Stop or go, twist or turn?

When it comes to measuring the exposure levels due to GSM and UMTS, the dot matrix method is considered to be the most accurate and the panning method to be the quickest. As with so many things, the truth is somewhere in between. Moreover, with an isotropic antenna, you can stop or go without having to twist or turn.

Radiation pollution due to GSM and UMTS: Mobile phone network providers, authorities, and measurement services acting on their behalf have the task of demonstrating that permitted limit values are not exceeded. Most of the time, radiation levels are well below the limit values, and because base stations are being more closely spaced and the cells are therefore smaller, the emissions from transmitting antennas and from the mobile phones themselves are reduced. It is possible in many cases to show by calculation that human safety limit values applicable to the general public are being adhered to. But the only way to be really sure is to make selective measurements to determine the influence of each source separately and with sufficient sensitivity.

Figure 1: The Selective Radiation Meter SRM-3000 fitted with a plug-in isotropic antenna is ideal for space measurements without the need to twist or turn.

Panning method

The so-called panning method is often preferred for measuring the exposure levels caused by mobile phone stations. The usual method employs single-axis antennas, which may even be strongly directional, to detect the measurement values. The analyzer is set to “maximum hold”, i.e. the maximum value measured is registered and retained. The antenna is then moved about in the area under investigation. Such movements should ensure that the various spatial points, angles of incidence, and antenna polarizations are covered with equal probability and with sufficient resolution. The maximum field strength measured in the investigated area is the result that will be available at the end of the movement sequence.

Convenient isotropic measurement

Isotropic antennas make it easy to perform measurements. You only need to take care that the various spatial points are covered with equal probability and with sufficient resolution during the sequence of movements. All the possible angles of incidence and antenna polarizations are automatically taken into account by the isotropic antenna (figure 1).

A look at the time

Nevertheless, one aspect needs consideration. Because isotropic antennas for the mobile phone frequency range consist of three orthogonally arranged elementary dipoles, and the test instrument usually has only one input channel, three consecutive single-axis measurements are combined to give an isotropic result. In other words, an isotropic measurement takes three times as long as a single-axis measurement. Does this mean that there is no net gain in time?

A more exact comparison serves to clarify matters. If an elementary dipole and a tri-axial antenna are both moved at the same speed along the same path within the space, and if the refresh rate for the single-axis measurement is three times as fast as that for the isotropic measurement, then the same number of single-axis raw values will be obtained from both antennas in the same time. The space is thus sampled with the same resolution in both cases. However, the basic principle involved means that using an isotropic antenna will also ensure that all the angles of incidence and polarizations are equally taken into account. When moving a single-axis elementary dipole along the prescribed route, though, careful attention must be paid to ensure that the dipole axis is aligned in all directions equally often. This means that the dipole axis has to be rotated continually and relatively quickly. With care and concentration, it is possible to obtain results of equivalent quality. However, the results obtained using an isotropic antenna are much less dependent on the skill of the operator.

Figure 2: The Selective Radiation Meter SRM-3000 with single axis antenna and "Maximum Hold" function used for the panning method.

If a strongly directional antenna is used for the panning method instead of an elementary dipole, the sampling of the space will be considerably worse for the same path, speed of movement and instrument refresh rate. The strongly directional antenna characteristic means that a comparatively smaller angle of incidence is taken into account for each measurement value. Reducing the speed of movement, resulting in appreciably longer measurement times, can make up for this disadvantage.

The relationship between the measurement times can be calculated from the difference in antenna gain. An elementary dipole has a gain of 1.76 dBi. If a directional antenna with a gain of, say, 7.78 dBi is used, then the measurement time must be four times as long to obtain results of equivalent quality.

The use of an isotropic antenna for the panning method does not, therefore, lead to an increase in measurement time, not even if the refresh rate for the isotropic results is three times slower than that of a single-axis measurement. On the contrary, it can be said that equal or shorter measurement times are possible when an isotropic probe is used, and the quality of the results is likely to be higher.

Controlled search for maximum values

It is also much easier to perform a specific, controlled search for maximum values with an isotropic antenna than with a single-axis antenna. Simply changing the spatial location and observing whether the field strength rises or falls is enough. With a single-axis antenna, though, the angle of incidence and the polarization also have to be varied, and this is relatively difficult to do.

Dot matrix method

The measurement values in the so-called dot matrix method are determined according to a predefined matrix of points in space. Individual values must be measured isotropically. This can, of course, be done using elementary dipoles, but three measurements are needed per measurement point and the dipole axis must also be aligned three times at each location. Only one measurement value needs to be recorded per measurement point when an isotropic antenna is used.

Figure 3: Single axis antenna on a rotating platform. The test instrument calculates the isotropic result automatically from three separate measurements at defined positions. Low ellipticity in the directional characteristic is essential for accuracy.

