

Application Note

Measurements on radio and TV transmitters

Determining the field exposure level in the vicinity of transmitter stations

The purpose of radio and television transmitter stations is to provide full coverage for television, radio, and multimedia broadcasting services. Long ranges are achieved through high-power transmissions, but the resulting high field strengths affect the environment. The move from analog to digital broadcasting methods does not result in any real change in this situation, although a tendency to lower field strengths has been reported [1].

This Application Note describes an example of the measurement of field emissions from radio and TV transmitters and their evaluation from the viewpoint of immission control and human safety. It looks particularly at the differences between analog and digital TV. While the overall emission levels can be determined and evaluated using a wideband measuring set, the individual contributions made by analog and digital transmitters can only be captured separately using a frequency-selective device. For this reason, the Selective Radiation Meter SRM-3006 was used to make the measurements.

Contents

1	Background	2
2	Standards and regulations	3
3	Distinguishing between near- and far-fields	3
4	Measurement preparation	4
5	Overview measurement, settings	5
6	Detailed measurement of individual analog TV channels	6
7	Detailed measurement of individual DVB-T channels	7
8	Measurement of DAB radio channels	8
9	Measurement of FM radio channels	9
10	Measurement of AM radio channels	9
11	Result evaluation and creation of a test report	10
12	Abbreviations	11
13	References	12



© 2010

Narda Safety Test Solutions GmbH

Sandwiesenstr. 7

72793 Pfullingen, Deutschland

Tel.: +49 7121 9732-777

Fax: +49 7121 9732-790

E-mail: support@narda-sts.de

www.narda-sts.de

1 Background

The term “broadcasting” includes a wide range of services and methods of transmission, some of which use the same frequency bands but which are measured differently because of their unique characteristics.

Analog TV

Analog TV channels have typical channel bandwidths between 6 MHz and 8 MHz; e.g. 7 MHz in the VHF band and 8 MHz in the UHF band in Germany. The transmission power is quoted in terms of the synch peak power, which is the power at which the line synchronization pulse is broadcast. The rest of the power depends greatly on the program content, with the greatest possible average broadcast power being some 2.3 dB below the synch peak power and the minimum average broadcast power about 7.5 dB below the synch peak power. The spectrum is unevenly distributed, with strong components around the video carrier (figure 1).

DVB-T – Digital Video Broadcasting, Terrestrial

The gradual introduction of digital television has meant that DVB-T uses the same channel spacing as analog TV. However, several programs can be broadcast at the same time in a single 7 or 8 MHz bandwidth channel; currently this is usually a “bouquet” of four programs. The data stream contains video and audio data as well as other payload content such as videotext. The spectrum corresponds to narrow-bandwidth white noise. The signal is also similar to noise in the time domain, having crest factors of between 10 and 12 dB.

DAB – Digital Audio Broadcasting

While analog and digital TV coexist within the same frequency band, DAB uses the VHF band or even higher frequencies for local broadcasts in contrast with UHF. The DAB signal is similar to the DVB-T signal, but only has a bandwidth of about 1.5 MHz per channel, so that four DAB blocks can be accommodated next to each other within one channel in the VHF band.

Analog UHF radio

Analog UHF radio is broadcast using frequency modulation, so the carrier amplitude remains constant. The effective channel bandwidth is around 200 kHz.

Long, medium, and short wave transmitters

These use amplitude modulation; channel bandwidth 9 kHz.

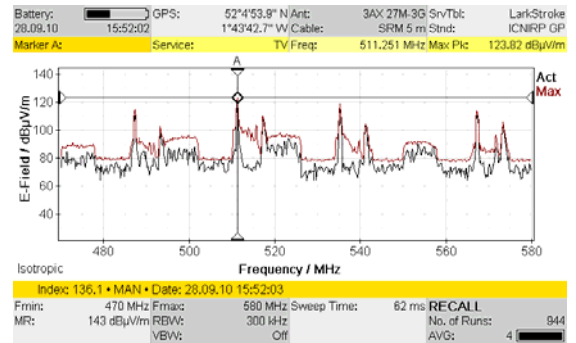


Figure 1: Typical spectrum in Band IV (UHF) with analog TV channels (PAL) and DVB-T channels directly adjacent to each other.

