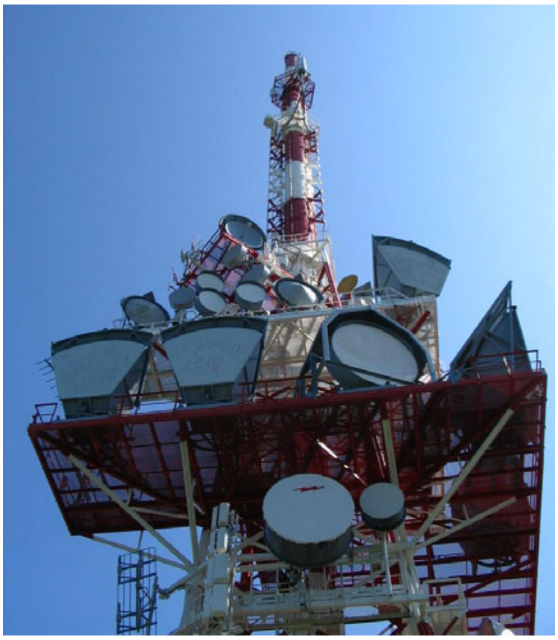
Application Note

Measurements in the vicinity of fixed wireless transmitters

Practical tips on the determination of high frequency electromagnetic immissions



This Application Note deals with the practicalities of high frequency exposure measurements, i.e. determining the electric, magnetic, and electromagnetic fields close to the installation sites and operating locations of mobile telephone base stations as well as radio and TV broadcasting stations in the frequency range above 10 MHz.
Important definitions and fundamental information on making exposure measurements and calculations can be found in the EN 50413 basic standard. These fundamental principles are substantiated in the EN 50492 basic standard. The practical application of these standards will be explained in more detail in the following, with particular focus on practicable, cost-saving, yet proper performance of the measurements.

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1 Different tasks require different measurement and evaluation techniques

Different requirements are placed upon the way exposure measurements are performed, i.e. the accuracy of recording as well as the evaluation of the results, depending on the task definition. The costs of making such surveys must also always be kept in mind.

Particularly when making measurements within the framework of occupational safety, the checking of adherence to limit values must be undertaken with special care and precision. The examination must guarantee that the worst-case exposure situation is recorded so that the question of whether the prescribed limits are being adhered to or not at the locations considered can be answered with certainty from the results of the measurements. Such investigations have a direct bearing on health and safety, with possibly serious consequences if the evaluation is incorrect.

Measurements to inform the public (i.e. determining immissions at sensitive locations such as homes, schools, kindergartens, etc.) naturally also require a certain minimum level of precision and reliability. However, since the immissions present at these locations are normally nowhere near as high as the permitted limit values, some reductions in the accuracy of the analysis can by all means be permitted in order to keep the costs of the investigations down. The emphasis here is therefore on applying a measurement technique that delivers reliable immission results with the least possible expenditure in terms of time and personnel.

Unfortunately, the measurement principles and instruments available do not provide the opportunity to define a measurement procedure for the high frequency range that is generally applicable to all tasks, simple, low-cost, and which uses equipment that is ideally suitable. Technicians have no option but to choose the best procedure and measuring equipment for each separate measurement task. Simple digital readout electromagnetic pollution testers priced below 1000 € ($ 1300) are generally unsuitable for professional immission measurements. This becomes all too clear when the price of calibrating the measuring antenna alone is a four-figure sum if the calibration is to be traceable to recognized standards.

In-depth knowledge of the way the instruments work is essential for making professional high frequency immission measurements. Just as important is knowledge of the time and frequency structure of the signals to be measured and the legal regulations regarding limit value philosophy, safety goals, and immission recording. Incorrect settings on the measuring device or misinterpretation of the results displayed by the instrument can easily lead to evaluations of the immissions that are erroneous by several orders of magnitude, and which are unacceptable, either as over- or as underestimations of the actual immission.

