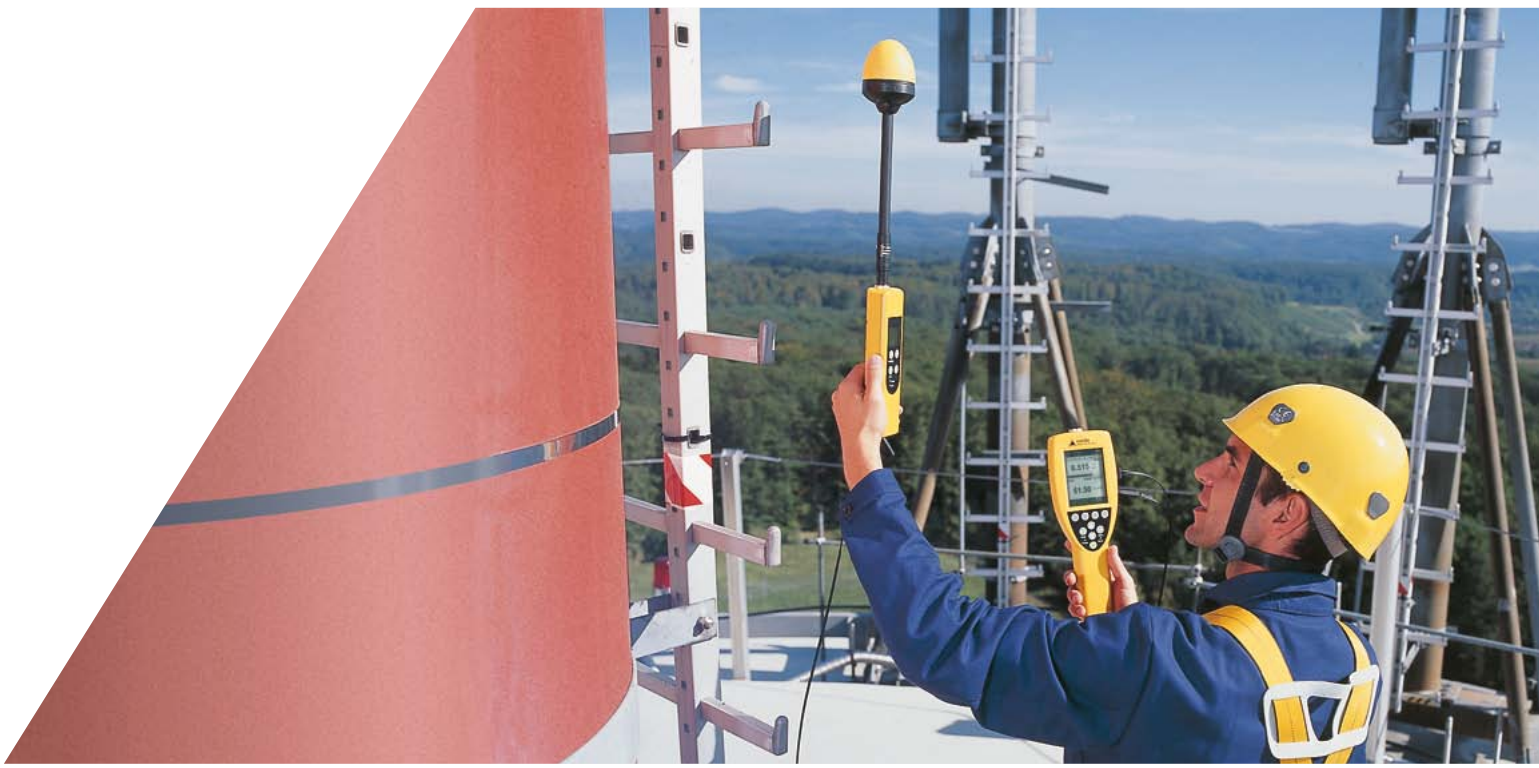
## NARDA BROADBAND FIELD METER NBM-500 SERIES



# SAFETY IN HIGH FREQUENCY ELECTROMAGNETIC FIELDS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narda
Safety Test Solutions®
an L3 Communications Company

# MEASURE SAFETY

Protecting humans and the environment from harm is less about things that occur naturally, but much more about problems that we have caused ourselves, such as noise, dangerous materials, electromagnetic radiation and radioactivity. Producers, equipment operators, employers, safety representatives, workplace safety bodies, and authorities are faced with great responsibility. The obligation to provide protection ranges from the workplace through to the public domain and even into the private sphere – in other words, the whole environment.

Subjective senses can provide protection: We can hear noise, feel vibrations, and smell chemicals – at least to some extent. So we can avoid these dangers, or take preventive action. But we cannot see, hear or smell electromagnetic radiation. That may make us feel nervous. But to make an objective assessment of the problem, we need to be able to measure the effect. Measurements are thus unavoidable.

