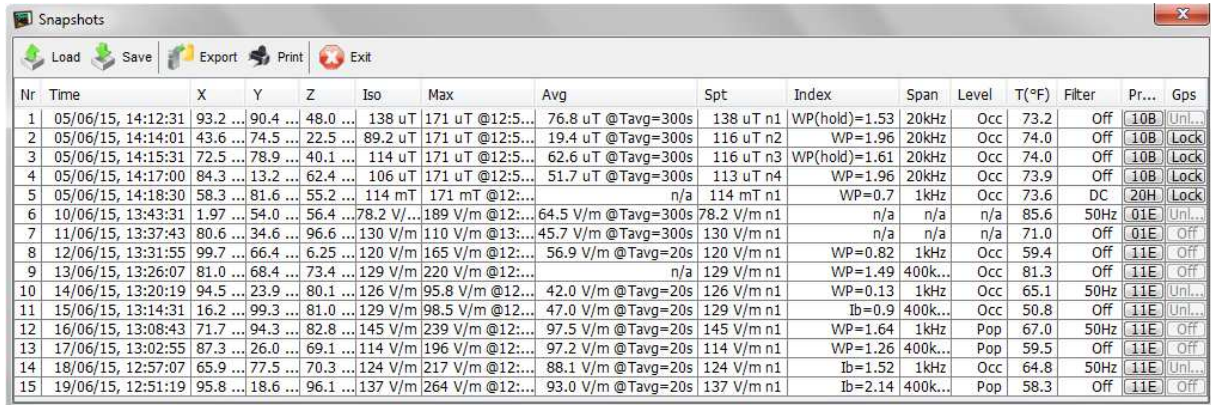
Fig. 7.4 – Markers

7.6 Snapshot panel

User access the Snapshot Panel each time data from the instrument are downloaded (*Snapshot → Download Snapshots* menu) or when they are loaded by files (*Snapshot → Load Snapshots* menu).

Each single measurement (snapshot) is represented by a line in a table which contains the following information:

Fig. 7.5 – Snapshot table

- Progressive number (from 1 to 1'024).

- Date and time.

- X, Y, Z instantaneous component values for the field.

- Instantaneous isotropic values of the field (ISO).

- Maximum isotropic value (MAX) with associated date and time.

- r.m.s. moving average value (AVG) and time window width.

- Spatial average value (SPT) and number of samples considered in its calculation;

- WP or Ib index which was displayed on the screen at the moment of acquisition, and Hold function presence.

- Frequency Span selected at the moment of acquisition.

- Reference level selected at the moment of acquisition.

- Temperature.

- Notch filter status (50Hz or DC filter depending on the probe).

- The model of the probe with which the measurement was taken (with a click above this field a window will appear with all the details of the probe).

- GPS status: if the GPS is active and locked on to a satellite during the measurement activity, a *Lock* message appears. By clicking on it the user can access to the GPS coordinates and time and to the map view as explained in paragraph 7.8.

Using the keys above the table, operator can load data from files (*Load*), save data (*Save*), export data in Excel format (*Export*), print data (*Print*) and exit from the Snapshot panel (*Exit*).

