Assessment of the Real Life Exposure to 2G and 3G Base Stations Over a Day from Instantaneous Measurement

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Abstract

In this paper, the general public daily exposure to mobile telephony is investigated. The considered signals are GSM900, GSM1800, UMTS and HSDPA. The study focus on the assessment of the maximal real electric field received over the day from an instantaneous measurement performed any time during the day. An extrapolation factor is presented to extrapolate an instantaneous measurement for any signal to the maximal possible value received by this signal over the day. This factor is also given to extrapolate the total electric field received to his possible maximum value over the day.

1. Introduction

The effect mobile phone radiation has on human health is the subject of recent interest and study due to the enormous increase in mobile phone usage throughout the world. Limits of electromagnetic field exposure are defined by the International Commission on Non ionizing Radiation Protection (ICNIRP) [1] and standards are available to check the compliance to these limits such as those given by the Institute of Electronics and Electrical Engineers (IEEE) [2], FCC [3] and CENELEC [4]. International standards used to check the compliance of radio communications equipments to the exposure limits are based on a worst case approach to guaranty a conservative assessment. This approach takes the worst case of a base station transmission that mean a full traffic situation is achieved in this case, it doesn't take also into consideration the fluctuation induced by the different services especially the temporal variation of the different signals. In [5-6] the real exposure facing the time variation of emissions has been investigated, it was shown that a full traffic situation is never reached in reality and that the FM signal remains constant over the day contrariwise to GSM and UMTS signals where the field variation are higher during daytime than at night because of the traffic demand.

HSDPA (High Speed Downlink Packet Access) provides an evolutionary path for Universal Mobile Telecommunications System (UMTS) networks allowing for higher data capacity. It is an evolution of the W-CDMA standard designed to increase the available data rate by a factor of 5 or more. Therefore, a new channel called the high speed downlink shared channel is used for downlink communication to the mobile. The temporal variation of the different carriers over one day for UMTS and HSDPA is representing in this paper.

The purpose of this paper is to characterize statically the maximum and daily exposures in real conditions induced by GSM900, GSM1800, UMTS and HSDPA networks. An extrapolation factor is presented to extrapolate an instantaneous measurement to the maximal possible value over the day. This factor is given to extrapolate the electric field received from a single system and also from all the systems together.

2. Assessment of the Maximal Electric Field

2.1 Measurements

Automatic measurements of all bands (GSM900 and GSM1800) and all operators (three operators in France) have been performed using special software developed in FT Orange Labs. Twenty measurements in nine different sites in urban areas have been performed every 10s (time sampling) for GSM900 and GSM1800 over a day.

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Two operating systems, UMTS (3GPP R99) and HSDPA are considered that are operating in the 2.2 GHz band. They are very similar in terms of signal characteristics and radio access interface. In HSDPA, a new channel is integrated for downlink communication to the mobile to increase the available date rate. The main difference between them is the power allocation. In fact, in HSDPA systems, all the power is affected to a single User Equipment (UE) at each time. We should use a W-CDMA decoder to perform measurements for these two systems to extract the total power and also the allocated power to each channel which is not possible with a spectrum analyzer. Eight measurements for UMTS and twelve measurements for HSDPA in five different sites in urban zones in France have been performed every 6s. Each of these measurements results in a total of 15000 measured samples per carrier per day.

2.2 Traffic Variation in 3G Technology

In practice, the extrapolation to a worst case induced by the International Standards is based on the measurement of the P_{CPICH} (pilot power) which corresponds to the signalization and on the value of N_{CPICH} (number of traffic) which corresponds to a maximum theoretical value deployed by operators. In [7-8] it has assumed for N_{CPICH} the value of 10 in UMTS Network, it is the maximum possible value (full traffic) that UMTS can have. There is no value yet assumed for HSDPA Network. So far, no one assumed the N_{CPICH} in HSDPA Network, because when the study for UMTS has done (2005), the HSDPA network was not yet deployed. Therefore, today the value of 10 has taken for both systems (UMTS and HSDPA). The real exposure which is quantify by the real equivalent N_{CPICH} active over one day for UMTS and HSDPA is compared to the maximum theoretical value.
Fig. 1 shows the temporal variation of the different carriers over one day for UMTS and HSDPA of one operator, it represents the N_{CPICH} which is defined as the ratio between the total powers received (called P_r) and the allocated power (called P_{CPICH}). We observe that the variation of HSDPA is very high compared to UMTS. In fact, in HSDPA systems, all the power is affected to a single User Equipment (UE) at each time. UMTS represents most of time the voice while HSDPA represents the data. This Fig. 1 shows that in the night there is communications only for HSDPA Networks contrary to UMTS where we can find a very low traffic, same behaviors as GSM and DCS Networks where the traffic is very low during the night. Therefore, in the night, people use data more than voice especially around 1am. The different measurements proof that the maximal N_{CPICH} (at 99%) in a realistic environment is about 5 for UMTS and 14 for HSDPA. These results show that a full traffic situation is never reached in UMTS systems contrary to HSDPA where a full traffic situation is possible especially during the rush hours and the realistic maximal value in HSDPA system exceeds the theoretical value. We mention here that the theoretical value for HSDPA has never been assumed so that we took the same theoretical value as UMTS. As for GSM900 and GSM1800 [9], the theoretical value (NTRX=8 in case of GSM) overestimates also the maximal real value (NTRX=4 in case of GSM) for UMTS systems. The results confirm that the temporal variation and the power received in HSDPA system are very high compared to UMTS. Moreover, the power received with the use of data is higher than the power received with the use of voice because in case of data, all the power is affected to the user at each time.
The results show that the equivalent TRX maximal in GSM system is equal to 2.70 [9] and the equivalent CPICH maximal is 4.80 for UMTS and 10.2 for HSDPA with a sliding time average of 6min applied on the measurements.