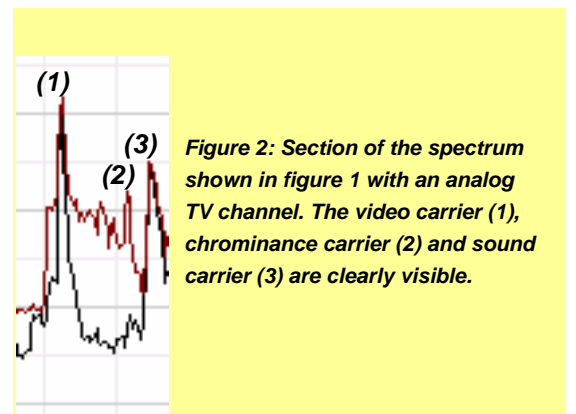


Figure 2: Section of the spectrum shown in figure 1 with an analog TV channel. The video carrier (1), chrominance carrier (2) and sound carrier (3) are clearly visible.

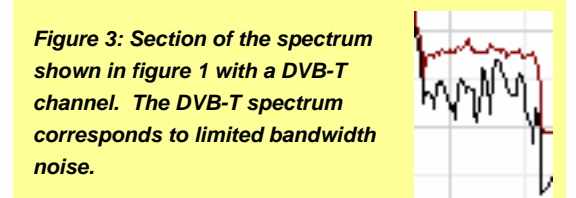


Figure 3: Section of the spectrum shown in figure 1 with a DVB-T channel. The DVB-T spectrum corresponds to limited bandwidth noise.

2 Standards and regulations

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) published its Guidelines on Limiting Exposure to Non-Ionizing Radiation in 1998 [2]. These guidelines include frequency-dependent limit values specified as two different limit value curves: a higher one for occupational safety and a lower one for the general public. The higher values apply in controlled areas for which safety procedures have been defined and which are only accessible to professionally trained personnel. This includes, for example, the locations of transmitting antennas for which the operators must define safety areas.

The limit values as well as the division into two parts are reflected in the European guidelines. Guideline 2004/40/EC of 29 April 2004 [3] applies to occupational safety; Recommendation 1999/519/EC [4] covering the safety of the general public was published as far back as 12 July 1999. Additionally, many countries have their own national standards, which often use the ICNIRP limit values, although some specify lower limit values than these.

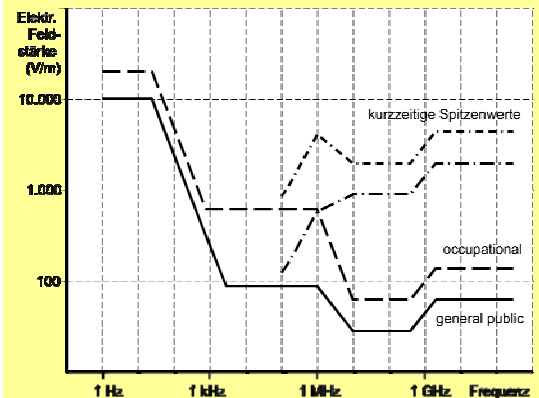
The ECC Recommendation 02(04) [5] describes general measurement procedures that are not dependent on the individual limit values.

3 Distinguishing between near- and far-fields

The electric and magnetic field components in the far field are perpendicular to each other, and their magnitudes are related by the characteristic impedance of free space. It is therefore only necessary to measure and evaluate one component, e.g. the electric field strength.

This relationship does not apply in the near field, so that both components need to be measured separately. The magnetic field strength is often the component that is most relevant for safety assessment.

The near field is generally defined as the area within a radius from the source corresponding to three times the wavelength. The near field therefore depends on the frequency. The wavelengths for each frequency can be calculated using the wave propagation velocity of around 300,000 km/s (speed of light; see table, right).



