RECENT TRENDS FOR MOBILE PHONE ANTENNAS WITH SPECIAL EMPHASIS TO INTERACTIONS WITH THE USER

ACHIM BAHR[(1)], MATTHIAS SCHNEIDER [(1)], DIRK MANTEUFFEL[(1)], DIRK HEBERLING [(1)]

[(1)] IMST GmbH
Carl-Friedrich-Gauss-Str. 2
47475 Kamp-Lintfort
Germany
Email: bahr@imst.de

ABSTRACT

The objective of this study was to compare the SAR (specific absorption rate) and EIRP (equivalent isotropically radiated power) for different classes of mobile phones currently on the market. The measurements were done with the dosimetric assessment system DASY and a radiation measurement setup for the characterisation of the mobile phone air interface (MOPAIR). The results demonstrate that the most promising antenna systems with respect to SAR are the flip type phone and mobiles with an integrated antenna. On the other hand integrated antennas introduce drawbacks when focussing at the EIRP.

INTRODUCTION

The global commercial success of GSM has driven a great variety of technical developments for mobile phones. Progress in battery size and integration level make it possible that today's mobiles are continuously becoming smaller. On the other hand the system complexity is increasing. Dual band capability GSM 900/GSM 1800 is a must for a modern phone.

The technical progress also influences the requirements for a successful mobile phone antenna development. First of all the antenna must have dual band properties. Additionally the size of the antenna has to decrease in the same order like the size of the mobile because of aesthetical aspects. This reduction in size is directly related to the efficiency of the antenna. On the other hand the coverage of most GSM networks at least in urban areas is no longer a problem so that some degradation in the link budget can be tolerated. A more severe problem with decreasing size of the mobile is the growing influence of the user on the antenna parameters like e.g. efficiency and resonance frequency. And last but not least the exposure minimisation of the user is another important design criterion.

METHODS

For the analysis of the antenna impedance, resonance frequency and bandwidth a conventional vector network analyser is well suited [1]. The influence of the user (human head and hand) on these parameters can be assessed under real world conditions by using a cable fed model of the mobile.

The assessment of the radiation characteristics in free space and including the user is preferably performed in an anechoic chamber. While 2d and 3d free space measurements of mobiles are quite straightforward measurements including the user influence are still a subject of research (COST259). At IMST a complete measurement setup was developed for the characterisation of the mobile phone air interface (MOPAIR) [2]. In Fig. 1 the measurement arrangement is depicted. The measurements are performed at a measurement distance of 3 m for different elevation angles and different channels at an azimuth angle varying form –180° to 180°. At the moment a laterally flattened sphere phantom is used which is filled with tissue simulating liquid. Two types of measurement can be performed. For EIRP-measurements the radiated power of the mobile is measured with a spectrum analyser. The RX characteristics of the mobile are determined by sensitivity measurements. The transmitted power of the base station antenna is reduced until the mobile reports that the RBERII value is exceeded.

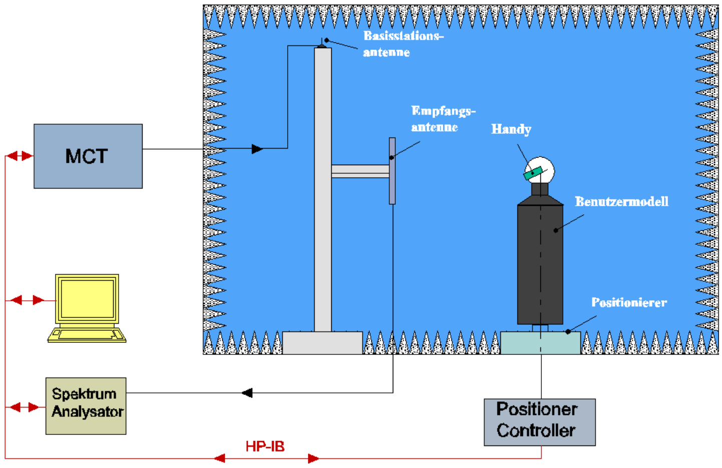

Fig. 1: Measurement setup for the characterisation of the mobile phone air interface (MOPAIR) including the user influence.

For the dosimetric assessment of mobile phones by means of the specific absorption rate (SAR) IMST has an accredited dosimetric assessment system (DASY) at it's disposal [3]. The system is based on a high-precision robot which positions an electrical field probe with a repeatability of better than ±0.02 mm inside a phantom filled with tissue simulating liquid. The E field sensor is loaded with a Schottky diode and directly connected to the data acquisition unit via high resistive lines. According to different international measurement specifications like e.g. [4] and standards concerning human safety in electromagnetic fields [5][6] different types of measurements are necessary for the qualification of the mobile.