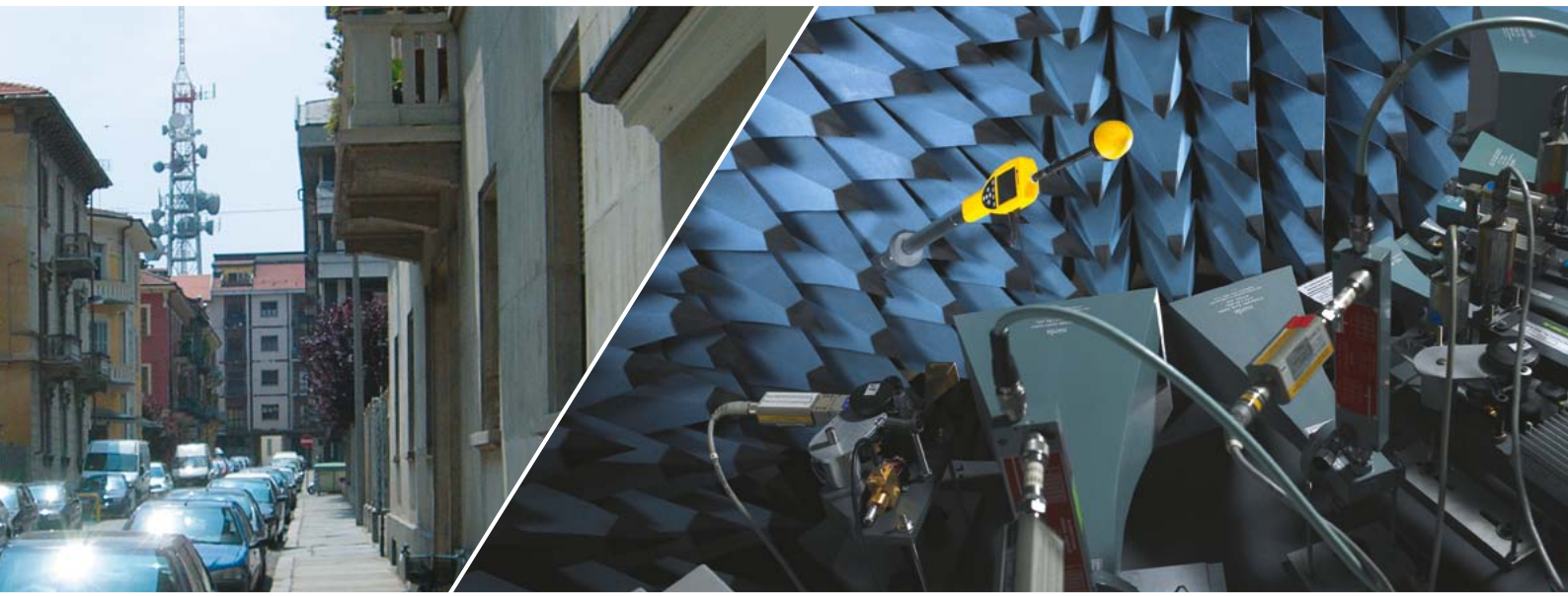
National and international bodies have specified frequency-dependent limit values to provide protection from damaging exposure to electromagnetic radiation. In this regard, the permissible field strengths for the occupational environment are usually higher than those for the general public. That is because those who routinely work in electromagnetic fields are trained,

aware of the potential dangers, and act accordingly. Conversely, employers must ensure a safe working environment, demonstrate that the limits are being adhered to, indicate safe zones, and give appropriate instructions on how to act.

Narda Safety Test Solutions has developed the NBM-500 series of Broadband Field Meters for just this purpose. They detect and measure high frequency electric and magnetic fields*) and are specially designed to make measurements to ensure human safety. Calibration traceable to national and international standards ensures that results are precise, reproducible, meaningful and beyond question.

NBM instruments show their strength in on-site applications, in any surroundings. Their accuracy means that they can likewise be used in the laboratory for making measurements. Or, they can simply be used to search for leaks or hot spots on high frequency lines and devices.

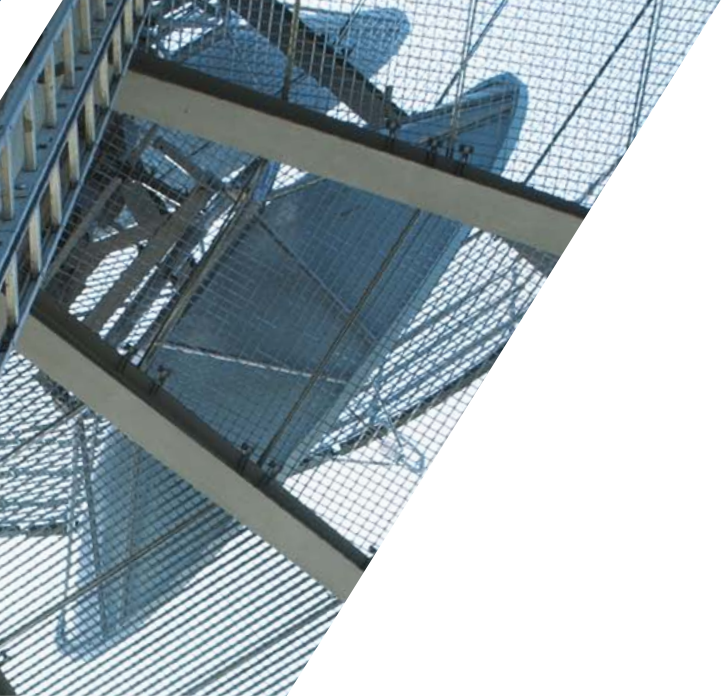
*) High frequency electric and magnetic fields with frequencies up to 300 GHz are also termed non-ionizing radiation (NIR), which is different from ionizing, „radioactive" radiation.