Various projects in Germany in recent years, particularly the "Deutschen Mobilfunkforschungsprogramm" (German Wireless Research Program) as well as studies in individual Federal States, have contributed on the one hand to increased data about the typical immission conditions in the vicinity of transmitting equipment and on the other hand to the development of suitable measurement and computing methods for determining the immissions [BOC 03, BOR 02, BOR 05, BOR 05-2, BOR 05-3, BOR 08, BOR 11, SCH 06, WUS 04]. Also worthy of mention are corresponding studies in Switzerland, which have led to detailed and practical measurement instructions [BUWAL 02, BUWAL 03, BUWAL 05]. The reliability and practicability of exposure measurements in the high frequency range has also been thoroughly investigated and verified by means of comprehensive inter-laboratory testing in Switzerland [METAS 02, METAS 06, METAS 08]. Indeed, Switzerland can be considered as the European role model in this sector.

International standardization also supplies some informative documents regarding the practical performance of such immission measurements (particularly [EN 50492, IEC 62232]).

The descriptions in the following concentrate on the practical procedures for determining immissions by measurement. However, correct application of the measuring equipment (I.e. selecting the parameter settings on the measuring set required for determining immission of the various wireless signals) is largely omitted here since some advice on this subject has already been given elsewhere [WUS 08].

2 Field distribution characterization and requirements for determining immission

Detailed analyses of immission distribution around GSM and UMTS mobile phone base stations have shown that the immission directly adjacent to the stations exhibits both large scale (caused by the directional characteristics of the wireless antennas) and small scale (caused by interference, particularly indoors, see figure 1) variations [BOR 05, BOR 05-3]. Measuring the value *at just one point* in the space therefore does not represent the average or maximum immission present in the space.

In addition to this, many wireless systems show large scale and small scale variations in immission over time: the former due to changes in the transmitted power level as dictated by the current number of users, and the latter resulting from discontinuous transmission or power regulation depending on connection quality, for example. An instantaneous measurement can only give an unsatisfactory idea of the maximum possible immission situation for this reason.

As a consequence of the requirements set out by ICNIRP [ICNIRP 98] and the EC recommendation [EU 99], the German Federal Immission Protection Regulations [26. BIMSchV] as well as the Performance Guidelines of the Federal States Committee for Immission Protection [LAI 04] stipulate that measurements of immission must be made at the location where immission is the strongest and the results must be evaluated on the basis of the *maximum measured values*. In addition, the measurements must be made at the *highest operating load of the installation* or the results extrapolated to correspond to this. This extrapolation is usually based on a measurement of certain control signals that are permanently transmitted by the wireless systems at a constant, defined power level. The exposure due to these control signals is then extrapolated to give the immission at maximum system operating load using extrapolation factors that are derived from the maximum power level of the wireless system and the power level of the control signal. More information on correct extrapolation for systems with time-varying power output can be found in [WUS 08] for example.

The limit values defined by ICNIRP, the EC recommendation and [26. BImSchV] for electric and magnetic field strength are specified as *root mean square values* (RMS). The Swiss regulations [BGR 01] define the recording of exposure values for occupational safety in the same way. The requirements must be met by a suitable measurement method (RMS recording).

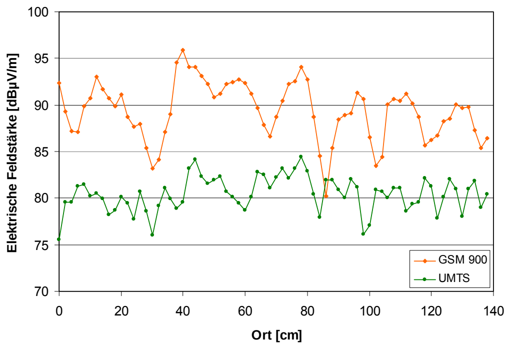

Figure 1: Immission characteristic for GSM-900 and UMTS in an enclosed room measured over a length of 1.4 meters [BOR 05-3]. Variations in immission of up to 15 dB within a few centimeters can be seen.