ICNIRP 1998 limit values for electric field strength.
Some other common standards and regulations:

North America

FCC OET Bulletin 65; IEEE C95

Europe

EN 50413 [6], EN 50420, EN 50421; EN 62110
 ECC Rec. (02)04 [5]

Germany

26. BImSchV [7]; BEMFV [8];
 VDE 0848-110 = DIN EN 62110:2010-08 part 1 [9];
 BGV [10] / BGR

Switzerland

BUWAL [11]

Frequency	Wavelength	Near field (approx.)
100 kHz	3 km	10 km
300 kHz	1 km	3 km
1 MHz	300 m	1000 m
3 MHz	100 m	300 m
10 MHz	30 m	100 m
30 MHz	10 m	30 m
100 MHz	3 m	10 m
300 MHz	1 m	3 m
1 GHz	30 cm	1 m
3 GHz	10 cm	0.3 m

4 Measurement preparation

Measurements in the high frequency range starting at around 400 MHz can generally be made using hand-held equipment. The measuring antenna can be fitted directly on to the SRM basic unit or connected to it via the 1.5 m long RF cable for this purpose. The measuring antenna should preferably be mounted on a tripod and connected to the SRM basic unit via the 5 m long RF cable for measurements in lower frequency ranges. The use of a tripod improves the reproducibility of measurement results. In any case, it is important that the person making the measurement does not come between the field source and the measuring antenna.

Three-axis (isotropic) antennas are recommended for making measurements using the **matrix method**, where specific points in the space are measured according to a fixed plan. The SRM basic unit then automatically determines the isotropic (non-directional) result for each measured point.

Either three-axis or single-axis antennas can be used for the **pendulum method**, where the antenna is moved continuously through the space being measured. If the antenna is connected to the SRM basic unit using the 1.5 m long RF cable, the device can be carried using the neck strap and the antenna moved to and fro with the hand. Single-axis antennas should be rotated at the same time as they are moved because of the field polarization direction. This is not necessary if a three-axis antenna is used. It is important that the **sweep speed** is slow enough for the SRM to record two or three measured values for each position of the antenna.

The measuring equipment

depends on the measurement task.

A complete set of equipment consists of:

- SRM basic unit with the latest firmware (download from www.narda-sts.de),
- One or more measuring antennas depending on the measurement task (see table below),
- RF cable, 1.5 m,
- AC adapter/charger, or spare battery if there is no AC power available on site,
- Writing materials for sketching the test setup and noting local conditions. The SRM basic unit includes a voice recorder, which can be used to record a comment for each measurement that is stored along with the result. The free SRM-3006 Tools PC software can then be used to save and display the results on a PC and replay the comments via the PC sound card.

If the matrix method using a single-axis antenna is to be used, or lower frequency ranges are to be measured, the following additional items are needed:

- Tripod,
- Antenna holder for single- and three-axis measuring antennas,
- RF cable, 5 m.

Measuring antennas from Narda for radio and TV frequency ranges					
Antenna type	Isotropic E-field antenna, dipole array, passive	Single-axis E-field antenna, dipole, passive	Single-axis E-field antenna, dipole, active	Isotropic H-field antenna, coil array, active	Single-axis H-field antenna, coil, active
Frequency range	27 MHz to 3 GHz	27 MHz to 3 GHz	9 kHz to 300 MHz	9 kHz to 250 MHz	9 kHz to 300 MHz
Preferred application	Fast, non-directional measurements, e.g. in the UHF and mobile phone frequency ranges	Precision measurements at USW and TV frequencies	Precision electric field measurements on radio / TV transmitters	Fast, non-directional near-field magnetic field measurements on radio / TV transmitters	Precision near-field magnetic field measurements on radio / TV transmitters

5 Overview measurement, settings

It is always a good idea to make an overview measurement covering the entire settable frequency range if unknown sources that could influence the response of the measuring equipment are in the vicinity of the measurement location. Spectrum Analysis mode is suitable for this.

