

Use of The

For

All handheld radios or those carried on the body such as radio-telephone systems, report senders and mobile telephones a high near field exposure is caused by electromagnetic fields due to the antennas operating close to the body. The strongly increasing use of mobile telephones contributes to the fact, that those fields more and more occur in daily life.

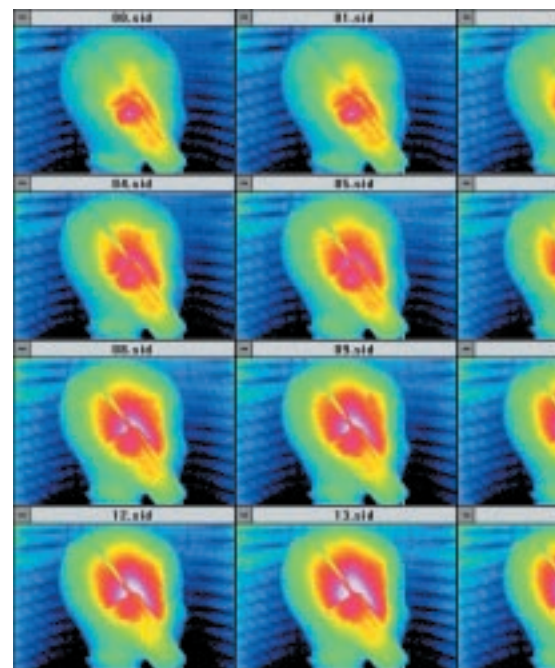
For an assessment of the biological effect and for the control of the respecting of limit values the energy absorbed by the human body has to be determined.

For this purpose numerical methods as well as methods for the measurement of the specific absorption rate (SAR) have been developed, having reached a high technical standard.

proband afterwards passed a 20 minute control phase without stimulus application. The second test group was not exposed to any stimulus.

After a previous pilot study had already shown modifications in the alpha band of the EEG as a result of a Sferics exposition, the researchers succeeded again this time. The brain current activity of the test group reacting with an increase of the alpha power differed from that of the non-stimulated control group which showed a „contrary reaction tendency“. Only near the end of the test the spectral power level of both groups approached each other again.

In a questionnaire the test participants had to specify from which meteorotrop complaints they usually suffered and how distinctive the correlative symptoms were. In a comparison with the results of measurements in the EEG it manifested, that the test persons sensitive to changes in the weather showed a stronger alpha power in certain parts of the brain under



Thermographic Methods

the Depiction of Absorbed HF-Energy on Surfaces

With the portable radio frequencies the energy absorption basically occurs in areas close to the surface of the body. We therefore investigate in how far thermographic methods, which generally register surface temperature distributions, are suitable for the visualization of the HF energy absorption.

Hereafter the results of thermographic measurements on head models and living tissue (skin surface) are described.

The Thermographic Method

In the established mobile radio SAR measuring methods the electric field strength in sphere phantoms filled with tissue-equivalent liquid is measured with robot-piloted field probes. The thermocamera on the other hand supplies a temperature distribution of the surface. In fact the SAR cannot be determined directly, but with some experience conclusions can be drawn

on the quantity of the SAR. As, however, a substantial part of the energy is absorbed close to the surface of head areas, the surface approximation which is necessary for the SAR measuring methods can be checked for plausibility. During the investigations the reproduction of a mobile telephone with a blade antenna served as HF radiator. The electrical characteristics of the blade antenna approximately correspond to those forms of blade antenna, which have often been used with mobile telephones up to now.

The use of this method is not restricted to definite forms of antennas. The HF radiator formed as a mobile phone was fed by the Rhode & Schwarz signal generator SMT 03 with a postconnected band amplifier. The output signal of the measurements at the phantom-head was in accordance with the GSM standards for the D-system (average HF power 0.3 W).

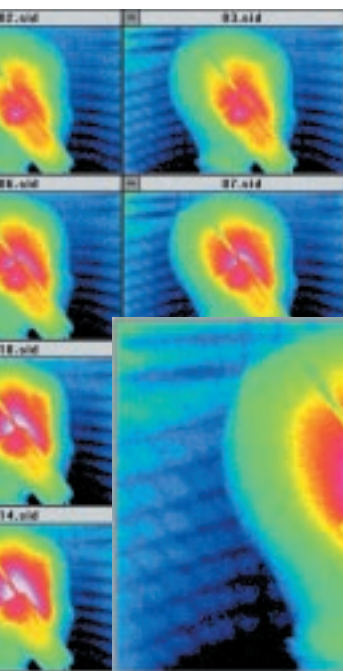


Figure 1: Delineation of the warming up process in a series of 15 single photos with intervals of 20 sec
($P_{HF} = 0,3 \text{ W (rms)}$, $f = 916,2 \text{ MHz}$, $d = 1 \text{ cm}$)