This still involves a lot of work. First of all, the room must be surveyed in order to establish the points where measurements are to be made. Then, each point must be measured and the results recorded. Often, though, it is only the highest level of exposure in the space under consideration that is of interest. A type of simplified dot matrix method, which is actually similar to the panning method, is sometimes used as a result. The instrument is set to “Maximum Hold” and each point in the room is approached in sequence with an isotropic antenna. You do not have to measure out the dot matrix to the nearest centimeter; simply having a rough idea where each point is and making a measurement in the general area is enough. You only need to stop at each point long enough for the instrument to make an isotropic measurement before going on to the next point. By observing the display during the measurement, you can easily spot the point where the field exposure is at its highest.

This modified dot matrix method has the advantage over the panning method that the space being investigated is much more likely to be evenly sampled, because the person making the measurement has a “map” in mind, and is not relying solely on feeling when making each measurement. The time needed for the measurement is still not more than for the panning method, assuming that an isotropic antenna is available.

Measurement speed and uncertainty for UMTS

To take the most difficult case, let us now examine measurement including UMTS P-CPICH demodulation that is provided in the Selective Radiation Meter SRM-3000 from Narda. The average time taken for a P-CPICH demodulation measurement is 500 ms for a single axis when the “fast” parameter set is selected. If the “sensitive” parameter set is used, the average measurement takes 750 ms. An isotropic measurement takes three times as long in each case. To obtain comparable results in a comparable time using a strongly directional antenna such as a log-periodic antenna with antenna gain of around 8dBi, the measuring instrument must not take longer than 125 ms per measurement. This is because the directional antenna only covers a quarter of the space compared to a dipole. The SRM-3000 equipped with a dipole antenna is thus quite fast enough to be used for the panning method.

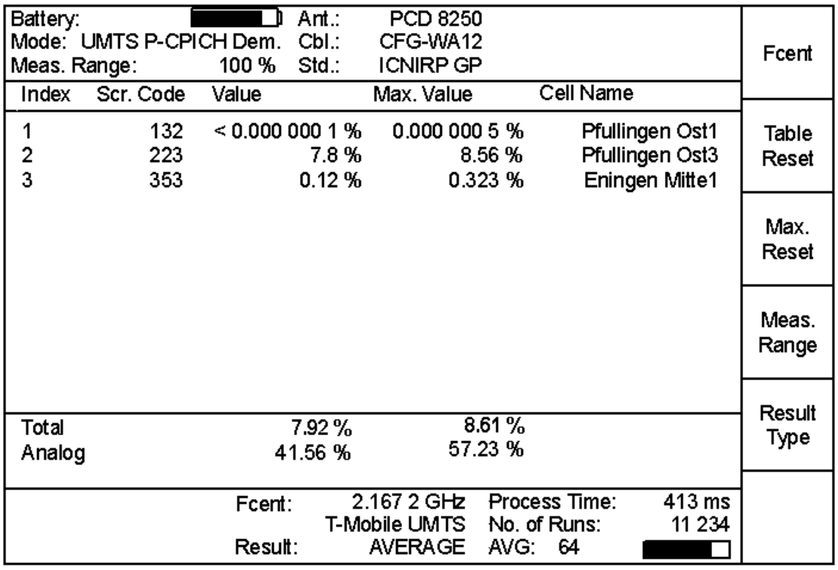

Figure 4: Result of an isotropic UMTS measurement with F-CPICH demodulation. The instrument lists the results according to their detected scrambling codes and assigns the cell names according to the table.

The extended total measurement uncertainty of the test system (antenna, extension cable and main instrument) when used for the panning method is 24.3% for the temperature range from 15 to 30 °C. When used for the dot matrix method, the ellipticity of the antennas must also be taken into account. This leads to an overall measurement uncertainty of 32.6%.

The Swiss Federal Environment, Forestry and Agriculture Office (BUWAL) specifies in [1] that the expanded measurement uncertainty of the measuring system and the expanded measurement uncertainty of sampling using the panning method should not exceed 45% when taken together. This assumes a value of 30% for the expanded measurement uncertainty due to the usage of the panning method. If the SRM-3000 is used for the panning method, square-law addition of the two measurement uncertainties yields an overall value of 38.6%, which more than adequately meets the BUWAL requirements.

LITERATURE

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SRM-3000

The Selective Radiation Meter SRM-3000 from Narda Safety Test Solutions GmbH is a portable spectrum analyzer that is provided with an isotropic (non-directional) antenna for measuring electromagnetic fields. The analyzer's frequency range extends from 100 kHz up to 3 GHz. The antenna covers the range from 75 MHz to 3 GHz. The combination was specially designed for measuring electromagnetic emissions and immissions. Applications range from measurements in close proximity to powerful TV and radio transmitters through to the detection of the smallest field strengths generated by distant GSM or UMTS base stations.

The instrument weighs around 2.3 kg complete with attached isotropic antenna, and can be operated with one hand. The instrument needs no external hardware to perform isotropic measurements or UMTS P-CPICH demodulation.

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