WAVECONTROL

Assessment of household and similar electrical appliances

APPLICATION NOTE

HO_AP_EN_V1.0

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Assessment of household and similar electrical appliances

Addressed to

- Manufacturers of household appliances.
- Testing laboratories.
- RF safety engineers.
- Anyone related to the assessment of household appliances with regard to human exposure.

Scope

This application note defines methods for evaluating the electric field strength and magnetic flux density around household and similar electrical appliances.

Appliances include equipment such as household electrical appliances, electric tools, electric toys and also appliances not intended for normal household use but which nevertheless may be approached by the public or may be used by laymen.

Appliances may incorporate motors, heating elements or their combination, may contain electric or electronic circuitry, and may be powered by mains, batteries, or by any other electrical power source.

The frequency range considered is from 10 Hz to 400 kHz.

PLEASE NOTE: *Wavecontrol will not be responsible for any errors that may be found in this document or for the results of any faulty application of regulations. This application note is meant to be used for assistance, but under any circumstance as a replacement for the standards that it mentions. We recommend that you study those standards carefully.*

1. INTRODUCTION

This application note summarizes the testing requirements of **IEC 62233:2005** [1] regarding the assessment of household and similar electrical appliances in respect of human exposure to electromagnetic fields (EMF).

IEC 62233:2005 is based on the old **EN 50366:2003** from **CENELEC**.

CENELEC adopted the new **IEC 62233:2005** with minor changes, as **EN 62233:2008**, which superseded **EN 50366:2003**.

This application note shows how the assessment can be performed by using the Wavecontrol **SMP2 EMF meter, WP400 and WP400-3 field probes**.

IEC 62233 measurement methods are valid from 10 Hz to 400 kHz. In the frequency range above 400 kHz and below 10 Hz appliances in the scope of this standard are deemed to comply without testing unless otherwise specified in **IEC 60335** series [2].

2. MEASUREMENT METHOD

Regarding the electric field (E-field) the measurement method is under consideration. However, appliances with an internal transformer or electronic circuitry working at less than 1000 V are deemed to comply without testing.

Regarding the magnetic field (H-field), the reference method, with has to be used in case of dispute, is the **Time Domain Evaluation**, also known with the name **Weighted Peak Method** (ICNIRP [3]).

Usually, fields have several frequency components and the reference limit levels are also frequency dependent. This means that the measured levels of the signal at each frequency have to be weighted with the reference level at such frequency. It is also common to find complex non-sinusoidal signals that are difficult to measure.

The Weighted Peak Method (WPM) solves both problems so is the most appropriate method to obtain the best results. There are other methods, such as the multifrequency fields summation method, which may give gross overestimates, since they fail to take signal phase into account.

WPM is done by implementing a transfer function which is the inverse of the reference level curve (limit levels as a function of frequency).

The WPM is implemented in the **SMP2** by using state-of-the-art digital signal processing technology that performs an inverse digital filtering, in real time, in the time domain. This gives a result directly as a percentage (%) of the limits for which exposure is being assessed, taking into account all frequency range. So all the calculations are made by the SMP2, making it surprisingly easy for the user to obtain the exposure assessment result (see [4] for additional information).

Important note: *It is important to highlight that the SMP2 can apply the WPM for any standard, by choosing the applicable one from a list. All international standards are included, can be added and modified with a simple firmware update. Examples are ICNIRP, EU EMF Directive, IEEE, FCC, SC6, etc. Updates are free for all registered* ***SMP2*** *users.*

Appliances with a full working cycle of less than 1 s have to be measured according to IEC 62311 [5] for pulsed fields; however operating conditions, measuring distances and coupling factors are given in IEC 62233, as explained in this application note.