## STANDARDS, GUIDELINES, REGULATIONS

- Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz). International Commission on Non-Ionizing Radiation Protection (ICNIRP). Published in Health Physics, Vol. 74, No. 4, pp. 436-522, April 1998
- Guidelines on Limiting Exposure to Non-Ionizing Radiation. International Commission on Non-Ionizing Radiation Protection (ICNIRP), July 1999; ISBN 3-9804789-6-3
- Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz – 100 kHz). Health Physics 99(6):818-836; 2010
- Directive 2013/35/EU of the European Parliament and of the Council of 26 June 2013 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields) (20th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) and repealing Directive 2004/40/EC
- Council Recommendation of 12 July on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC). Official Journal of the European Communities L 199/59, 30.7.1999
- IEEE C95.1-1991: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
- Federal Communications Commission (FCC), „Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation," Report and Order, ET Docket 93-62, FCC 96-326, adopted August 1, 1996. 61 Federal Register 41006 (1996).
- Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz. Safety Code 6, 99-EHD-237, 1999, ISBN 0-662-28032-6
- Revised ECC Recommendation (02)04: Measuring non-ionizing electromagnetic radiation (9 kHz – 300 GHz). Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT). October 2003 edition.





# COMMUNICATE

In touch everywhere. Access anywhere. For most people, this dream has become reality.

Devices are getting more and more versatile. You can do much more than just make a phone call with the latest mobile phones. You can have wireless access to all Internet services with your notebook PC or your PDA. And, you can make that phone call if you want to.

Radio networks have developed to keep pace: Wireless LANs and other wireless communications systems for local "islands", mobile systems such as GSM, UMTS, CDMA and LTE for complete on-site coverage, coupled with wide area communications using fixed networks. And even the fixed networks are no longer cable bound: radio links transmit thousands of channels over distances of 50 km or more, and satellite links cover the whole world.

More mobility means more antennas, and less space between them. Things are not just getting cramped on transmitter towers and masts; even rooftops are getting crowded. Authorities are obliged to grant permission for antenna locations, going as far as specifying the distances between them for safety reasons. Operators are responsible for adhering to these distances, as well as to field strength limit values, to ensure the safety of staff working on or near the antennas and to protect the general public.

Those responsible need test equipment, with a wide enough bandwidth to capture the entire spectrum of frequencies that may be present. Sensitive enough to measure low field strengths at considerable distances from the source, and accurate enough to give definitive results. Last but not least: Reliable reproducible measurement results can be clearly communicated.

**ABBREVIATIONS**

| | |
|---|---|
| PDA | Personal Digital Assistant |
| LAN | Local Area Network |
| GSM | Global System for Mobile Communications – 2nd generation mobile communications |
| UMTS | Universal Mobile Telecommunications System – 3rd generation (3G) mobile communications |
| CDMA | Code-Division Multiple Access – modulation method; also the name of mobile communications networks that use this method |
| LTE | Long Term Evolution, specified as the successor to UMTS by the 3rd Generation Partnership Project (3GPP) committee |

# TRANSMIT, RECEIVE, LOCATE

Radio and TV cover every area. Listeners and viewers expect high quality reception, even if they are a long way from the transmitter. Not everyone is connected by cable, and even the cable network needs a head end station that receives all programs perfectly. Apart from the modulation method used, high quality and long range are achieved through high output power levels.

The same is true of non-public radio services: Police, rescue services, operational radio, and air traffic control.

