

Human exposure evaluation to mobile phone electromagnetic emissions

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Abstract — In this study was investigated the transmitted (Tx) power of mobile phones for different usage modes and in different conditions of environmental signal reception. Tx power was measured by an experimental system set-up for this investigation. The variation of mobile phone exposure for the operation with 2G or 3G network technologies and for different levels of environmental signals was analyzed.

I. INTRODUCTION

Output power of the mobile phones is an important factor for exposure assessment of electromagnetic fields emitted by these devices. So the characterization of time variation of output power is of interest to evaluate the differences in level of exposure to mobile phones and to estimate the people exposure during real use in operating networks [1,2,3]. Time variation of phone output power is due to power control technologies which regulate transmitted power depending on the received signal strength (Adaptive Power Control – APC). Previous works evaluated output power via software by network analysis tool [4,5]. In this study, measurements of transmitted power were made for three models of smart phone operating both in GSM and in UMTS networks. To verify the variability of transmitted power with network technology, the smart phones were forced to operate with only one technology. Further tests were carried out considering the two different usage modes: voice call and data transmission.

Output power was determined by on site measurements in seven areas with different reception quality and electric field exposure levels.

II. EXPERIMENTAL SET UP

The instrumental chain for radiofrequency power emitted from mobile phones is shown in figure 1.

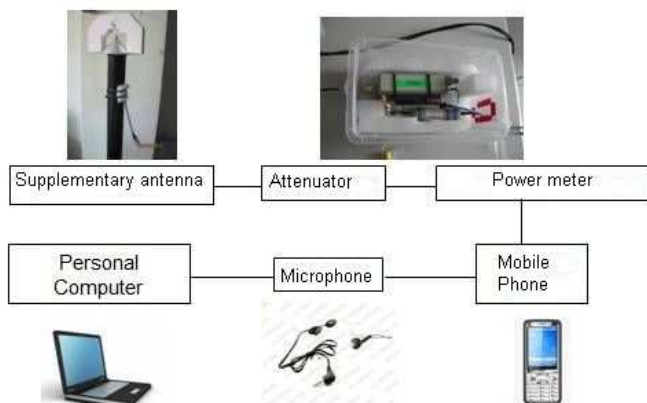


Fig. 1 Measurement system set up for output power of mobile phones

A supplementary antenna outside the mobile phone was used because the signal detection at the feeding connector of inner antenna was not possible. A variable attenuator was

added into the system before the signal entered the outside antenna and the attenuation value was fixed so that quality reception was comparable with that of inner antenna (about 20 dB). RF output power was measured by power sensor R&S mod. FSH-Z1 with a frequency range 10 MHz - 8GHz and a dynamic range 200 pW – 200 mW. Power sensor, connected to mobile phone by a directional coupler, was remotely controlled by a self made application based on LabView. Power measurements were acquired with a time step of 30 msec for determining average and maximum exposure during mobile phone usage. Usage mode of phone was standardized by reproducing a typical registered voice call and by downloading the same video during tests on data mode.

Environmental electric field levels were measured for relating exposure levels and quality reception with phone transmitted power. These measurements were carried out by spectrum analyzer Narda mod. SRM3000 connected to a triaxial antenna. By this instrumental chain, the Broadcast Control Channel (BCCH) signal level was measured in frequency domain, for GSM network, and Common Pilot Channel (CPICH) power was measured in code domain, for UMTS signal [6]. BCCH and CPICH level do not depend on the traffic load and they can be good indicators of reception level for GSM and UMTS signals in the investigated area.

Tests were made on three different models of smart phones.

III. RESULTS AND DISCUSSION

An example of mobile phone transmitted power measured for the three considered usage mode is shown in figure 2.

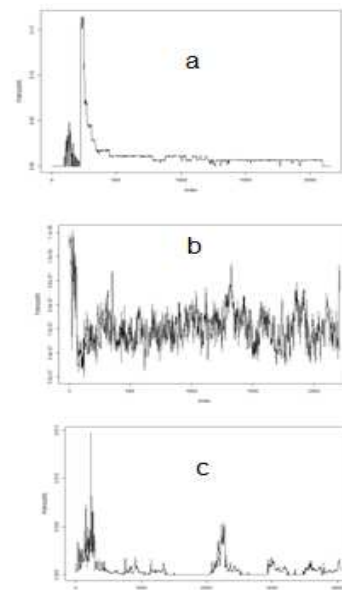


Fig. 2 Example of measured transmitted power of mobile phone for three usage mode: a) voice call with GSM network, b) voice call with UMTS network, c) data mode with UMTS network.