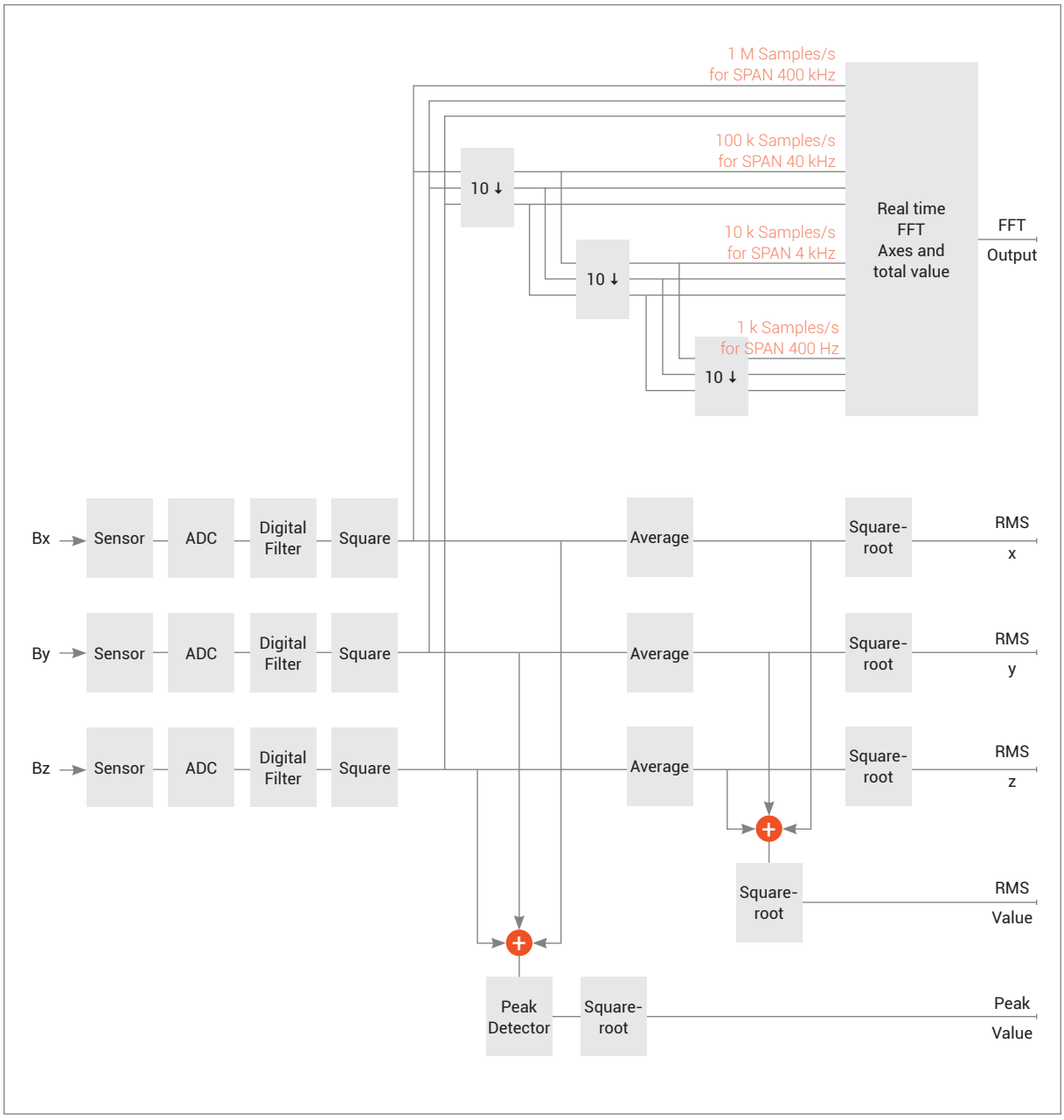


Figure 1. **SMP2 digital signal processing including the Weighted Peak Method**

Measurement conditions:

- The background level has to be less than 5 % of the limit value.
- Tests have to be carried out at an ambient temperature of 25 °C ± 10 °C.
- For the final measurements the field probe has to remain stationary.