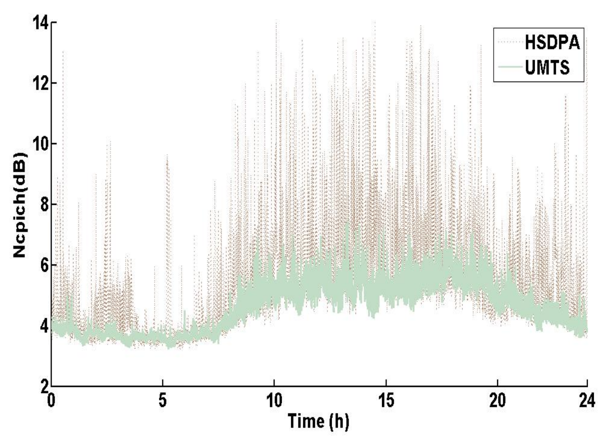

Figure 1. Temporal variation over 24h of the Pr/CPICHs for UMTS and HSDPA (dotted line)

2.3 Assessment of the Maximal from an Instantaneous Measurement

We can now extrapolate an instantaneous measurement to the maximal real value by performing a measurement only for BCCH/CPICH and use the values of equivalent TRX/CPICH for the different systems. However, in practice, the measurement is not performed only for BCCH/CPICH, but also for the entire GSM/UMTS band. Therefore, we are interested to extrapolate an instantaneous measurement E(t) for all the band performed during the day to the maximal value. Fig. 2 shows the cumulative distribution function (CDF) for GSM900, GSM1800, UMTS, HSDPA systems and the sum of these signals (total) in urban areas, it represents the CDF for an extrapolation factor which is defined as $E_{max}/E(t)$ with a sliding time average of 6min applied on the measurements.

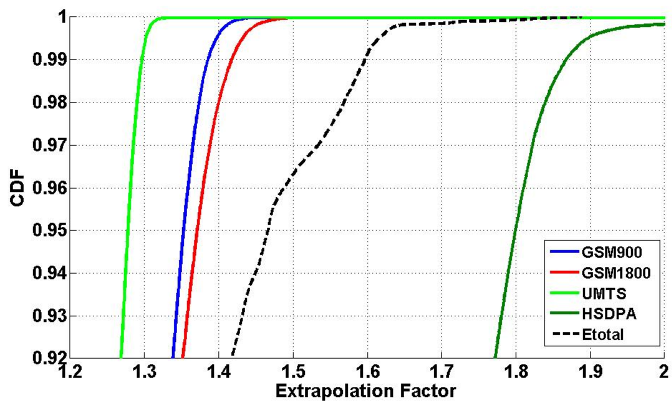

Figure 2. Extrapolation factor of the electric field E of the different signals and the Etotal (dotted line) with a sliding time average of 6min

We observe that the extrapolation factor 1.5 is conservative for a measurement of GSM900, GSM1800 or UMTS while the factor 1.9 is conservative for a measurement of HSDPA. Therefore, the factor 1.9 is conservative for all the systems. The extrapolation factor for the electric field total received is 1.7 for the entire band with all the signals. The extrapolation factor is given for different period of the day in Fig. 3 for the different systems. The extrapolation factor 1.2 is conservative for a measurement of GSM900, GSM1800 or UMTS performing any time during the working day (10am-10pm) while the factor 1.5 is conservative for a measurement of HSDPA.

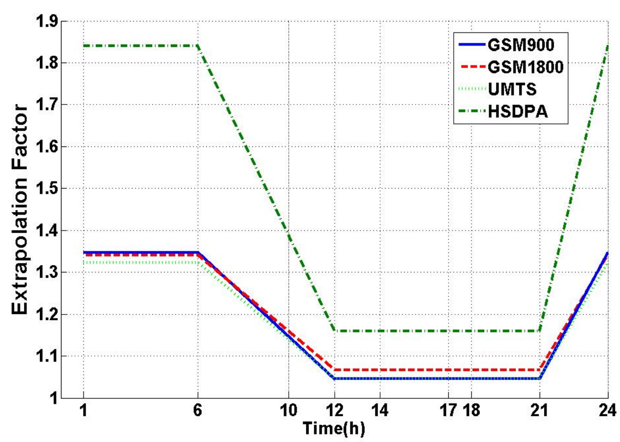

Figure 3. Extrapolation factor for GSM900, GSM1800, UMTS and HSDPA measurement performed any time during the day

3. Conclusion

Real life exposure to 3G base stations of the general public in environment during a period of one day is investigated in this paper. The field variation in UMTS and HSDPA systems are higher during daytime than at night due to the traffic demand. Moreover, the temporal variation of HSDPA is very high compared to UMTS and a full traffic situation can be achieved in HSDPA systems contrary to UMTS systems where a full traffic situation is never reached in reality.

The instantaneous measurement E(t) with a sliding time average of 6min for GSM900, GSM1800, UMTS and HSDPA should be multiplied by 1.9 and the total electric field received Etotal(t) with a sliding time average of 6min should be multiplied by 1.7 to be conservative.

This work is of interest for elaborating standards of exposure based on measurements in operating systems to assess the real exposure to cellular networks.

4. Acknowledgments

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