7.7 Monitoring panel

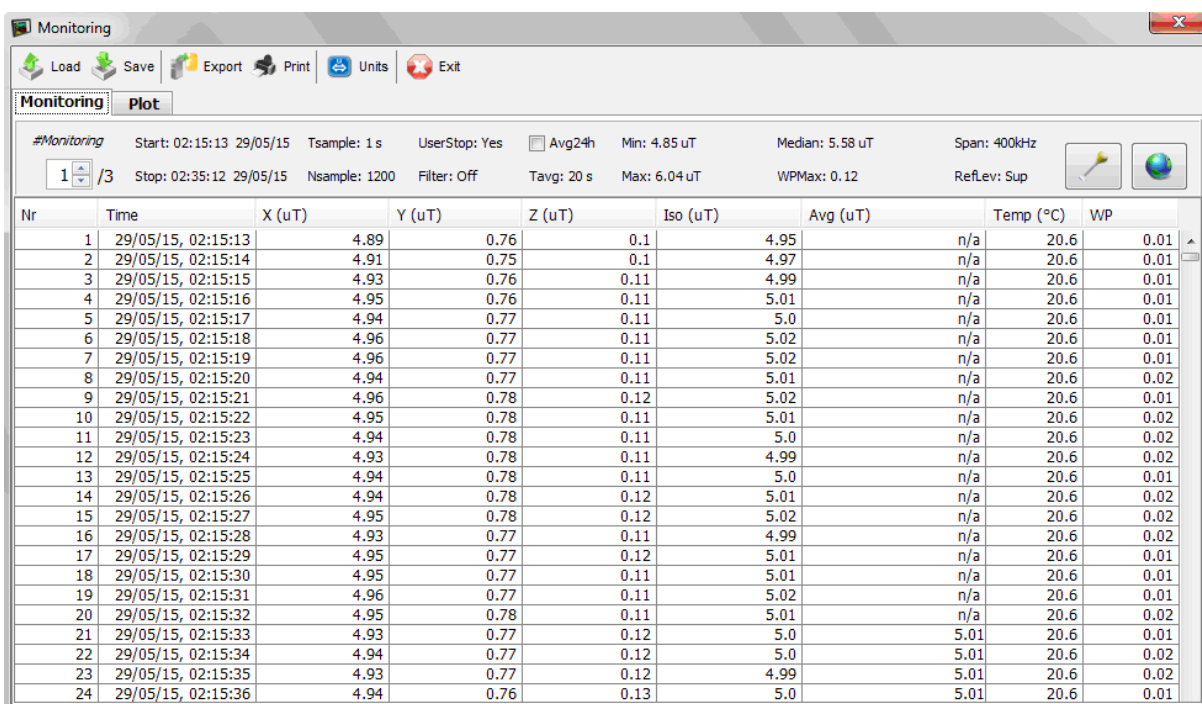User access the Monitoring Panel each time data from the instrument are downloaded (*Monitoring → Download Monitorings* menu) or when they are loaded from files (*Monitoring → Load Monitorings* menu).

Using the keys above the table, operator can load data from files (*Load*), save data (*Save*), export data in Excel format (*Export*), print data (*Print*) and exit from the monitoring panel (*Exit*).

The panel offers two different formats of data: numeric data can be accessed from the *Monitoring* tab, and the graphic data from the *Plot* tab, immediately below the keys just described.

7.7.1 Monitoring data numeric format

Up to 29 separate monitors, selectable by the control on the top left corner, below the label *#Monitoring,* are managed.

Fig. 7.6 – Monitoring data numeric format

Data are in the rows of a table, a sample per line (up to 24,576) and for each one the following information are displayed:

- Progressive number.
- Date and time.

- X, Y, Z instantaneous component values for the field.

- Instantaneous isotropic values of the field (ISO).

- r.m.s. moving average value (AVG) calculated using the Tavg parameter that was selected at the time of the monitoring start, or calculated on 24h when the function *Avg24h* is selected.

- Temperature.

- WP or Ib index if selected at the moment of acquisition.

On the table top, many important information about the monitoring are displayed:

- The monitoring sequence number (1 to 29) and the total number of sequences present in the device memory (#*Monitoring*).

- Date and time of start (*Start*) and stop (*Stop*).

- Sampling step used (*Tsample*).

- Number of samples acquired (*Nsample*).

- *UserStop* indicator, if *Yes* is displayed the monitoring has been stopped manually (by tapping the instrument or pulling out the probe) and then the last data may be disturbed by the operator proximity. As an alternative to manual shutdown, it is possible to stop monitoring by remote control (*Monitoring* → *Load Monitorings* menu), setting a scheduled stop (*Meter* → *Set Monitoring* menu), or stop for memory depletion.

- *Filter* indicator, returns the On / Off status of the instrument filter (50Hz or DC depending on the probe used) during monitoring.