Setting the measurement range (MR)

The automatic “MR Search” function is generally the quickest way to set the optimum measurement range in all operating modes. The measurement range *must* be set manually only if pulse-type sources such as radar installations with dominant field strengths are located nearby. Of course, the setting *can* be made separately following the result of an overview measurement. In most cases, using the “Highest Peak” marker function to determine the field strength of the highest peak in the spectrum and then setting the measurement range to about twice this value will suffice.

Setting the frequency range (Span)

To achieve good display screen resolution and a high measurement speed, it is a good idea to restrict the frequency range to the frequencies of interest. The upper and lower frequency limits can be selected using “Fmax / Fmin” or by using the zoom functions.

Setting the resolution bandwidth (RBW)

The resolution bandwidth depends on the channel spectrum to be measured and is therefore indicated separately in the sections which follow. A special algorithm in the SRM ensures that the true value is shown when the spectrum is evaluated using the Peak Table or when the “Highest Peak” marker function is used, even if the selection filter is not tuned exactly to the center of the channel, as long as the RBW selected is sufficiently large.

Setting the Result Type

The result type depends on the purpose of the measurement and the standard or regulation that applies for evaluating the results.

Setting the Display Unit

The choice here for making the measurement is between physical units (V/m, A/m, W/m², dB μ V/m etc.) or as a percentage of the limit value (%). Subsequent conversion from one physical unit to another is possible.

6 Detailed measurement of individual analog TV channels

Measurement in Level Recorder mode

(corresponds to Time Analysis mode on the SRM-3000)

Recommended settings:

Resolution bandwidth (RBW): **8 MHz**

Detector type: **Peak**

Procedure:

Tune the center frequency to a video carrier, preferably using the *Extras* -> *Select Service* function if a service table with TV channels has been recorded. Otherwise enter the value numerically if it is known, or determine it from a spectrum analysis. When switching from Spectrum Analysis mode to Level Recorder mode using the *Extras* -> *Go to* function, the SRM-3006 automatically uses the position of the active marker (figure 5) as the center frequency for the Level Recorder (figure 4).

Wait until the peak value settles, then read off the value.

No mathematical correction is necessary.

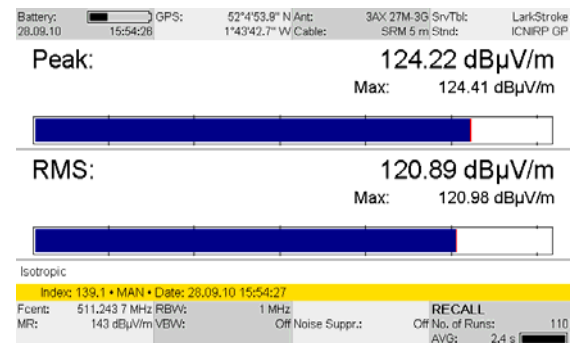


Figure 4: Measurement of an analog TV channel in Level Recorder mode.

Measurement in Spectrum Analysis mode

Recommended settings:

Resolution bandwidth (RBW): **1 MHz**

Result Type: **MAX**

Procedure:

Wait until several sweeps have been completed and then read off the maximum values for the video carriers using the Peak Marker or display them using the Peak Table function.

Evaluation:

Worst case average value = Maximum value minus 1.5 dB.

Average value for black screen (PAL) = Maximum value minus 2.2 dB

Average value for mid-gray tone (PAL) = Maximum value minus 3.7 dB

Explanation: The modulation method used (PAL: vestigial sideband AM for the monochrome signal) means that the transmitted power and therefore the field emission vary according to the picture content. However, the synch peak power is constant, i.e. the power level of the line synchronization impulses. When Result Type MAX is selected, the SRM registers this synch peak power, which leads to an overestimation. The measurement result should be corrected by the values given above in order to determine the actual field immission.