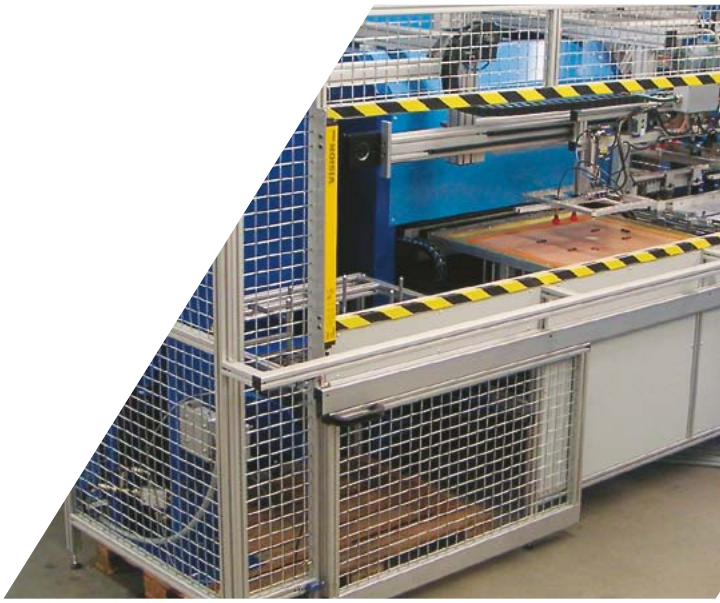
But even where no programming is being broadcast, there are other signals being used – such as radar to locate objects. Radar evaluates the echoes of high frequency impulses to determine position. The higher the impulse power level and the shorter the impulse, the better the resolution.

In this context too, we need to be protected from excessive radiation levels, as does the environment we live in. Safety zones need to be classified and marked in the direct vicinity of transmitter antennas, and maximum exposure times must be specified. Checks are needed to test that the limit values are being adhered to, both close to the source and in the wider surroundings. The measuring equipment must not only be able to withstand high field strengths and short impulses, it must measure them accurately, as true RMS values, as peak values, or both – depending on the situation.

# WELD, HARDEN, HEAT, DRY

We can utilize high frequency electromagnetic radiation in a variety of ways. It can weld plastics, harden metallic surfaces, dry paints and enamels or wood and leather, or heat materials for industrial processes – as well as warming up our dinner in the microwave oven.

The so-called ISM frequencies are reserved for these purposes (ISM = Industry, Science, Medicine). Example frequencies are 13.56 MHz, 27.12 MHz and 2.45 GHz – the frequency used by the microwave oven.



By kind permission of Willems Industriele Producties B.V., www.willems-ip.nl

# DIAGNOSE, TREAT

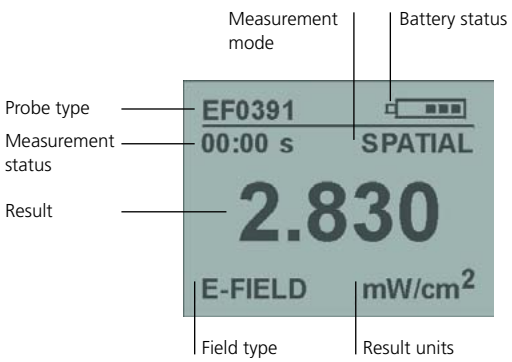
High frequency radiation is useful in science and medicine for non-invasive examination of materials or of the human body. As an example, modern nuclear magnetic resonance tomography makes use of superimposed high frequency fields. Diathermy and hyperthermy, i.e. deep tissue warming using electromagnetic fields, can promote or accelerate the healing process.

Controlling the electromagnetic field strength is part of occupational safety. The industrial process should work on the material, and not make the operator sweat. In the same way, subjecting patients to controlled doses of radiation in medical applications should not mean that medical personnel are exposed to uncontrolled or excessive field strengths. A suitable test device can show that permitted field strengths are not being exceeded. It can also help to detect defects, even if it's only a missing screen or a door that doesn't shut properly.

# MEASURE WHAT'S THERE

You will often find that electromagnetic field strengths have to be measured in places that are awkward to get at. We have designed the Narda NBM-500 series of Broadband Field Meters so they can be used anywhere. The casings are impact-resistant, the probes are robust. The monochrome displays – backlit LCDs – can be read in the dark and in bright sunlight. So you still get reliable results, immediately, even under difficult working conditions.

The tasks are many and varied, so right now Narda has two types of instrument on offer:




Everything at a glance: It may be small, but the NBM-520 can average the results over time as well as space (spatial averaging).


**NBM-520: FOUR BUTTONS FOR RESULTS**

This handy device tells you the field strength immediately, in V/m, A/m, mW/cm², W/m² – or directly as a percentage of the permitted limit value if you are using a shaped probe. You can use the built-in optical interface to remote control it from a PC or to configure it before you use it on site.