Figure 2: Temperature distribution on the surface of the head model after 300 seconds
($P_{HF} = 0,3 \text{ W (rms)}$, $f = 916,2 \text{ MHz}$, $d = 1 \text{ cm}$)

Correlation between Specific Absorption Rate and Thermographic Pictures

The specific absorption rate (SAR) is a measuring quantity which gives the absorbed power referred to the body mass (W/kg). All presently existing limit values for personal security and recommendations for limit values for electromagnetic fields in high- and highest-frequency range ($f < 10 \text{ GHz}$) have underlying knowledge about the thermal effects. The correlation between SAR, tissue parameters, field quantities and thermal quantities is given by formulas 1 and 2:

$$SAR = \frac{\sigma}{\rho} E_i^2 \quad (1)$$

$$SAR = c \frac{\Delta T}{\Delta t} \quad (2)$$

- with
- SAR specific absorption rate in W/kg
 - σ electric tissue conductivity in S/m
 - ρ tissue density in kg/m³
 - E_i effective value of the electric field strength in the tissue in V/m
 - c specific heat constant of the tissue in J/kg (K)
 - T temperature increase during warming up period t in K
 - t Warming up period in sec

In investigations with absorber or phantom materials their material parameters have to be used.

The thermocamera supplies a distribution of the surface temperature based on formula 2.

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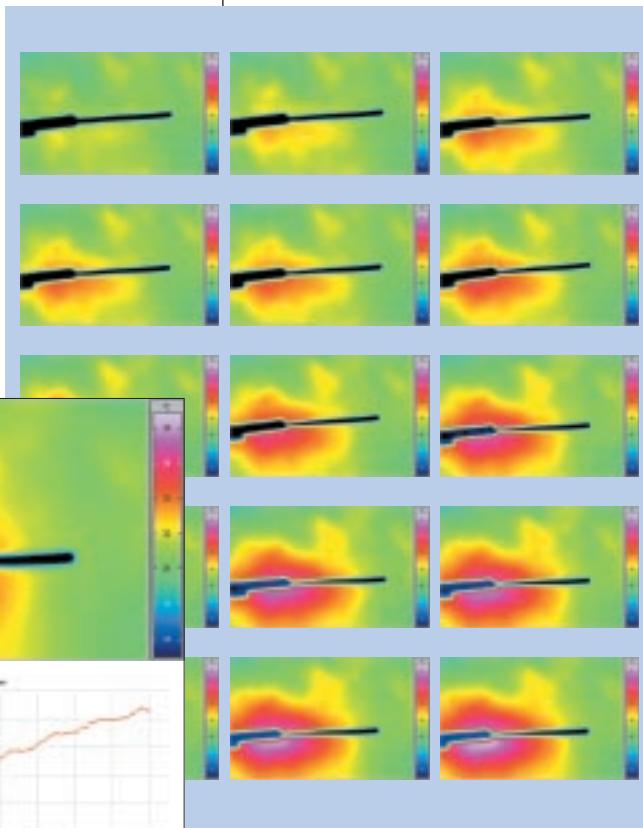


Figure 3: Development of the temperature distribution on human skin during a 15 minute exposition with PHF = 5 W (rms), antenna distance $d = 1$ cm

Figure 4: Final picture of the photo series with graph of the temperature increase measured at the hottest spot

All figures clearly show, that the maximum energy absorption with a blade antenna form happens in the range of the antenna nadir (antenna current maximum), i.e., that the magnetic field of the antenna essentially determines the energy entry. The distribution of the surface temperature corresponds to the surface SAR calculations and measurements of analogue antenna forms. First publication in: EMC Kompendium 1998, pp 298-300.

Summary and Results

The influence of antennas operating close to the body can be quickly and clearly delineated by means of thermography and hence also be used, e.g., for the optimization of antennas. As the results of the head model show, thermographic methods can also be used in the range of low HF power under adequate prerequisites. The thermography completes established SAR measuring methods which cannot enable a straight determination of the surface absorption due to the finite peel thickness of the phantom models, the only restricted reducable E-field probes and the measurement inside the model. The use of thermographic systems in connection with high-frequency absorber materials can be extended to many fields of the high- and highest-frequency technology to realize intended or unintended energy absorptions and to arrange appropriate countermeasures.

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With the measurements on living tissue a mean power of 2 W or 5 W respectively was chosen. In the investigations a head model made of foam polystyrene was used. In the area of the mobile telephone position it was covered with an absorption layer of about 1 mm thickness, which shows electrical characteristics copied from human skin and a high HF absorption grade.

To measure the surface temperature distribution of the human skin, the transmitter was fixed onto the back of a test person so that the distance of the antenna from the skin came to 1 cm.

In the process the antenna ($\lambda/2$ wave trap antenna) was pulled out a bit from the case to be able to better delineate the temperature distribution in the area of the antenna nadir. The thermographic system was the system VARIOSCAN 3011 with a frequency range of 8...12 (m of the Jenaoptik L.O.S. company. The investigations took place in a temperature stable room.