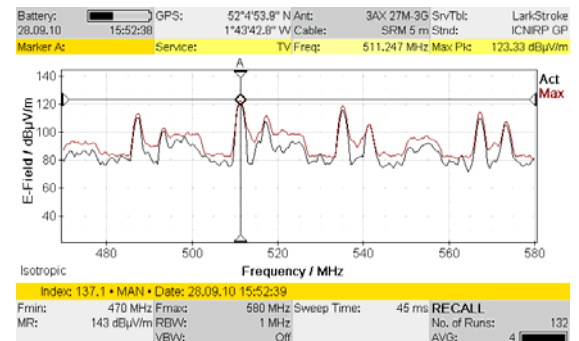


Figure 5: Measurement of analog TV channels in Spectrum Analysis mode.

7 Detailed measurement of individual DVB-T channels

Measurement in Level Recorder mode

(corresponds to Time Analysis mode on the SRM-3000)

Recommended settings:

Resolution bandwidth (RBW): **8 MHz**

Detector type: **RMS**

Procedure:

Tune the center frequency to the center of a channel, preferably using the *Extras* -> *Select Service* function if a service table with DVB channels has been recorded. Otherwise enter the value numerically if it is known, or determine it from a spectrum analysis as described in section 6 above.

Wait until the RMS value settles, then read off the value.

No mathematical correction is necessary.

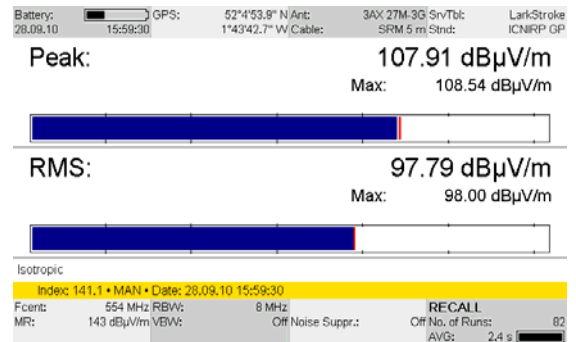


Figure 6: Measurement of a DVB-T channel in Level Recorder mode using a resolution bandwidth matching the channel width (RBW = 8 MHz).

Measurement in Safety Evaluation mode

This operating mode is generally used to make a rapid assessment of the overall field situation. For this to work, corresponding service tables that define the frequency ranges of the frequency bands of interest must be recorded in the instrument. This mode can also be used to detect the individual DVB-T channels within a frequency band by defining each channel as a service. The easiest way to create service tables is to use the SRM-3006 Tools software, and then upload the tables to the SRM basic unit.

Recommended settings:

Resolution bandwidth (RBW): **50 kHz or less**

Result Type: **AVG**

Number of Averages: **at least 16**

Procedure:

Wait until the averaging time has elapsed.

Evaluation:

Safety Evaluation mode automatically delivers results for the individual contributions made by the defined services or channels, as well as the total field immission value.

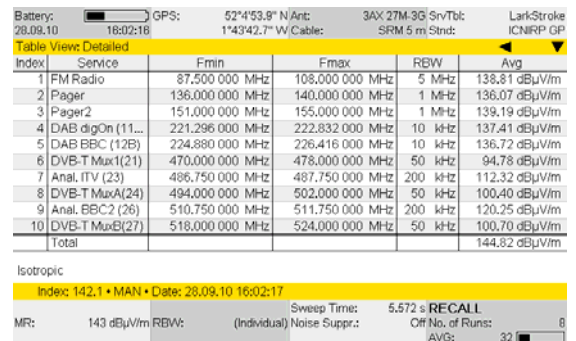


Figure 7: Measurement of all DVB-T channels along with other sources in Safety Evaluation mode. The resolution bandwidth is set manually to increase the measurement speed.

Measurement in Spectrum Analysis mode

Recommended settings:

Resolution bandwidth (RBW): **100 kHz**

Result Type: **AVG**

Number of Averages: **at least 16**

Procedure:

Wait until the averages have been completed.