## A STRONG FAMILY

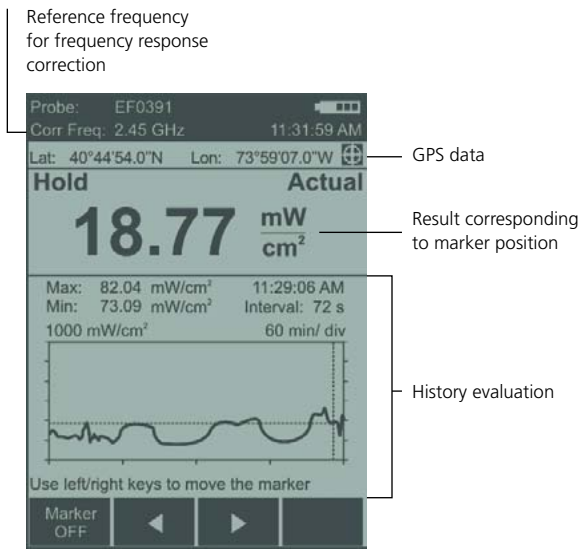
All the instruments in the NBM-500 series really do belong to a family. The probes are designed to work with both instruments and are therefore completely interchangeable. Also, you can control the „small" NBM-520 from its „big brother", the NBM-550, turning it into an extended probe handle: With the probe fitted to the smaller device, you can get it into awkward corners but conveniently read off the results from the display on the bigger unit held comfortably in your hand.

## ACCURACY BEHIND THE SCENES

All NBM instruments have an automatic zeroing function to eliminate the effects of temperature on the results. You do not have to put the instrument in a screened room for this. You won't even notice that it is taking place, any more than you will notice the detection of individual probe parameters stored in an EPROM in the probe itself. The NBM basic unit recalls them via the intelligent probe interface and takes them into account automatically. So, measurement accuracy always stays high. The NBM even tells you when the next calibration of the basic unit or probe is due, to ensure the best possible accuracy.

## NBM-550: THE EASY WAY TO FINE DETAIL

This instrument provides additional convenient on-site evaluation features as well as memory space for up to 5000 results, so you can analyze them and document them later. You can use it as a hand-held device, or position it precisely using a tripod. You can program it for long-term measurements, or remote control it from a PC.




A brief summary of events: The NBM-550 shows the variation with time as a graph. You can use the marker to read of the values numerically.

# RECORD WHAT'S NECESSARY

There's an NBM probe for virtually every application. E-field probes with exceptionally broad bandwidths detect electric field strengths at frequencies ranging from long waves up to microwaves. H-field probes make separate measurements of the individual magnetic field components in the vicinity of transmitters or industrial equipment, where high currents are flowing. So-called shaped probes automatically evaluate the field strength in compliance with a specific human safety standard.

**ISOTROPY**

All NBM probes are isotropic, i.e. non-directional. You don't have to think about what direction the radiation is coming from.

**CALIBRATION**

All NBM probes are calibrated at several frequencies within their frequency range. The data are stored in an EPROM in the probe, and the NBM basic unit takes them into account automatically. Because the probes and the basic unit are calibrated separately, you can combine any NBM basic unit with any NBM probe without any loss of accuracy.

This multi-frequency calibration can be used to give even greater accuracy with the NBM-550: If you know the frequency of the field source, you can recall the specific correction value for this frequency or interpolate it from two neighboring correction values.

**EXAMPLE: E-FIELD PROBE TYPE EF0391**

This probe has a frequency range from 100 kHz to 3 GHz, enabling it to detect electric fields such as those that occur in industry, broadcasting, and telecommunications. Its high sensitivity of 0.2 V/m coupled with its good linearity makes it particularly suitable for checking human safety limit values for the general public.

**EXAMPLE: E-FIELD PROBE TYPE EF5091**

The thermocouple sensors in this probe deliver true RMS results even with short impulses or multiple superimposed frequencies. The 300 MHz to 50 GHz frequency range covers practically everything used for satellite communications and radar.

**EXAMPLE: H-FIELD PROBE TYPE HF3061**

This probe detects magnetic fields from 300 kHz to 30 MHz. It is especially useful in the near field of medium wave transmitters or industrial equipment. Its dynamic range from 0.012 A/m up to16 A/m (62 dB) makes it ideal for checking limit values in both the occupational and the general public environment.

**EXAMPLE: E-FIELD PROBE TYPE ED5091**

This „shaped probe" measures and evaluates electric fields in the range between 300 kHz and 50 GHz automatically according to the ICNIRP 1998 human safety standard for occupational areas. Even without knowing the frequencies, you can immediately see if the field exposure is within the allowed range. The result is displayed directly as a percentage of the permitted limit value.