- The *Avg24h* control enables a 24 hours calculation of the moving average in the Avg column, by forcing a 24-hour *Tavg*. This calculation is useful only in case of monitoring sequences lasting more than 24 hours.

- Time interval for moving average calculation set during acquisition (*Tavg*).

- Minimum (*Min*) and maximum (*Max*) instantaneous isotropic value measured.

- Median index or middle value (*Median*).

- Weighted index maximum value (*WPMax* o *IbMax*) if selected when monitoring starter, or r.m.s. moving average maximum value (*AvgMax*).

- Frequency span selected during acquisition (*Span*).

- Selected reference levels at the time of acquisition (*RefLev*).

Finally, through 2 dedicated buttons at the top right, operator can access the probe data used for monitoring and GPS information. Coordinates and GPS time refer to the location and time at the monitoring start.

7.7.2   Monitoring data graphic format

In this section, operator accesses the time diagram (Fig. 7.11) of the monitoring sequence selected in the numerical display panel pressing the control *#Monitoring.*

By highlighting (dragging the mouse with the left key depressed) parts of the table, the corresponding portions of the diagram automatically highlight and vice versa.

Fig. 7.7 – Monitoring graphic format

Controls displayed in the panel on the left are described below.

- *Y Scale*: allows to switch from the linear view of the field values to the logarithmic (except temperature and weighted indexes that are always displayed on a linear scale); in the case of logarithmic display, the value of 0 dB is assigned to the maximum value of the isometric field; then each point assumes a decibel value according to the relation:

$$E(dB) = 20 \, Log_{10} \, (\, E \, / \, E_{isomax} \,)$$

- *Tracks*: allows the viewing of the ISO instant field values, of the individual axes (X, Y, Z), of the r.m.s. value (AVG), of temperature (T), and of weighted index (WP or Ib) diagrams.

- *Marker*: indicators (horizontal lines) for the maximum and minimum value of each plot displayed.

- *Tools* : functions to zoom time dimension and to export the diagram to bitmap or jpeg files.

7.8 GPS and Google maps

Localization information (latitude and longitude) from the GPS sensor are always displayed on the instrument screen, even inside the bar at the top right of the Waves main screen.

In addition, as already seen, GPS location and UTC time are saved in the instrument both with single acquisitions and with monitoring.

In this case, after data download to the PC, not only the GPS coordinates and the time are recorded, but the user also has the facility to view them using Google Maps which indicates the positions from which the measurements were taken.

This is done by establishing a connection between the PC and the internet and then clicking on the **Maps** button which appears in the window as shown in Fig. 7.8.
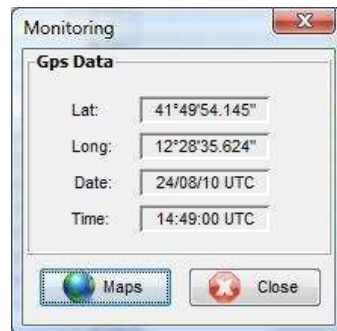