3 Fundamental measurement methods

A basic distinction is made between wideband and frequency selective measurement methods for high frequency immissions. The main difference is that wideband procedures determine the total value of immissions within the (large) frequency range covered by the measuring instrument, so that information about how the immission components are distributed according to frequency and therefore also according to emitter cannot be determined. This makes it more difficult or even impossible to evaluate the results against the appropriate (sometimes frequency dependent) limit values when several signals in different frequency ranges are present.
In contrast, it is possible to determine which immissions at what frequencies are present at the measurement location when frequency selective methods are used. In many cases, the frequency information allows a correlation with the source of the immission. The often somewhat limited sensitivity of conventional wideband meters (typically 1 V/m, occasionally even less) also means that they (figure 2) are mainly useful only for exposure measurements where the field strength is comparatively large, such as is usually the case in the immediate vicinity of transmitting antennas.
Spectrum analyzers or test receivers with suitable receiving antennas and RF cables are normally used for frequency selective measurements. Integrated solutions where the test antenna and analyzer are fixed together are increasingly becoming the standard equipment for this measurement task (figure 3).

Figure 2: Wideband measuring equipment for high frequency fields (EMR and NBM-550 from Narda Safety Test Solutions).

Figure 3: Field strength measurement close to a mobile phone antenna using a modern field analyzer (SRM-3000 from Narda Safety Test Solutions)

4 Methods for recording field strength in the measurement space

The requirements for recording the maximum value in an area can be fulfilled very efficiently using the so-called *pendulum method*: This measures the high frequency fields that are present not just at one fixed point, but throughout a volume of space. The measurement space is sampled using a hand-held measuring antenna, with the predominant direction and the polarization of the antenna being varied at the same time. During this search, the spectrum is recorded continuously using the *Max Hold* function of the measuring instrument. It is particularly easy to sample the space using isotropic antennas, which have been available for several years now, not only for wideband measuring sets but also for frequency selective measuring systems (figure 4). The maximum values of the individual signals can then be taken from the *Max Hold* spectrum for further evaluation. However, the antenna must be moved slowly in relation to the measurement speed of the spectrum analyzer.

The pendulum method, though, does not allow an analysis of the spatial distribution or a spatial average of the immissions to be made in a room, for example, which is of interest when recording immissions for epidemiological studies. The *matrix method* represents a useful alternative for such cases. Here, the immission is measured at several fixed points within the room and then averaged. The results of such average measurements are always smaller than the results obtainable with the pendulum method [VOI 04], which underlines the "maximization aspect" of the measurement requirements of [26. BImSchV]. Depending on the requirements laid down in the relevant regulations, a decision has to be made as to which method of determining the maximum value is to be used (the time-saving pendulum method or a more complex matrix measurement). It can, however, be concluded that an exposure measurement at just one point in the space is generally not enough.

EN 50492 envisages recording at three or six points in a fixed, defined raster with subsequent power averaging for measurements where the assessment quantity is the immission averaged over the human body area (figure 5). For cases where the local maximum values of the individual fields present in the measurement space are to be added together and used for limit value comparison, EN 50492 in Appendix B specifies the pendulum method as an alternative procedure. Use of the matrix method for reliable detection of the field strength maxima would mean a disproportionately high measurement effort, as the number of

Figure 4: Searching for local field strength maxima using the pendulum method.