| Frequency range | 100 kHz – 6 GHz | 100 kHz – 3 GHz | 3 MHz – 18 GHz | 300 MHz – 50 GHz | 100 MHz – 60 GHz | 300 kHz – 30 MHz | 27 MHz – 1 GHz | 300 kHz – 50 GHz |
|---|---|---|---|---|---|---|---|---|
| Field quantity | E | E | E | E | E | H | H | E, weighted |
| Measurement range | 0.38 – 650 V/m (RMS value up to 22 V/m) | 0.2 – 320 V/m 0,8 – 1300 V/m* | 0.8 – 1000 V/m (RMS value up to 35 V/m) | 8 – 614 V/m 18 – 1090 V/m* | 0.7 – 400 V/m (Effektivwert bis 61 V/m) | 0.012 – 16 A/m (RMS value up to 0.7 A/m) | 0.018 – 16 A/m (RMS value up to 1 A/m) | approx. 0.5 – 600 % |
| Measuring principle | Dipoles with detector diodes | Dipoles with detector diodes | Dipoles with detector diodes | Dipoles formed by thermocouples | Dipoles with detector diodes | Coils with detector diodes | Coils with detector diodes | Dipoles with detector diodes and thermocouples |
| Model number | EF0691 | EF0391 EF0392* | EF1891 | EF5091 EF5092* | EF6092 | HF3061 | HF0191 | EA...ED5091 |
| Mobile radio / telecoms | ● | ● | ● | | | ● | ● | ● |
| Radio / TV broadcasting | ● | ● | ● | | | ● | ● | ● |
| Satellite communications | | | ● | ● | ● | | | ○ |
| Radar | | | ○ | ● | ○ | | | ○ |
| Industry: Heating and hardening | ● | ● | | | | ● | | |
| Industry: Plastics welding | ● | ● | | | | ● | | |
| Industry: Semiconductor production | ● | ● | | | | ○ | | |
| Medicine : Diathermy, hyperthermy | ● | ● | | | | | | ○ |
| Radiation leak detection | | | ● | ● | ● | | | ○ |
| Human safety (general public) | ● | ● | ● | ○ | ● | ● | ○ | ○ |
| Occupational protection and safety | ● | ● | ● | ● | ● | ● | ● | ● |

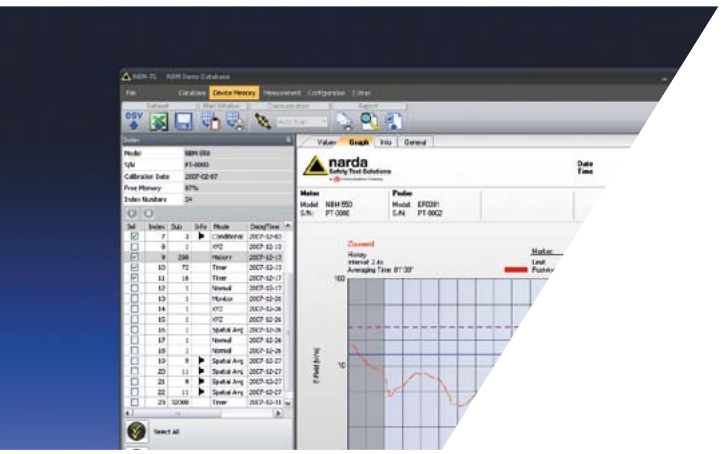
● very suitable ○ partly suitable

# KNOW WHERE YOU ARE

Who measured what, when, and where? You need to keep tabs on what is happening during large-scale test campaigns, long-term observations, or when monitoring multiple locations. That's simplicity itself with the NBM-550.

The instrument automatically supplies a timestamp with the date and time for every measured value. The GPS option supplies the position coordinates. The GPS receiver simply plugs onto the unit and is linked to it via the USB socket. The NBM saves the geographical latitude and longitude along with the measured value.

You can also add a voice comment using the microphone, and play it back through the earphone. Each comment is stored with the measured value and is also available after you transfer the results to a PC.

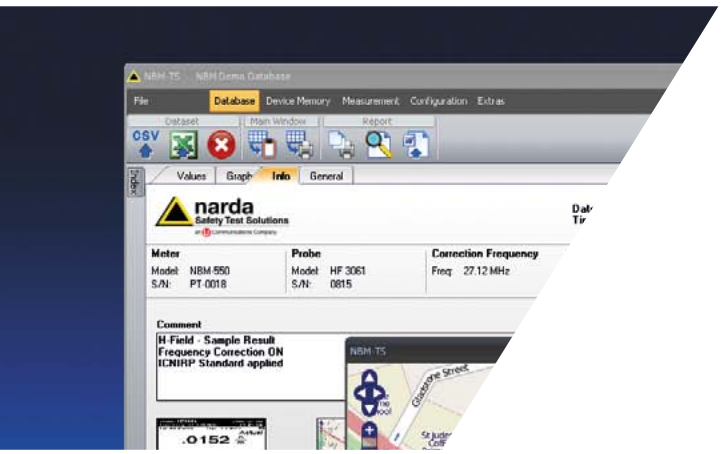


# RECORD WHAT YOU HAVE

NBM-TS, the PC software for the NBM family is included with each instrument. Since the software is for the entire family, you just install it once, learn how to use it once, and then use it for everything.

With NBM-TS, you can
- create and manage instrument configurations,
- update the firmware, and
- measure by remote control.

Used with the NBM-550, NBM-TS can also
- transfer results to a PC,
- manage them in a database, and
- analyze them and print them out.



# MIX AND MATCH

Narda has developed the Field Analyzer EHP-50F for measuring low frequency fields from 1 Hz up to 400 kHz. It measures isotropically, or non-directionally, as a stand-alone device or linked to a PC. The optical interface means that it can be used in places that are difficult to reach or that are exposed to high levels of radiation.