Evaluation:

Integrate over the channel bandwidth. Read off the values.

Explanation: Result Type **AVG** *must* be selected because the signal versus time characteristic of the DVB-T signal is similar to noise. The result is therefore the field immission corresponding to the average (root mean square) transmission power. Recording the maximum value would lead to an overestimation by the equivalent of the crest factor, around 10 to 12 dB.

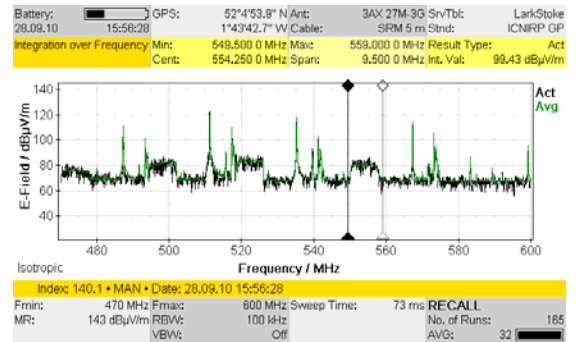


Figure 8: Measurement of a DVB-T channel in Spectrum Analysis mode at high resolution (RBW = 100 kHz) with subsequent integration over the channel bandwidth.

8 Measurement of DAB radio channels

DAB channel measurements are made in basically the same way as DVB-T channel measurements. DAB and DVB-T do not only use common frequency bands; they can also be measured together.

Figure 7 shows the corresponding results obtained in Safety Evaluation mode.

It is also possible to make measurements in Level Recorder mode. In this case, the resolution bandwidth can be set to the DAB channel bandwidth of 2 MHz.

9 Measurement of FM radio channels

Measurement in Spectrum Analysis mode

Recommended settings:

Resolution bandwidth (RBW): **200 kHz**

Result Type: **AVG**

Because the amplitude of the FM signals does not vary with time, the ACT, AVG and MAX result types do not yield different results. Using the AVG function results in a much “quieter” display trace at the noise limit, however.

Evaluation preferably using the Peak Table.

10 Measurement of AM radio channels

The measurement antenna selection depends on the frequency ranges to be measured (section 4). Because the measurement location is often in the near field region (practically always the case for long wave transmitters), the electric and magnetic field strengths must be measured separately (section 3). The isotropic H-field antenna (a special feature of the SRM) has practical advantages over single-axis H-field antennas: Only one measurement needs to be made for each point in the matrix method, and the direction of polarization of the field does not need to be taken into account in the pendulum method. Three measurements need to be made at each measurement point using the single-axis E-field antenna, and the antenna must be rotated accordingly during measurements using the pendulum method.

Measurement in Spectrum Analysis mode

Recommended settings:

Resolution bandwidth (RBW): **10 kHz**

Result Type: **AVG**

Evaluation preferably using the Peak Table.

11 Result evaluation and creation of a test report

The purpose behind all these measurements of field immissions is to determine

- whether the permitted limit values have been adhered to, or
- which service provider has exceeded the limits, and by how much, resulting in a need to reduce output power, or
- which areas are off-limits to personnel because of safety concerns.

Summation

Wherever average values are applied as limit values, the *power* levels of individual channels must be summed together to obtain the total immission. The value for two channels of equal strength can be obtained simply by adding 3 dB to the value of one channel if the field strength can be displayed as a logarithmic value (e.g. in dBV/m or dBμV/m), add 6 dB if there are four equal channels, and so on. Otherwise, the total field strength is determined by taking the square root of the sum of the squares, i.e.:

$$E_{total} = \sqrt{E_1^2 + E_2^2 + \dots} \quad \text{or} \quad H_{total} = \sqrt{H_1^2 + H_2^2 + \dots}$$

The total field strength of a contiguous frequency band can be determined using the Integration over Frequency function in Spectrum Analysis mode.

The SRM-3006 automatically determines the overall field strength of defined services or channels even if they do not form a contiguous frequency band, eliminating the above calculation. A corresponding Service Table must be defined first and stored for this to work.