3. MEASUREMENT INSTRUMENT REQUIREMENTS

Basic requirements for measurement instruments in the range 1 Hz to 100 kHz can be found in IEC 61786-1 [6].

- It is recommended that it has the capacity to apply the Weighted Peak Method.
- Must have a maximum noise level of 5% of the limit value.
- The response time for the measuring equipment to reach 90 % of the final value should not exceed 1 s.
- The magnetic flux density has to be determined by using an averaging time of 1 s.

Note: *the SMP2 field meter complies with all those requirements.*

When using an SMP2, a 10 Hz high pass filter can be activated in order to measure the exact frequency range of 10 Hz – 400 kHz as specified by IEC 62233.

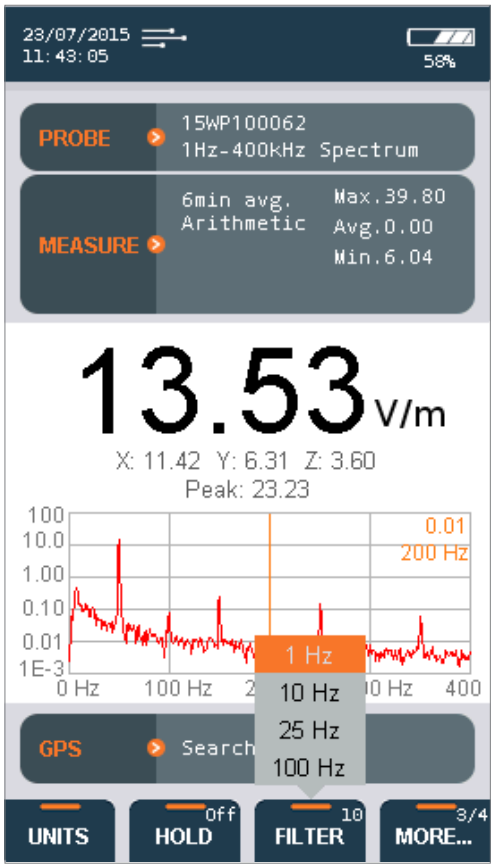


Figure 2. **High pass filter selection.**

Magnetic field sensor

The reference sensor consists of three orthogonal coils with a measuring area of 100 cm^2 ± 5 cm^2. The outside diameter of the reference sensor shall not exceed 13 cm.

Note: *the WP400 field probe was designed in accordance with those requirements.*

For the determination of coupling factors, an isotropic sensor having a measuring area of 3 cm^2 ± 0,3 cm^2 is used.

Note: *the WP400-3 field probe was designed in accordance with those requirements.*

Figure 3. **SMP2 with WP400 field probe and SMP2 with WP400-3 field probe**

4. MEASUREMENT PROCEDURE

4.1 SMP2 set up

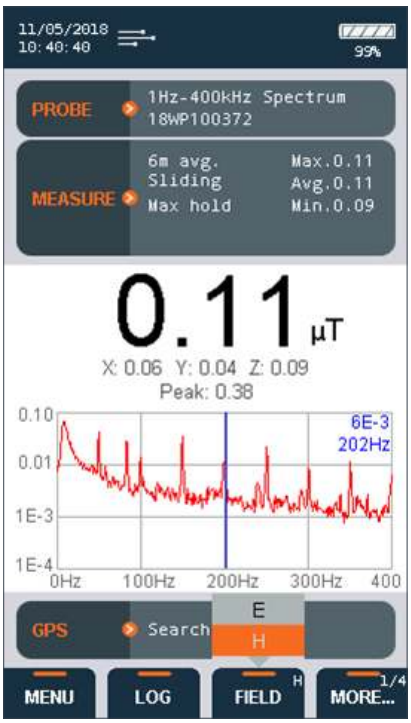
The following is a detailed guide to correctly set up the **SMP2**:

- **Connect the field probe to the SMP2:** WP400, or WP400-3 in case you are determining the coupling factors (see point 5).
- On the virtual menu: **set the FIELD to H**.
- **Choose the applicable LIMIT:**
  - **In the European Union:** ICNIRP 1998 – general public (*).
  - **In the USA:** IEEE C95 – general public.
  - **In other countries:** choose as applicable.