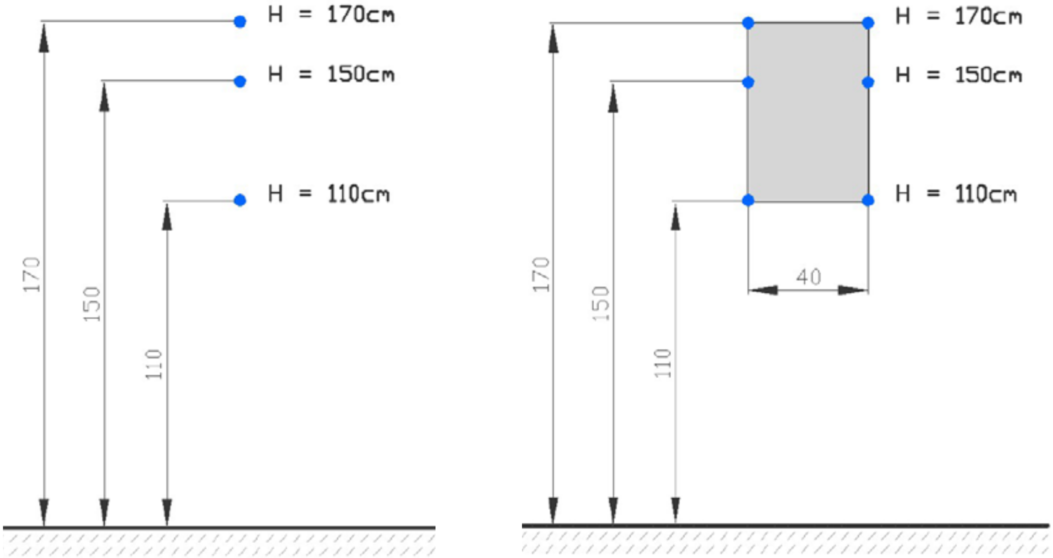

Figure 5: Matrix method, matrix geometries as per EN 50492

points to be measured and evaluated would have to be very large in this case. The pendulum method has clear advantages in such situations.
According to [KÜH 09], evaluation using the local maximum values represents the more conservative strategy, since comprehensive simulations have shown that simply considering the *average immission over the body* (comparison with the limit values for whole body exposure) cannot exclude the presence of local immission peaks in the measurement space that are above the limits for partial body exposure. ICNIRP stipulates that both the limit values for average immission over the body as well as the limit values for local energy absorption (part body exposure) also specified by ICNIRP must be adhered to.

5 Reactive near field, RMS recording, and measurement uncertainty

It should also be pointed out that a check must be made for every measurement to see if the location is within the reactive near field of the radiation source(s), since if this is the case the electric as well as the magnetic field within the space must be measured and a comparison with the limit values for both fields must be made. In contrast, it is enough to measure just one of the two field components (E or H) when outside the reactive near field. Useful formulas for determining the distance limit to the reactive near field can be found in chapter 7 of EN 50492, for example.
It must be ensured that the field strength value determined by frequency selective as well as wideband measurement is proportional to the square root of the absorbed power (RMS detection). The measurement of signals with large *crest factors* (i.e. signals having short instantaneous power levels that are much higher than the average signal power level) poses particular problems in this regard. This is typical of UMTS, LTE, DAB, and DVB-T transmitter signals, but also of locations where several UHF basic coverage transmitters are radiated from one antenna.
The measuring device must be suitably set to ensure correct RMS detection for frequency selective measurements.
The field strength range over which wideband sensors give a practically true RMS value can vary widely and be distinctly different from the specified measurement range of the sensors (Table 1). The immissions may be overestimated or even underestimated outside the “true RMS” range specified by the manufacturer [KEL].

True RMS range for some field probes with diode detectors made by Narda Safety Test Solutions				
Sensor	Sensor type	Frequency range	Specified measurement range	True RMS range
EF 0391	E-Field	100 kHz - 3 GHz	0.2 V/m - 320 V/m	0.2 V/m - 10 V/m
EF 1891	E-Field	3 MHz - 18 GHz	0.6 V/m - 1.000 V/m	0.6 V/m - 35 V/m
EF 6091	E-Field	27 MHz - 60 GHz	0.7 V/m - 400 V/m	0.7 V/m - 61 V/m
HF 0191	H-Field	27 MHz - 1 GHz	0.018 A/m - 16 A/m	0.018 A/m - 1.0 A/m
HF 3061	H-Field	300 kHz - 30 MHz	0.012 A/m - 16 A/m	0.012 A/m - 0.7 A/m

Table 1

The ever-present measurement uncertainty must not be forgotten, particularly in measurements for checking that human safety is not compromised. Consider the reality that the actual field strength present in the measurement space has a 50% chance of being greater than the measured value. The measurement uncertainty is an estimated value that indicates the probability that the real value is within a certain range about the measured value. For this reason, the uncertainty occurring during the measurement should always be determined and recorded by the person making the measurement. Chapter 11 of EN 50492 contains some helpful information on this. The applicable standard will determine whether the measurement uncertainty is to be added to the measured value or not.