RESULTS

For all existing mobiles the body of the mobile acts as the counterpart of an asymmetrically fed dipole. Therefore the combination of the body of the mobile and the antenna has to be interpreted as the antenna system. At least five different antenna systems can be found on the market which are depicted in Fig. 2. Extractable antennas with a top or bottom loaded helix have been used extensively for single band devices. For the current dual band mobiles this antenna solution has lost importance because four different operating conditions have to be matched at the antenna feeding point. The most common antenna type at the moment is the helix antenna. The version where the antenna is tilted away from the users head is used to prevent excessive SAR values. Two other antenna systems have found attendance in the meantime, mobiles with integrated antenna and flip type phones.

In the following SAR and EIRP measurements for different mobiles are shown. The results indicate certain trends but this does not imply any statement about the characteristics of a specific mobile.

In Fig. 3 the worst case SAR GSM 900 values averaged over a mass of 10 g according to ES 59005 [4] are summarised four fourteen typical mobiles arranged within the categories defined above. It can be seen that for extractable antennas lower SAR values are measured in the case where the antenna is extracted. The case "antenna retracted" can be compared with the SAR values of mobiles with fixed antenna. Looking at antenna systems with low SAR values it can be seen, that tilting a fixed antenna away from the users head offers some improvements compared to a normal fixed version. On the other hand the lowest SAR values can be found for flip type phones and mobiles with integrated antennas.

The interpretation of the results is as follows: The SAR is directly related to the square of the magnetic near field incident on the users head and therefore also related to the square of the current density on the antenna and the body of the mobile. For integrated antennas the antenna is mounted on the backside so that the maximum antenna currents are quite far away from the users head. The currents on the body of the mobile are mainly on the backside so that the magnetic field on the front is quite low. This causes low SAR values. The behaviour of flip type phones is similar. Because of the flip the main antenna currents and the main currents on the body of the handset are far away from the users head. This implies also low SAR values.

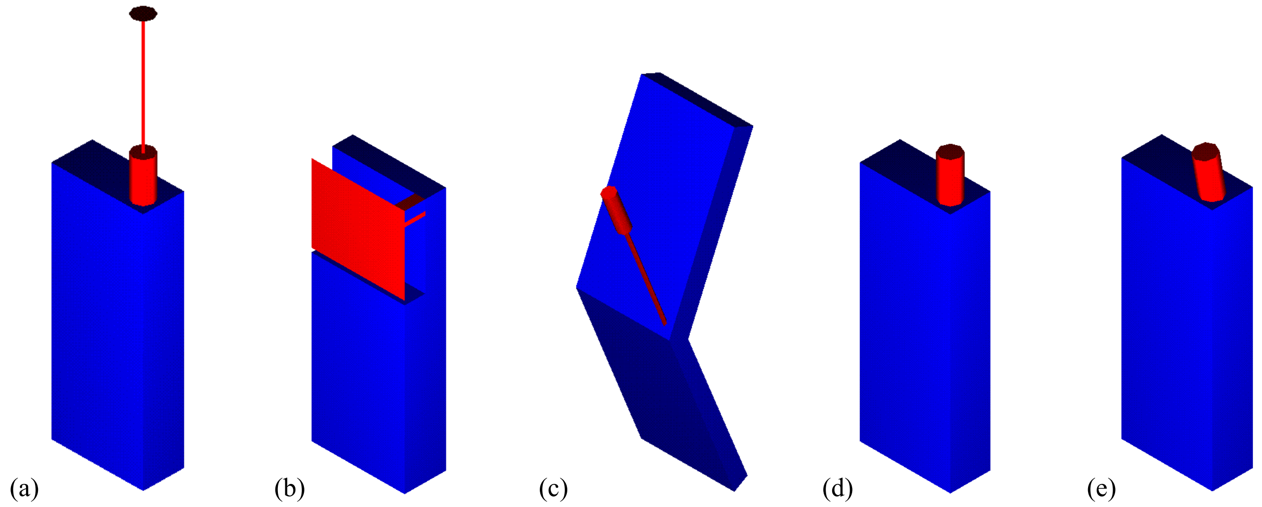

Fig. 2: Market overview of antenna solutions for mobile phones, (a) extractable, (b) integrated, (c) flip, (d) fixed, (e) fixed, tilted (back view of the devices) .