- **Set MODE to "FFT".**
- **Set HOLD to "Max".**
- Your **Max value** result will appear as the **main big number** on the screen.

- **Move the unit sweeping the testing areas** (see 4.2).
- You may also **leave the field probe stationary** at the maximum level point and wait for a reasonable time **until you see the max does not increase any more**.
- **If Peak and RMS values are below 100% then you are below the limit.**
- **Press LOG** to save the final result.
- Find your measurement in MENU → MEASUREMENT LOG.

(*) In the European Union the limits that must be respected according to EN 62233:2008 are those of the European recommendation 1999/519/EC, which are the same as ICNIRP 1998 for the general public.



Virtual menu

4.2 Measuring points

The measurements are usually taken in front, on top or around the appliance, at distances of 0, 10 or 30 cm depending on the type of appliance. IEC 62233 contains a table including most types of appliances, along with the required test positions and distances.

As a general rule, if not otherwise required by IEC62233, the appliances used in contact with the body have to be tested at a distance of 0 cm; all other cases should be tested at 30 cm.

Figure 4. **Top and front measurements**

Figure 5. **Around measurements**

During testing, the appliance has to be operated at the nominal voltage and frequency of the country or region in which will be used. Controls have to be adjusted at the maximum setting.

Multifunction equipment has to be tested with each function operated separately, if possible.

Battery and mains operated appliances must be tested in both conditions. When tested with battery, it must be fully charged.

Induction hobs and hotplates

Measurements have to be made at 30 cm distance from each cooking zone, sweeping a vertical line up to 100 cm above and 50 cm below. There is no need to measure on the back side if it is intended to be installed against a wall.