Evaluation

The results must be compared with the limit values for each frequency if they are displayed in physical units, e.g. in V/m.

As a specialized instrument, however, the SRM-3006 provides a direct display of the result in all operating modes as a percentage of the limit value of a selectable human safety standard.

Measurement uncertainty

The measurement uncertainty must be taken into account in all results. Please refer to our Application Note "Taking measurement uncertainties into account with the SRM-3000" (AN_HF_1004), which can also be applied to the SRM-3006.

Test report

Normally, a test report is produced as a record of the evaluation and assessment. The free SRM-3006 Tools (or SRM-3006 TS, available as an option) PC software is very useful for this purpose. Simple copy and paste functions can be used to copy the data and graphs into the test report or export the measurement data sets to standard spreadsheet applications.

12 Abbreviations

DAB	Digital Audio Broadcasting
DVB-T	Digital Video Broadcasting, Terrestrial
E-field	Electric field
H-field	Magnetic field
MR	Measurement range
RBW	Resolution bandwidth
SRM	Selective Radiation Meter

13 References

- [1] Chr. Bornkessel, M. Schubert, M. Wuschek, et al.: "Exposure of the General Public to Digital Broadcast Transmitters Compared to Analogue ones", Radiation Protection Dosimetry, Volume 124 No 1, pp. 53-57, 2007
- [2] Guidelines on Limiting Exposure to Non-Ionizing Radiation. International Commission on Non-Ionizing Radiation Protection (ICNIRP), July 1999; ISBN 3-9804789-6-3.
- [3] Directive 2004/40/EC of the European Parliament and the Council of 29 April 2004 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields). Official Journal of the European Union L 159 of 30 April 2004.
- [4] 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.
- [5] 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). Edition October, 2003.
- [6] VDE 0848-1, DIN EN 50413:2009-08: Basic standard on measurement and calculation methods for human exposure to electric, magnetic, and electromagnetic fields (0 Hz to 300 GHz).
- [7] Twenty-sixth ordinance regarding execution of the Federal Immission Protection Act (ordinance regarding electromagnetic fields – 26. BImSchV). 16 December 1996.
- [8] Ordinance regarding the verification procedure for limiting electromagnetic fields dated 20 August 2002. Federal Law Papers Volume 2002 Part I No. 60, 27 August 2002.
- [9] VDE 0848-110, DIN EN 62110:2010-08: Electric and magnetic fields generated by alternating current energy supply systems; measurement procedures with regard to exposure of the general public (IEC 62110:2009); German version EN 62110:2009
- [10] BGV B11: Electromagnetic field accident prevention regulation (Employers' Liability Insurance Association regulation for workplace health and safety). 1 June 2001.
- [11] Radio broadcasting and pager transmitting equipment – Recommendation for implementing the non-ionizing radiation ordinance (NISV). Swiss Federal Bureau for Environment, Forestry, and Countryside (BUWAL), draft of 6.7.2005.

Narda Safety Test Solutions GmbH
Sandwiesenstrasse 7
72793 Pfullingen, Germany
Phone: +49 (0) 7121-97 32-777
Fax: +49 (0) 7121-97 32-790
E-Mail: support@narda-sts.de
www.narda-sts.de

Narda Safety Test Solutions
435 Moreland Road
Hauppauge, NY 11788, USA
Phone: +1 631 231-1700
Fax: +1 631 231-1711
E-Mail: NardaSTS@L-3COM.com
www.narda-sts.us

Narda Safety Test Solutions Srl
Via Leonardo da Vinci, 21/23
20090 Segrate (Milano) - Italy
Phone: +39 02 269987 1
Fax: +39 02 269987 00
E-mail: support@narda-sts.it
www.narda-sts.it

© Names and Logo are registered trademarks of Narda Safety Test Solutions GmbH and L3 Communications Holdings, Inc. – Trade names are trademarks of the owners.