A new feature is the combination with the NBM-550, which controls the EHP-50F and displays the results. Three operating modes are available for various measurement applications: wideband measurement over a selectable frequency range, measurement of just the highest level in a frequency band, or measurement of the spectrum with marker functions for evaluation of individual frequencies.

The Field Analyzer EHP-50F extends the frequency range of the NBM-550 down to 1 Hz. With appropriate probes, the NBM-550 covers the entire frequency range from 1 Hz to 60 GHz. This means that the range of applications for the NBM-550 stretches from the analysis of low frequency fields in the industrial environment through to high frequency measurements on mobile phone antennas, transmitting equipment, and radar installations.

**NBM-550 + EHP-50F:**
**1 Hz – 60 GHz!**

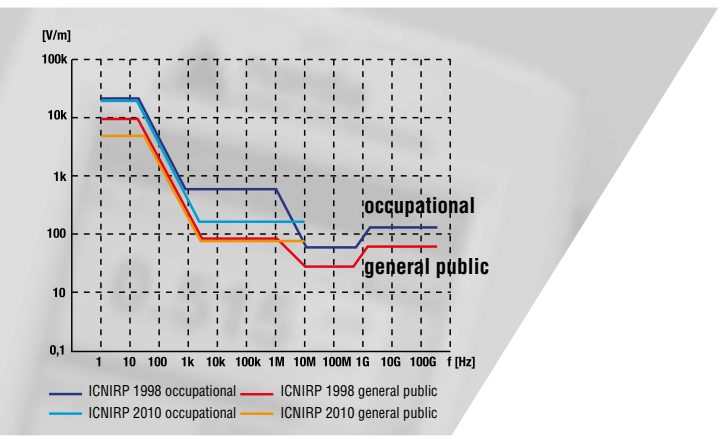
# UNDERSTAND ELECTROMAGNETIC FIELDS

The frequency spectrum is usually divided into two segments: low frequency (up to 30 kHz) and high frequency (30 kHz to 300 GHz).

**E-FIELD – H-FIELD. FAR FIELD – NEAR FIELD**

High frequency electromagnetic fields have an electric and a magnetic field component, called the E-field and the H-field. At a long distance from the source, in the far field, these two components are in a fixed relationship. So, you only need to measure one of them (e.g. E-field in V/m). You can then calculate the other field strength component (e.g. H-field in A/m) or the power level (e.g. in $W/m^2$) from it. This relationship does not apply in the near field, however, so you have to measure the E-field and the H-field separately.

The near field is defined as within three wavelengths from the source. The higher the frequency, the shorter the wavelength and the smaller the near field area. A long wave transmitter with an output frequency of 100 kHz, corresponding to a wavelength of 3 km, has a near field area that stretches some 10 km. In contrast, the near field of a microwave oven operating at a decimeter wave frequency of 2.45 GHz ends some 35 cm from the source.




**WEIGHTING**

Limit values for exposure to electromagnetic fields have been laid down in several national and international standards. They are generally based on the "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz), which was published by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 1998.

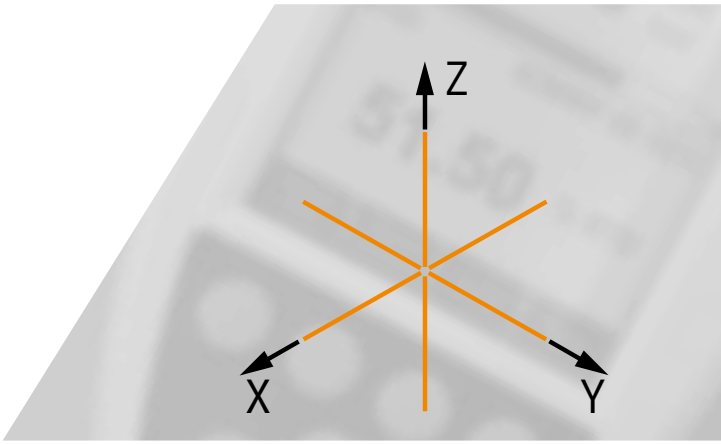
The limit values depend on the frequency. Higher levels of exposure are permitted in the occupational environment than for the general public.

So-called shaped probes weight the results by taking the prescribed frequency response into account automatically.