6 Measurements for checking compliance with limit values: The influence of the task on the measurement effort

If the measurements are to determine compliance with limit values, the exact task definition will determine whether the probable outlay for the measurement is high or if it can be kept within reasonable limits. Basically, the distinction is between the two following types of task definition:

Type 1:
Measurements are to be used to determine that the limit values are not exceeded within a certain predefined area.

Type 2:
Measurements are to be used to determine as accurately as possible the limits of the safety zone around transmitting antennas.

Checking the safe accessibility of platforms on TV masts (figure 6) by measurement is a typical type 1 task definition, as is determining by measurement whether the immissions generated in the area of a roof garden on an apartment block from mobile communications antennas nearby exceed the limit values specified in [26. BImSchV]. Similarly, measurements for checking that the relevant limit values are adhered to in sensitive locations can be included in this category.
In contrast, type 2 measurements are intended to determine as accurately as possible the clear area around antennas where persons are not permitted or only permitted for short periods (designation of safety zones).

Figure 6: The often large numbers of antennas installed on radio masts mean that measurements must be made to check safety on the various platforms.

7 Type 1: Checking compliance with limit values in certain specified areas

The effort can be kept low initially for type 1 measurements: The first step should be to use the simplest possible means to verify that the limit values are not exceeded within the space under investigation. More complex measurement methods should be used only if this cannot be shown with certainty. As an example, the following procedure may be used:

First step:
Verification using a simple wideband measurement and pendulum method

Figure 7: Field strength measurement with a wideband probe.

If the field sources are systems with *power output that is constant over time and not dependent on the load* (e.g. UHF, DAB and DVB-T transmitters), a simple wideband measurement can be used initially to determine the overall field strength within the measurement space (figure 7). If the pendulum method is used here, the maximum total field strength in the measurement space will be the result. However, if several sources with different frequencies are present, different limit values will have to be applied for each radiated signal. Because the wideband measurement cannot give results for each separate frequency, the result should be evaluated according to the lowest limit value of all the signals radiated from the antennas to be sure that the immission is not underestimated.
If the result still does not use up 100% of the limit value despite this possibly significantly overestimated exposure level (no averaging for body volume, comparison with the most stringent limit value), the safety of the space under investigation has been verified with certainty. Where the results use up more than 100% of the limit value, safety within the space is not explicitly verified. In this case, a more detailed immission analysis can give more exact information about the immission situation in the space (see next section).
Measurements made using a wideband probe at locations where the sources also include those with *power output dependent on load* (e.g. GSM, UMTS, TETRA and LTE transmitters) do not generally provide a result that is clearly applicable because the actual output power level of the individual sources at the time of measurement is unknown and often different extrapolation factors apply to the different variable power sources. A result that can be safely said to verify that the limit values are not being exceeded can be obtained only if it is assumed that all load-dependent sources are radiating at their minimum power levels at the

time of measurement, and subsequent extrapolation of the wideband measurement result is done using the largest of all the factors relevant to the various sources, and then only if the result does not exceed 100% of the limit value after such extrapolation. Admittedly, it must be reckoned that this procedure will result in a very large overestimation of the immission, which will often result in areas being classified as "no go" or "limited time only" even though this is not really necessary. Here, too, the further steps described below (particularly steps 3 and 4) can give a more reliable picture of the actual immission situation within the space.

