Comparison between head losses of 20 phones with external and built-in antennas measured in reverberation chamber

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Abstract

We have measured the total radiated power of 20 telephones in the free space position and in four talk positions close to a head phantom, and we have from these values calculated the head loss, i.e, the reduction in radiated power when the telephone is located in the talk position compared to in free space. The results show that telephones with built-in antennas are much less sensitive to how the telephone is held than telephones with external antennas. The built-in antennas show about 1 dB lower head loss than external antennas at 1800 MHz.

Index Terms
Inspec

Controlled Indexing

antenna testing dosimetry electromagnetic wave absorption loss measurement mobile handsets telecommunication equipment testing

Non-controlled Indexing

1800 MHz SAR built-in antennas external antennas free space position head losses head phantom loss measurement reverberation chamber specific absorption rate talk positions total radiated power

COMPARISON BETWEEN HEAD LOSSES OF 20 PHONES WITH EXTERNAL AND BUILT-IN ANTENNAS MEASURED IN REVERBERATION CHAMBER

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INTRODUCTION

A mobile phone must radiate in order to work. Thereby it is also unavoidable that part of the radiated power is absorbed in the human head. This absorption is characterized in terms of a Specific Absorption Rate (SAR), and there exist requirements to the maximum allowed value of the SAR. These values have been determined by considering the possibility of health hazards. It has therefore been an issue that the SAR value should be as low as possible, without actually mentioning the fact that a phone must radiate in order to work satisfactorily. TCO has therefore in their new quality and environmental labelling of mobile phones - the TCO'01 Certification of Mobile Phones [1]- introduced a complement to the SAR value. This is the maximum power the phone can utilize for communication, and it is called Telephone Communication Power (TCP). This is meant to ensure that phones radiate sufficient power to work properly. The TCP can be measured in many ways. E.g., it can be measured in a standard anechoic chamber. The antenna group at Chalmers has in cooperation with Bluetest AB developed a procedure by which the TCP can be measured in a reverberation chamber. This has many advantages over an anechoic chamber. The anechoic chamber needs to be several meters in cross section, whereas the reverberation chamber we use is 0.8m x 1.05m x 1.6m in size. The measurements takes also much shorter time. We will in the present paper show some results for head loss measured in this chamber. The complete set of results can be found in [6].

DEFINITION OF TCP, HEAD LOSS AND RADIATION EFFICIENCY

The TCP is the power leaving a closed surface, which surrounds the phone and the head phantom when these are located far from other objects and when the phone is set to radiate maximum power. The TCP is the figure of merit of a mobile phone, when it is transmitting. The higher the TCP, the better the phone will work in the transmit mode. A high quality phone must provide a good compromise between high TCP and low SAR. This is possible by directing the radiation from the phone away from the head. In order to compare different antennas on the phones we choose to define a head loss. This is the difference between the TCP in dBm when the phone is in talk position relative to the head phantom and the TCP in dBm when the antenna radiates in free space far from the head phantom. The difference between the two TCP values is the same as the difference between the radiation efficiencies (in dB) of the phone antennas for the two cases. The radiation efficiency as defined in [2] has three contributions: The reflections due to impedance mismatch of the phone antenna, the absorption in the phone and its antenna, and the absorption in the phantom. High radiation efficiency in talk position represents the best compromise between high TCP and low SAR, and this is obtainable by designing the antenna to radiate away from the phantom (head).

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MEASUREMENTS IN REVERBERATION CHAMBER

The present tests make use of a so-called reverberation chamber. The reverberation chamber is well known within the EMC area. It has recently also been used to characterize antennas. The reverberation chamber is also called a mode stirred chamber, as it contains several cavity modes, which are stirred mechanically to provide several statistically independent field distributions. These field distributions correspond to what in mobile communications result from multipath propagation. The mechanical stirrers can have many forms. The reverberation chamber at Chalmers makes use of two plate stirrers. One of these can be moved across the back wall of the chamber, and the other can be moved over a complete horizontal cross section in the upper part of the chamber, see Figure 1.

The antenna group at Chalmers has shown that reverberation chambers can be used to measure radiation efficiency of antennas. In order to improve accuracy we have developed platform stirring [3] and polarization stirring [4]. We have also shown that it can be used to measure the "free space" input reflection coefficient of small antennas in the vicinity of some object such as a head phantom. Experimental results produced in the chamber have been verified towards numerical results for a simple validation case. Furthermore, we have shown that reverberation chambers can be used to measure effective diversity gain very accurately, if the phone has more than one antenna and makes use of diversity. We have developed a procedure for measuring total radiated power, i.e. TCP. Measurements of both radiation efficiency and TCP in Bluetest's chamber are in [5] validated against measurements in another reverberation chamber and in two anechoic chambers.

RESULTS FOR HEAD LOSS

We will here give results for measured head losses of 20 phones. The complete results including the TCP values are given in [6]. The phones as well as the results are shown in Fig. 2. We have chosen to letter-code the phones as we want to study the effect of different antennas solutions and not the different phone models. The phone code contains even an antenna code that is an abbreviation for external (E), built-in (BI) and extractable (EL).