Figure 2a shows the peak level due to setting initial uplink transmission power when mobile phone is accessing to GSM network. Graph in figure 2b shows a typical noise like transmitted signal due to the codes used in UMTS technology which have a pseudo random bit sequence. In figure 2c the different peak levels are representative of the packet mode communication.

Average output power measurement results as a function of environmental electric field (BCCH and CPICH levels) are shown in figure 3 for one of the tested smart phones.

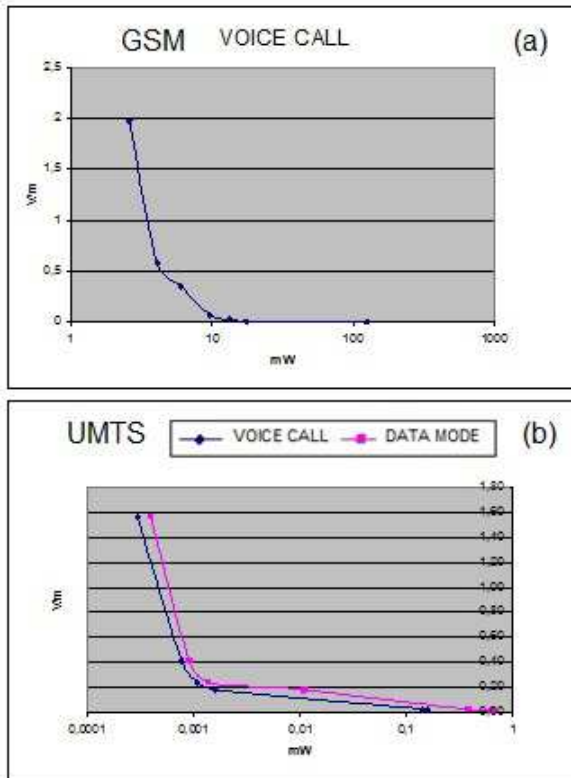


Fig. 3 Average output power versus environmental electric field for one of the tested mobile phones: a) GSM network; b) UMTS network for voice call and data transmission usage mode

Measured transmitted power changed as a function of electric field reception level. For GSM voice call the average transmitted power varies from 2 mW, in areas with electric field strength of about 2 V/m, to levels higher than 100 mW, in areas with electric field strength of about 0.001 V/m. So the reduction in electric field level of a factor of 2000 corresponds to an increasing of transmitted power of a factor of about 60. Similarly, we observed the transmitted power increasing with the reduction of reception level for UMTS voice call and data transmission mode. The average transmitted power for UMTS voice call varies from 0.4 μ W to some mW passing from areas with electric field of about 1 V/m to areas with lower levels (0.01 V/m).

The above reported results indicate also that mobile phone average output power for UMTS voice call is very lower than for GSM voice call in all investigated environments. The difference between average output powers is of a factor of 15 in environments with low reception level (100 mW for GSM and some mW for UMTS). This difference raises to a factor of 5000 in environments with high reception levels, where

average output power passing from 0.4 μ W for UMTS network to 2 mW for GSM network.

IV. CONCLUSIONS

In this study the real transmitted power for GSM and UMTS services was measured in different configurations. Variation of average output power of mobile phones was quantified with relation to environmental reception level.

Measurement results indicate that exposure level to GSM mobile phone in outdoor areas with higher environmental electric field strengths and a good reception quality is 60 times lower than in indoor situation with bad signal reception. This variability in exposure levels is much higher for UMTS voice call usage reaching a factor of about 2000. In the investigated areas, exposure levels due to UMTS voice calls resulted from 15 times to 5000 times lower than those due to GSM voice calls.

Further studies will be necessary to compare head exposure to mobile phones with whole body exposure to environmental radiofrequency fields from base stations.

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