Second step:
Additional frequency selective overview measurement

If the result obtained by wideband measurement of signals that do not vary in power over time is more than 100% of the limit value, it may still be possible (if the limit value is not exceeded by too much) to use a simple frequency selective overview measurement (spectrum analysis) to show that although various signals with different frequencies can be measured in the entire space under investigation, the predominant part of the overall immission comes from a source that is operating at a frequency for which the limit value is not the most stringent of all the signals present. As an example, measurements might need to be made on a platform on a TV mast fitted with UHF antennas (limit value according to [26. BImSchV]: 27.5 V/m) as well as DVB-T transmitting antennas (limit value in UHF range: between 29.8 and 38.6 V/m). If the platform is immediately adjacent to the DVB-T antennas, the UHF fields are negligible, so applying a higher limit value than 27.5 V/m for the evaluation is justified. Thus, possibly supplementing the wideband measurements with a spectrum analysis enables verification of the safety requirements.

Third step:
Detailed analysis from spectrum measurement and pendulum method

The expenditure for a detailed spectrum analysis may be justified when even though compliance with limit values could no longer be verified by the wideband measurement, the amount by which the limit was exceeded was not large so that detailed frequency selective analysis can still verify compliance.
When there are sources with time variable power output also present at the site, a spectrum measurement of many such systems allows selective measurement of the non-varying control signals (e.g. for GSM, TETRA and LTE) followed by extrapolation to maximum system power using the individual extrapolation factors. (Note: Pure spectrum analysis on UMTS systems only allows imprecise extrapolation to maximum power level; code selective measurement is the method required for precise extrapolation to maximum power level.)
The primary procedure for performing a spectrum measurement when recording the spatial immission is the pendulum method, i.e. examination of the field distribution is initially very conservative (the measurement principle assumes that the local maxima for the field distributions of all sources are at the same point in the space). If after extrapolation to maximum power if necessary and subsequent standard-compliant summation of the individual immissions this method yields a value that is less than 100% of the limit value, this shows that the limit has not been exceeded in the space examined.
The pendulum method, which does not resolve individual points, is particularly suitable for determining immissions in spaces that are not too large (e.g. in residential property, on smaller platforms, and in standing areas on masts). Where larger volumes need to be analyzed (e.g. extensive platforms or flat roofs), it is a good idea to divide these into several smaller spaces and analyze each of these separately using the pendulum method to minimize the possibility of strongly overestimating the immission because of the field distribution when more than one immission source is present.
Limit value comparison and subsequent addition of the separate immissions can be performed automatically by many instruments, so that a result indicating if the total immission is above or below 100% is available immediately after the measurement, which obviously simplifies on-site measurements. However, such automatic routines fail if sources with time-varying power output are also present at the site, since the equipment currently available cannot (yet) take different extrapolation factors into account automatically. In this case, the measurement results

will need further processing, e.g. using an Excel table, before a final statement regarding compliance with limit values can be made.
Frequency selective analysis using the pendulum method has proved valuable in recent years, particularly for measurements intended to provide public information (measurements in houses, schools, kindergartens, etc.). Since it can usually be assumed from the outset that the immissions will be well under 100% of the limit value due to the position of the measurement points [WUS 04], any overestimation of the immission due to the use of the pendulum method is not a problem and usually supports the conservative approach to immission evaluation in the context of risk communication. The Swiss measurement regulations likewise specify the pendulum method as the preferred procedure for scanning a space [BUWAL 02, BUWAL 03, BUWAL 05].