## ISOTROPY

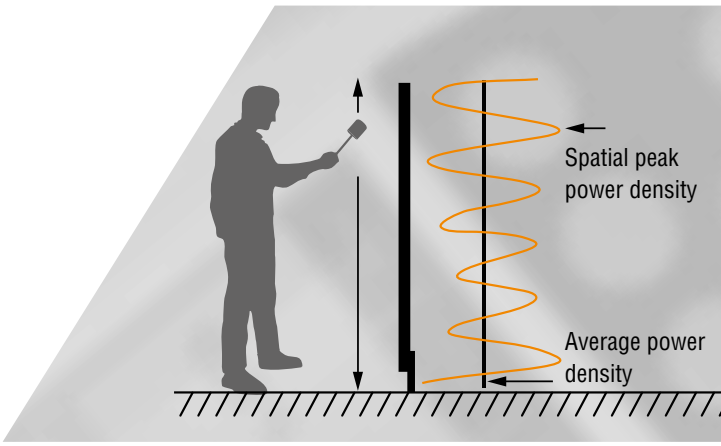
Sensors such as electric dipoles or magnetic coils have a major sensitivity axis. This characteristic can be used to select a certain spatial component of the field. However, this is not very helpful when you are measuring field strength in the context of human safety, since the measurement has to be in all directions equally, i.e. isotropic.

For this reason, NBM probes use an arrangement of three mutually perpendicular sensors. The NBM basic unit or the probe itself forms the correct sum of the power levels from these three components. The result is therefore independent of the direction the probe is pointing in and the positions of the field sources. For special applications, however, you can also show the results for each spatial axis individually if you use the NBM-550.




## SPATIAL FIELD DISTRIBUTION

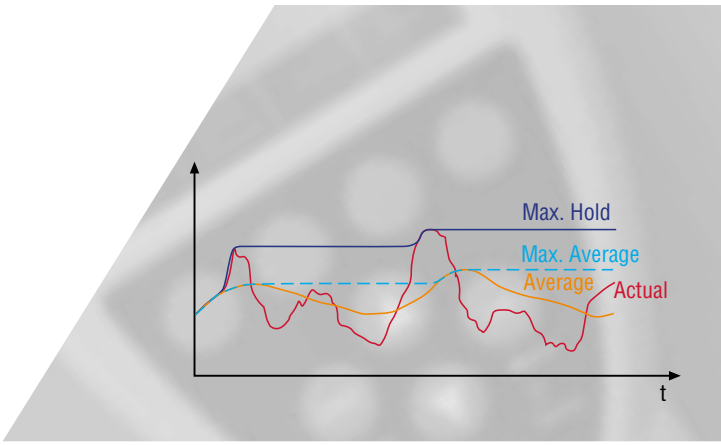
Field distribution is hardly ever homogeneous. To simulate exposure of the entire body, you have to measure at several different points and take the average of the sum of the squares of the results (spatial averaging). All you need to do on an NBM instrument to get this result is press a button.




## TIME-DEPENDENT FIELD DISTRIBUTION

Most human safety standards take the thermal effects due to electromagnetic fields into account. As a result, they specify that the results should be time-averaged over a period of 6 minutes, for example. Nevertheless, the peak value of the field strength must not exceed, say, one thousand times the average value. You can therefore set the result display on NBM instruments to show

- ACT (instantaneous or actual value),
- AVG (average value),
- MAX (maximum or peak value), or
- MAX AVG (maximum of all averaged values; NBM-550 only)



**LOW-FREQUENCY TEST EQUIPMENT**

Test equipment for electric and magnetic fields from DC up to several hundred kilohertz. For power utility companies, electric railroads, industry. Standard-compliant evaluation, e.g. conforming to the IEC / EN 62233 standard for domestic appliances.

**BROADBAND TEST EQUIPMENT**

NBM-500 – the new series that covers practically every application between 1 Hz and 60 GHz.

# CHOOSE SAFETY

NARDA Safety Test Solutions is a global leader in the development and production of measuring equipment for electric, magnetic, and electromagnetic fields. The fact that we own around 95% of all published patents for measuring such fields bears witness to this. Choosing a Narda instrument is choosing a product from a company renowned for innovation, that is specialized in EMF (measurements for safety in electromagnetic fields), and that is continually building upon its reputation in this sector.

**THREE LOCATIONS – ONE GOAL**

Our three sites are located at Hauppauge, Long Island / USA, Pfullingen / Germany, and Cisano / Italy. Our goal is to provide you, the user, with products tailored exactly to your needs, using the highest quality in cutting-edge technology.


**SELECTIVE HIGH-FREQUENCY TEST EQUIPMENT**

SRM-3006 – the tester that selectively detects and measures every source in the range from 9 kHz to 6 GHz. With a sensitivity that can still detect individual telecommunications channels, even inside buildings.

**PERSONAL MONITORS**

Worn on the body, these devices give reliable warning of excessive radiation levels.

**AREA MONITORING STATIONS**

For permanent monitoring of the field strength situation. Frequency-selective or broadband. With data transfer via mobile phone.

**WHAT WE OFFER**

Our comprehensive range of products for human safety in electromagnetic fields (EMF) includes broadband measuring instruments, selective measurement equipment, monitoring stations, and personal radiation monitors. Under our PMM brand, we offer instruments for assessing the electromagnetic compatibility (EMC) of devices. As our customer, you can benefit from our program of services, including servicing, calibrating, and training.

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