We have measured the TCP in dBm for all the talk positions of the phones defined in the new European Standard for SAR measurements developed by CENELEC; free space, cheek right, cheek left, tilt right and tilt left. From these values we have calculated the head loss for each talk position. We have chosen to plot the maximum and average value of these head losses, taken over the four talk positions of the phone. The results are sorted in such a way that phones with extractable antennas (EL) are to the left, with external antennas (E) in the middle, and with built-in antennas (BI) to the right. Within each antenna group, the phones are sorted according to decreasing average head loss in dB. Note again that the head loss value is due to both antenna mismatch and absorption in the head. The head loss represents a quality factor of the antenna on the phone. The lower head loss the better is the antenna. We see that the extractable antennas are very good at 900 MHz. There is not much difference between built-in and external antennas at 900 MHz, whereas the built-in antennas show typically 1 dB smaller head loss at 1800 MHz. The TCPs vary much more with phone position for phones with external antennas than for phones with built-in antennas. The built-in antenna seems to be less sensitive to how the phone is used. The head loss is between 2.5 and 9 dB at 900 MHz, whereas it is between 1 and 4 dB at 1800 MHz. We must here note that the present results do not take into account the effect of a users hand.

CONCLUSION

We have measured the total radiated power of 20 phones in free space position and in four talk positions close to a head phantom, and we have from these values calculated the head loss, i.e. the reduction in radiated power when the phone is located in talk position compared to in free space. The results show that phones with built-in antennas are much less sensitive to how the phone is held than phones with external antennas. The built-in antennas show about 1 dB lower head loss than external antennas at 1800 MHz.

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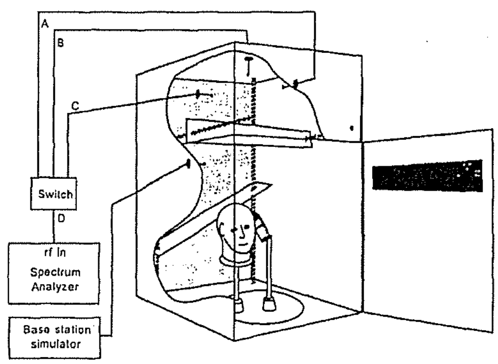

Figure 1. Drawing of the Bluetest (www.bluetest.se) reverberation chamber used in the tests.

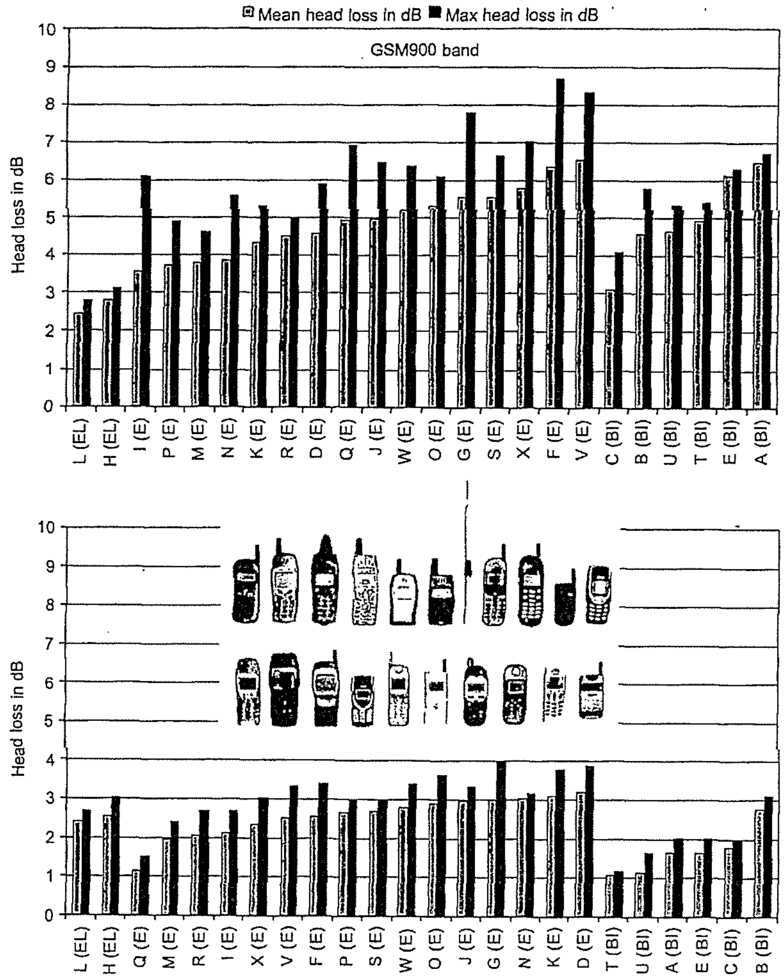

Figure 2. Maximum and average head loss at GSM 900 (upper) and 1800 (lower) bands. The 20 phones are shown in the inserted photo in a different order.