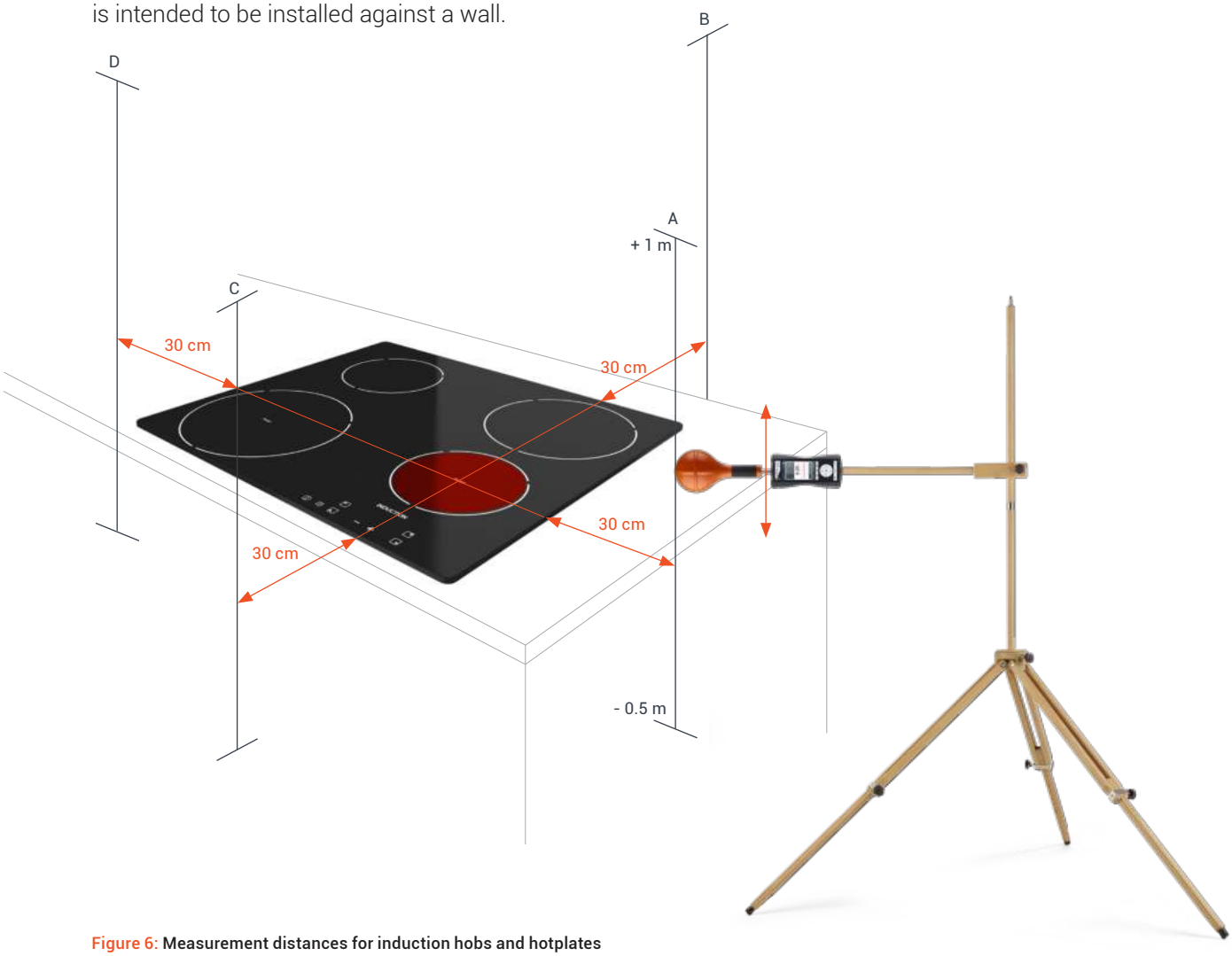


Figure 6: **Measurement distances for induction hobs and hotplates**

The procedure is to place an enamelled steel cooking vessel, half filled with water, on the cooking zone to be measured. It should be the smallest vessel recommended by the manufacturer. If no recommendation is provided, the smallest standard vessel that covers the marked cooking zone should be used.

The induction heating units should be operated one at a time, at maximum power, while the other hobs remain without being used.

It is important to note that, if the measurement exceeds the reference level the coupling factor can be taken into account to show that the basic restrictions are met, as explained in chapter 4.

5. DETERMINATION OF THE COUPLING FACTORS

The reference levels given by the standards are meant for homogeneous fields. However, the magnetic fields around appliances are strongly inhomogeneous. Such inhomogeneity is taken into account correcting the value measured (B_m) with the coupling factors (a_c).

IEC 62233 provides only worst case coupling factors. If an accurate assessment has to be made, avoiding overestimations that may lead to a NO PASS situation, coupling factors must be determined.

To determine the coupling factors, it is both necessary measurements and calculations, in 4 steps:

Step 1: Measurement of the hot spot

The magnetic flux density (B) has to be measured along a tangential surface, radially from the hot spot, and up to a distance where B has decreased to a 10% of the maximum value at the hot spot.

The distance between measuring points must be in the range of 0.5-1 cm.