Fourth step:
Detailed analysis from spectrum analysis
and matrix method

If the measurements performed according to step 3 yield results that are more than 100% of the limit value, compliance with the limit values within the space has not been clearly verified, but proof that the limit values have been exceeded has not been given, either. It is possible that the non location-specific pendulum method overestimates the immission to a certain extent, since the local maxima of the individual signals present are found at widely different locations. In such cases, a more precise picture of the spatial distribution of the field can be obtained using the matrix method. However, the measurement point matrix must be spaced closely enough to ensure that a significant underestimation of the immission is ruled out.
Matrix measurements also provide the opportunity of forming spatial average values from a larger number of measurement points in order to obtain an exposure value that corresponds to the power absorption averaged over the human body.
It should again be mentioned here though that ICNIRP stipulates that the limit values for the body-averaged immission as well as for the local energy absorption (part-body exposure) must always be adhered to. According to [KÜH 09] evaluation using the *local maximum values* (i.e. measurements using the pendulum method) is the more conservative strategy, since simulations have shown that simply looking at the *body-averaged immission* (matrix measurement + average formation) cannot exclude the presence of local immission peaks within the measurement space that exceed the limits for partial body exposure.

For matrix measurements, the antenna can be positioned exactly using a tripod, for example (figure 8). Practical experience has shown, though, that using tripods in “difficult” sites (measurements on TV masts, on roofs, and in well-furnished living or office space) often becomes awkward (lack of space, stability in windy conditions), so that a hand-held matrix measurement is often the quicker and better option. Measuring instruments that automatically perform the measurement at each point and save the results are useful here. Two people are generally required for efficient measurement when a tripod is used, but a just like the pendulum method, just one person can easily perform a matrix measurement with a hand-held isotopic antenna (figure 4).

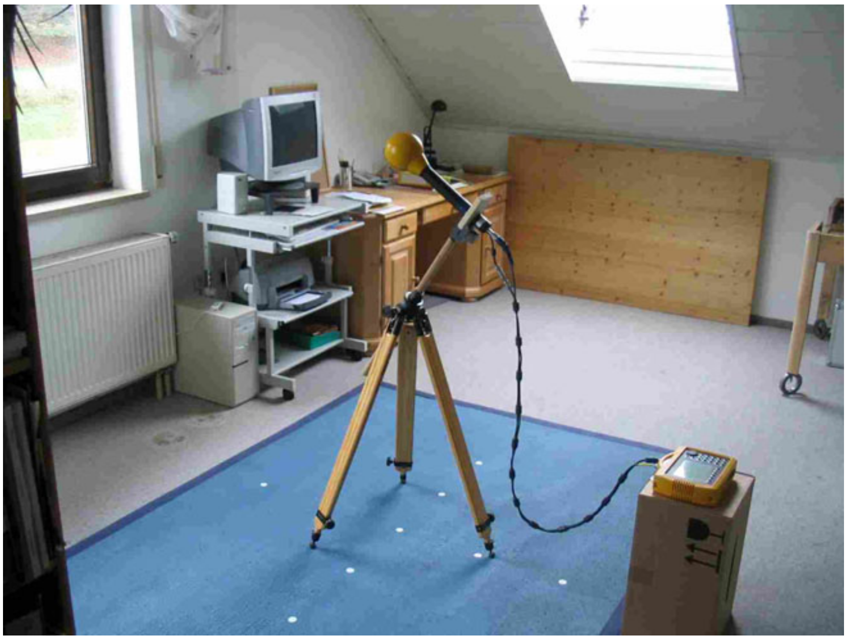

Figure 8: Field strength measurements using the matrix method in an enclosed space [BOR 05-2].

If sources with load-dependent power output are also present at the site, the same applies as for the third step: The final result for the degree to which the limit value has been utilized cannot be read off directly from the measuring instrument, but is only obtained after additional evaluation, which naturally considerably increases the time needed for the matrix method because each point has to be processed separately.