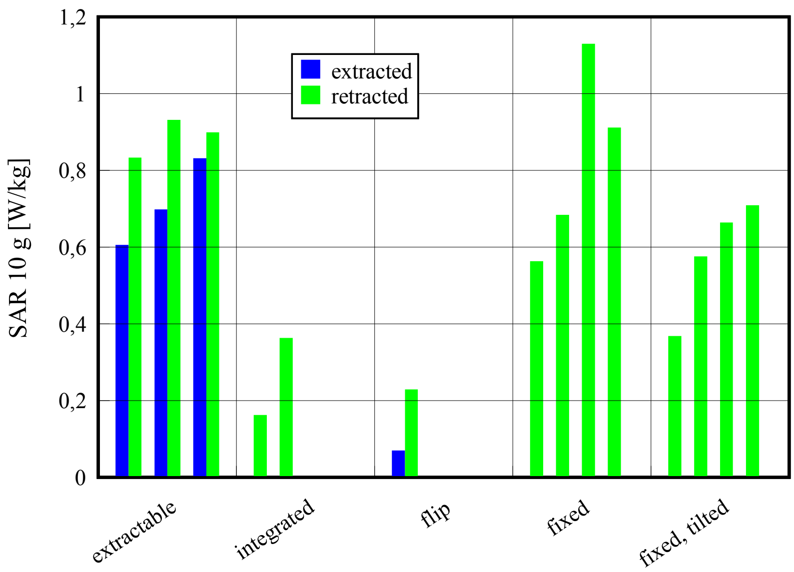

Fig. 3: Measured GSM 900 SAR values for different mobile phones as a function of the implemented antenna concept.

The analysis of the radiation characteristics shows particularly different results. The GSM 900 EIRP for seven different mobiles shown in Fig. 4 is averaged over three different elevation angles (0°, 30°, 60°) of the base station. The highest EIRP is found for a wire antenna where the antenna is extracted. Retracting the antenna leads to a degradation of the EIRP in the order of 1 dB. The EIRP of the investigated flip type phone is comparable with the results for the extractable antenna. Fixed and tilted fixed antennas introduce some further degradation of the EIRP. But the worst case EIRP is found for the integrated antenna.

With the exception of the integrated antenna the differences in the EIRP can be attributed to differences in the output power of the mobiles, to different geometries especially the thickness of the mobile, to losses in the human head and to losses in matching circuits and in the antenna itself. The situation for the integrated antenna is different. The SAR results indicate that only a small amount of the radiated power is absorbed in the human head. On the other hand the plastics covering the antenna introduce losses. Additionally most available integrated antenna solutions do not offer sufficient bandwidth to cover the whole GSM frequency band. Therefore TX/RX switching elements are used which introduce further losses. The small bandwidth might cause also relevant mismatch in the case when the antenna is used near the human head.

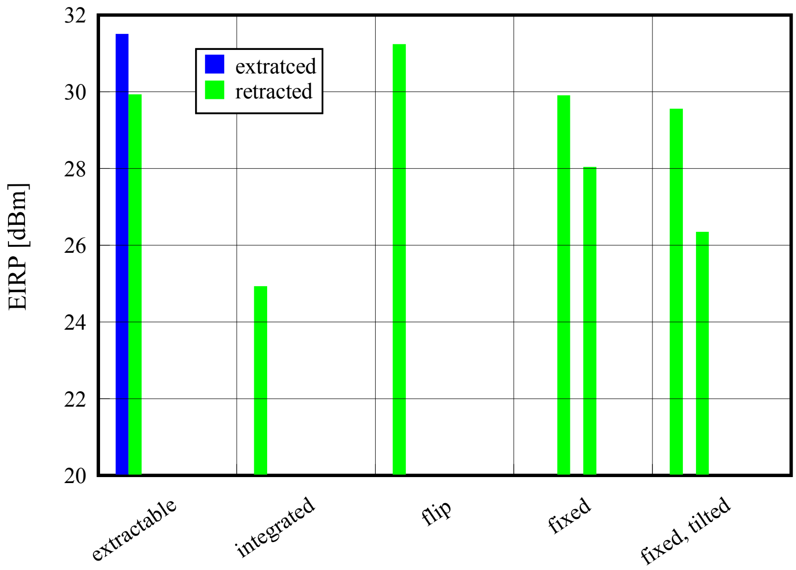

Fig. 4: Measured GSM 900 EIRP values for different mobile phones as a function of the implemented antenna concept.

CONCLUSIONS

The most promising antenna systems with respect to SAR are the flip type phone and mobiles with an integrated antenna. On the other hand integrated antennas introduce drawbacks when focussing at the EIRP.

REFERENCES

[1] K. Hirasawa; M. Haneishi: Analysis, Design, and Measurement of Small and Low-Profile Antennas, Artech House, 1992

[2] M. Schneider; M. Gehrt; D. Heberling; J. Wicke: Charakterisierung des Air-Interface von Handys für das GSM1800-Mobilfunknetz, ITG-Fachtagung “Antennen”, München, 1998

[3] T. Schmid; O. Egger; N. Kuster: Automated E-Field scanning system for dosimetric assessments, In: IEEE Trans. Microwave Theory Tech., MTT-44, pp. 105-113, 1996

[4] European Specification ES59005: Considerations for evaluation of human exposure to Electromagnetic Fields (EMFs) from Mobile Telecommunication Equipment (MTE) in the frequency range 30 MHz - 6 GHz, CENELEC, 1998

[5] European Prestandard ENV 50166-2: Human exposure to electromagnetic fields - High frequency (10 kHz to 300 GHz), CENELEC, 1995

[6] ANSI C95.1: IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Inst. of Electrical and Electronics Engineers, Inc., 1992