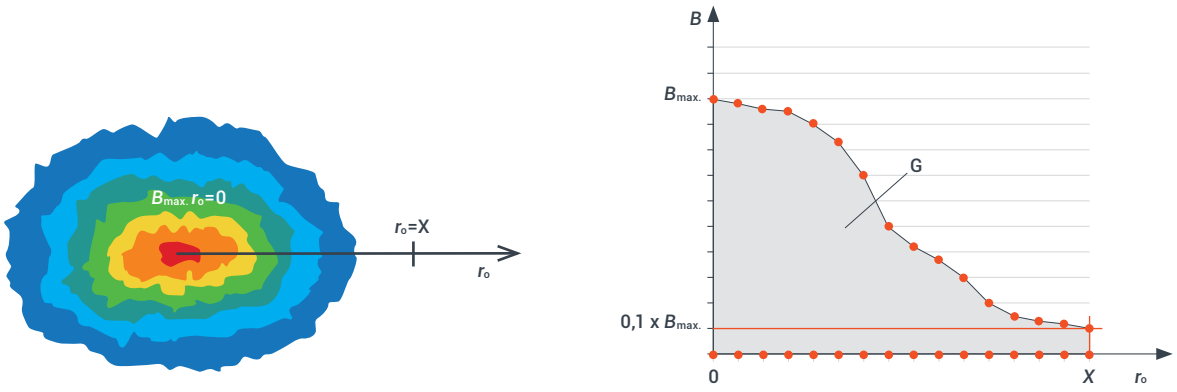


Figure 7: **magnetic flux gradient around a hot spot and its graphical representation**

Important note: *It is necessary to use a field probe with a small sensor. A field probe like WP400-3 with a 3 cm² sensor is recommended by IEC 62233.*

Figure 8. **WP400-3 field probe**

Step 2: Determination of the equivalent coil

The radius of an equivalent coil is determined using the measurements from step 1. The equivalent coil is such that located in the same position as the magnetic field source, it produces a similar integral G. More information can be found in the IEC 62233.

Step 3: Determination of the k factor

Using the radius of the equivalent coil, the measuring distance, the frequency and the body conductivity, the k factor is determined.

Step 4: Calculation of the coupling factor

The coupling factor is calculated by re-scaling the k factor.

Note: *Formulae and guidance are provided in IEC 62233.*

Step 5: Calculation of the corrected measured value

$$B_{mc} = a_c \, B_m$$

B_m : measured magnetic flux density
a_c : coupling factors
B_{mc} : corrected magnetic flux density

6. FINAL EVALUATION OF RESULTS

The requirements of IEC 62233 are fulfilled if:

a. The measured values, including the measurement uncertainty, do not exceed the reference levels, or

b. If the corrected measured value, calculated using the coupling factor as explained in point 5, do not exceed the reference level.

Note: *See [7] for additional information on measurement uncertainty*

Note: *Reference levels and maximum permissible exposures can be found, amongst others, in the following documents from ICNIRP [8], the EU [9] and the IEEE [10] and [11].*

References

- **[1] IEC 62233:2005**, Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure.
- **[2] IEC 60335 (all parts),** Household and similar electrical appliances - Safety
- **[3] International Commission on Non-Ionising Radiation Protection**, Guidance on Determining Compliance of Exposure to Pulsed and Complex Non-Sinusoidal Waveforms below 100 kHz with ICNIRP Guidelines, Health Physics, Volume 84, Number 3, March 2003, p.383-387.
- **[4] Wavecontrol Application Note,** "SMP2+WP400 Measurement Capacities".
- **[5] IEC 62311:2007**, Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz).
- **[6] IEC 61786-1:2013**, Measurement of DC magnetic, AC magnetic and AC electric fields from 1 Hz to 100 kHz with regard to exposure of human beings - Part 1: Requirements for measuring instruments.
- **[7] Wavecontrol Application Note,** "Calculation of the Total Measurement Uncertainty of a Field Strength Meter".
- **[8] International Commission on Non-Ionising Radiation Protection,** Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 kHz), Health Physics, Volume 99, Number 6, 2010, p.818-836.
- **[9] Council Recommendation 1999/519/EC** of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), Official Journal L 199, 30.07.1999, p.59-70.
- **[10] IEEE Std C95.1-2005,** IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, USA.
- **[11] IEEE Std C95.6-2002,** IEEE Standard for Safety Levels with Respect to Human Exposure to electromagnetic Fields, 0–3 kHz, The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, USA.

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