8 Type 2: Exact determination of safe distances by measurement

Whereas for type 1 measurement tasks the measurement space has a fixed definition and the test is merely to establish whether it is permissible to be in the defined area or not, type 2 investigations are designed to exactly determine safe distances. Here, too, the aim should be to keep the effort required for measurements as low as possible. Since it is usually an additional requirement not to overestimate the extent of the safety zone too much, wideband measurements are mostly only suitable for investigations in the vicinity of sources emitting just one (single frequency) signal or of multi-frequency sources where one signal is absolutely dominant (perhaps verified by first measuring the spectrum). Exact delineation of the safety zone is further complicated if sources with load-dependent power output are also present on the site, as a wideband measurement can usually only allow a very conservative extrapolation to the maximum immission to be made, as already explained above. The continually changing values shown on the instrument display that result from the variations in the signal power over time also make it difficult to reliably read off the measurement result.
In many cases it is only possible to determine the safe distances around wireless antennas with satisfactory accuracy and without too much overestimation by means of frequency selective measurement. The same applies here in principle as stated above for type 1 measurements. Nevertheless, the following additional points should be considered and taken into account if necessary:

- The pendulum method can lead to an overestimation of the immission with multi-frequency sources and large measurement volumes, since all the fields from the different sources measured in the area investigated (e.g. the volume of a standing person) are again “concentrated” at one point by this measurement.
- Possibly more realistic values are obtained from matrix measurements. Using a hand-held isotropic antenna to record the values lends itself particularly to this task, whereby measurements are made at several points at different heights above one another (see EN 50492). The total immission values can then be determined for each separate point and compared point by point with the limit value. Once again, it is also possible to form the spatial average from these points.
- Having said that, comprehensive studies of the radiation behavior of GSM wireless antennas show that the characteristic (size and direction) of the side lobes of current GSM base station antennas can

be very much dependent on the operating frequency [BOR 05]. Thus the immission distribution in a measurement matrix in the area of side lobe radiation can be highly frequency dependent. Because the transmitting frequencies of GSM systems are often changed regularly (sometimes several times a year due to network optimization), measurements made using the matrix method would give significantly different results each time the frequency was changed. This fact again speaks in favor of using the more conservative pendulum method.

- Measurements are much more complicated when there are sources with load-dependent power output as well those that remain constant over time are present at the location under test, since some of the measured signal results will have to be extrapolated. In many cases, a single survey of the immissions in the measurement space is enough for type 1 measurements. Although subsequent processing of the measured values (extrapolation, limit value comparison, addition) cannot be carried out directly by the measuring instrument, it is also not usually necessary to do this immediately on site. When the measurement is to establish safe distance limits (type 2 measurements), it is usually not possible to avoid iterative measurements: Firstly, measurements are made at a certain distance from the antennas. These then need to be evaluated directly on site (extrapolation, limit value comparison, addition). Depending on the results, new measurements and subsequent evaluations are made in a new space (either closer to or further from the radiation sources). This process is repeated until the safety zone has been mapped out precisely enough. This procedure remains relatively straightforward when the task involves only one dimension such as when this method is used to approach the safety zone by advancing up a vertical ladder. The effort required for measuring and evaluating over and over again can be enormous if the safety zone is to be delineated in more than one dimension (e.g. on a flat roof).

9 Summary

Depending on the specific task definition, the recording and assessment of immissions caused by high frequency signals from wireless transmitters places very different requirements on the measuring equipment used, the measurement methods, and the way the results are evaluated. The basis for correct determination of immission is always the standards and measurement regulations that apply in each case. Exposure measurements in the high frequency range require intensive training and extensive experience on the part of the staff employed for the task. It is not enough just to use the right test equipment for the job without the necessary knowledge about the measuring process. There are even different strategies for performing the actual measurement in the space under investigation, each of which has its own advantages and disadvantages and which are more or less suitable for certain tasks.

The measurement effort is particularly high when making as accurate a determination as possible of safety zones in the immediate vicinity of transmitting antennas, since such safety zones can usually only be determined iteratively.

For this reason, and for reasons of cost saving, the aim should be to define as far as possible in advance the limited spaces within which the adherence to limit values needs to be checked (e.g. the area of an antenna platform on a TV tower, or the access path to the equipment cabinets on a flat roof). Such task definitions make it possible in many cases to answer the question posed (“Is it safe in the defined space?”) with a single on site measurement run, making repeated performance of the entire measurement procedure unnecessary.

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