Fig. 7.8 – GPS Information

This command automatically opens Google Maps in the predefined browser of the system and shows the position from which the measurement was taken on the map (Fig. 7.9).
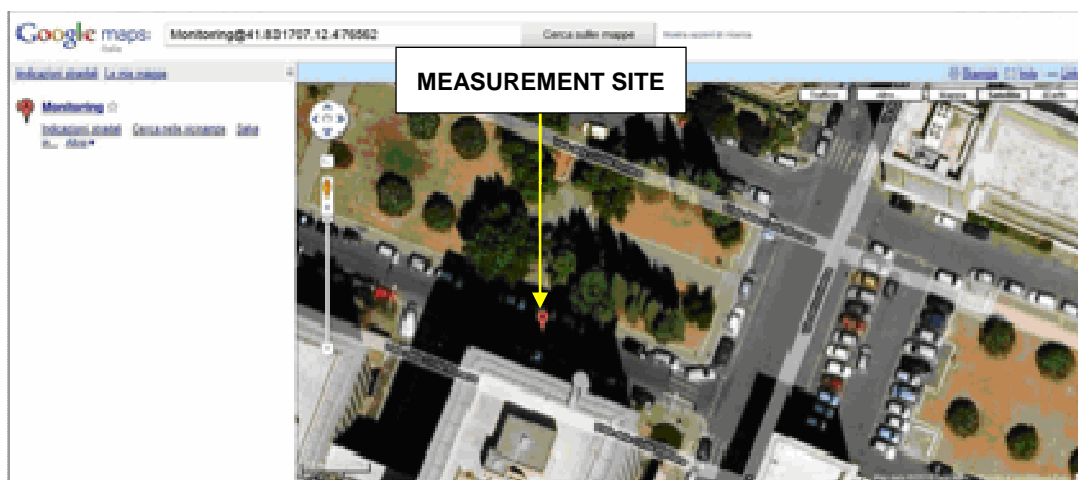

Fig. 7.9 – Location on maps

7.9   NHT-3D firmware update

The Waves software is designed to allow eventual updates to the firmware located inside the NHT-3D device when they are released by the manufacturer.

The file containing the new firmware version is recognizable through the extension **.rom** and may be downloaded from the manufacturer website: www.microrad.it.

To carry out an update the following procedure is used:

- Make sure the NHT 3D device is switched off before connecting it to the PC via the optical cable supplied with the kit.

- After the start of Waves software, click *Meter → Firmware Update* menu.

- A window will open that allows to select **.rom** files on the PC's hard disk. Select and open the file (double-click or *Open* key).

- A message to switch on the instrument in firmware update mode appears on the screen; proceed as described in the following points.

- Press the **RESET** key on NHT-3D keyboard and, keeping this key pressed, contemporarily press the instrument **POWER ON**.

- Release **POWER ON** key but keep the **RESET** key pressed until the following message appears on the screen:

"FIRMWARE UPDATE MODE"

- Release the **RESET** key.

- Confirm the switching on by clicking the OK button inside the message displayed in Waves.

- The update started, and a bar indicates progress, until full filling.

At the end of the update procedure the Waves software sends a message that the update procedure has been successful. The NHT-3D will then reboot automatically.

ANNEX A   COMMUNICATION PROTOCOL

The measurements made by the instrument can also be accessed through proprietary applications, using the fiber optic communication line and the USB adapter.

To enable communication between the PC and the instrument USB line, operator must first install the Virtual COM Port (VCP) driver provided by FTDIChip; the driver allows the software to see the USB line as a normal serial port and establish communication with UART protocol.

Driver installation is not required if a PC where *Microrad* Waves software is already present is used.

In any case, operator should verify that the VCP option is enabled:

Device Manager (Gestione dispositivi) → Controller USB → USB Serial Converter → Properties → Advanced
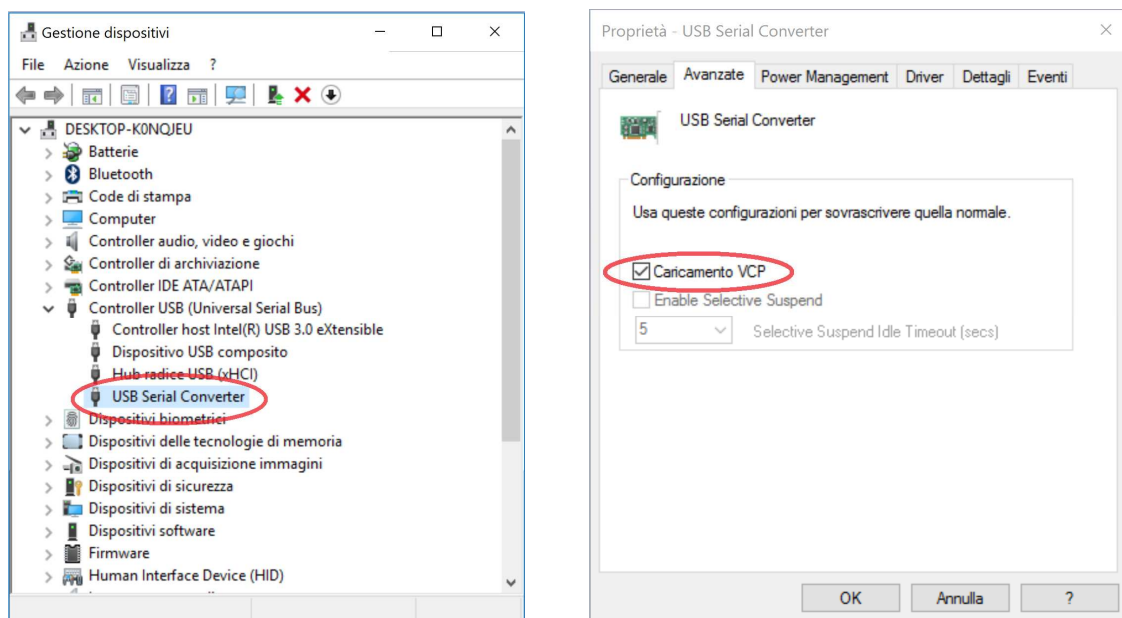

Fig. A.1 - Virtual COM Port enable

To this end, the communication port must be configured by the user application to work with 8 data bits, no parity bit, 1 stop bit (8n1) and a 9600 baud rate.

It is then necessary to enable the serial data communication mode in the instrument, keeping the SHIFT key pressed for about 10s until a blinking 'R' appears to the left of the ISO value. This mode remains active permanently, even after the instrument is switched off / on again. Deactivation takes place with the same procedure.

When the serial data communication mode is active, the instrument continues to operate normally, and it is able to send measurement data to the optical fiber when required.

However, it is no longer possible to perform memorization operations (single acquisitions and monitoring) on the instrument. Furthermore, it is no longer possible to interface it with the application software, first disable the serial data communication mode and the driver's VCP option.

The communication protocol is based on the exchange of ASCII messages between the user's custom application (master) and the instrument (slave).

The commands consist of single characters sent by the master.

The responses of the slave consist of strings with common characteristics: they all start with the character '**$**' (24h) and end with the sequence *****checksum<CR><LF>**.

$ campo1, campo2, ... , campoN *checksum<CR><LF>

- the first character of the string is always '**$**' (24h)
- '*****' (2Ah) is the character used as checksum delimiter
- the fields are always delimited by the character '**,**' (2Ch)
- characters carriage return and new line, '**<CR>**' (0Dh) and '**<LF>**' (0Ah) always end the string
- the checksum consists of 2 hexadecimal characters corresponding to the XOR of all the bytes between '$' and '*' ('$' and '*' excluded).
  The calculation methods are the same as those foreseen in the NMEA protocol (https://en.wikipedia.org/wiki/NMEA_0183).

The command of the measurement data request consists in sending to the instrument the uppercase character '**A**'.

Il comando di richiesta dei dati di misura consiste nell'invio allo strumento carattere '**A**' maiuscolo. The instrument responds with the string:

$Eiso,Ex,Ey,Ez,T*checksum<CR><LF>

where the 5 fields shown are:

- **Eiso** : total value of the isotropic field
- **Ex** : value of the field component along the X direction
- **Ey** : value of the field component along the Y direction
- **Ez** : value of the field component along the Z direction
- **T** : temperature (°C)

The measurement unit of the field is the default one adopted by the probe in use (V/m for all the electric probes, µT for the magnetic low field probes, A/m for the magnetic radiofrequency probes, mT for the static high field).

Example with probe 01E:

*$103.94,10.42,103.4,1.83,19.9*1B<CR><LF>*

- *Eiso= 103.94 V/m*
- *Ex= 10.42 V/m*
- *Ey= 103.4 V/m*
- *Ez= 1.83 V/m*
- *T= 19.9°C*