RADIATED MEASUREMENTS OF MOBILE PHONES USING REVERBERATION CHAMBER

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ABSTRACT

The reverberation chamber as a general measurement chamber for radiated measurements of mobile phones and other wireless devices is discussed. Current applications of the chamber at Flextronics Design include radiated transmit and receive measurements and pre-compliance measurements of radiated harmonics. Radiated measurements of mobile phones are performed during the design phase, as antenna design verification. An initial study at Flextronics of the feasibility of a radiated production sample test was presented in [1]. Extended final radiated tests on sample basis can be performed in production and recent developments are presented in [2-3].

EXPERIMENTAL SETUP

Figure 1: Reverberation chamber at Flextronics Design in Linköping, Sweden

The reverberation chamber has dual stirrers, driven by stepper motors. In statistical sense over all positions of the stirrers, the field distribution is homogeneous and isotropic. The chamber has a size of 2.00 x 1.45 x 0.85 meters and it is designed for frequencies above 800 MHz. The chamber was designed with 50 dB shielding to enable receiver measurements without outside interference. The phone under test is placed on a rotating dielectric platform stirrer [4]. The call is established by a basestation simulator by an antenna pointing at the phone. The power radiated from the phone creates an electromagnetic field, which is scattered in the chamber. Field diffusers are mounted above the rotating platform, to further enhance the random scattering of the field. A horn antenna is connected to a spectrum analyzer set in zero span and averaging mode at the selected frequency of test. The horn antenna is pointed away from the phone, to minimize the line of sight coupling to the phone. The average measured power from the phone under test can be used for relative comparisons between phones. In order to convert measured average power into absolute radiated power; a calibration of the path loss was made with a network analyzer. A reference dipole antenna was used for calibrations.

STATISTICS OF REPEATED RADIATED TRANSMIT MEASUREMENTS

A series of tests were conducted to determine the variation of the results when the measurement was repeated 12 times with the phone on the 25 cm diameter platform stirrer. The measurements were performed at *f*=897.6 MHz and *f*=1747.6 MHz. The experiments were also conducted when the platform stirrer was not rotating – to see what improvement the platform stirrer will have on the repeatability of results. The statistics from the 12 repeated test runs are listed in Table 1 below, in which $D_{cond,\,dB}$ denotes the measured span in dB for the data and $s_{dB,RC}$ *is* the standard deviation in dB. The values within brackets are computed according to Eqs. (1-3) as discussed below.

Table 1: Statistics without and with platform stirring

f (MHz)	897.6	897.6	1747.6	1747.6
	$D_{cond,dB}$	$s_{dB,RC}$	$D_{cond,dB}$	$s_{dB,RC}$
Without platform stirring	1.50	0.45	1.0	0.35
With platform stirring (1.5 s)	1.0 [1.4]	0.30 [0.35]	0.42 [1.0]	0.12 [0.26]

In order to compare the observed span in measurement data for the rotating platform with the theory from [5], the number of independent samples, N_{ind}, was determined by analyzing the autocorrelation. It was determined from the measurements with platform stirring, that N_{ind} = 150 for *f*=897.6 MHz and that N_{ind} = 280 for *f*=1747.6 MHz. To estimate with a certain confidence the interval, $D_{cond,\,dB}$, within which the measured data shall reside, the following expression is used:

$$D_{cond,dB} = 10\log\left(\frac{1+k/\sqrt{N_{ind}}}{1-k/\sqrt{N_{ind}}}\right) \tag{1}$$

It is also known from theory in [5] that the relative standard deviation relates to N_{ind} according to:

$$s = \frac{1}{\sqrt{N_{ind}}} \tag{2}$$

The relative standard deviation s can also be expressed in an approximate dB-value, by using:

$$s_{dB,RC} = \pm\frac{1}{2}\log 10\left(\frac{1+s}{1-s}\right) \tag{3}$$

The parameter *k* gives the confidence level (*k*=1 for 68 % and *k*=1.96 for 95 %). Using the previously determined values for N_{ind} in equation (1) with *k*=1.96 and equations (2-3), the theoretical values for $D_{cond,dB}$ and σ_{dB} are listed in Table 1 within brackets. The agreement is very good at 897,6 MHz.

RADIATED POWER OF A DUAL BAND PHONE WITH DIFFERENT ANTENNAS

A dual band phone with external antenna was tested for radiated power. The platform stirrer was rotating at a higher speed than the repeatability results of Table 1. The number of independent samples was determined to be 250 for *f*=897.6 MHz. An estimation of the chamber standard deviation is made using Eqs. (1-3), in order to distinguish the statistical variation of the measurement from the variation of the antenna samples. First the phone was tested with the original antenna (AntOrg) and then the original antenna was replaced with 10 other antennas. Finally, the original antenna was re-measured (AntOrgRM). Fig. 2 below shows the results at the 900 MHz band. The largest measured deviation between two antenna samples was 1.8 dB at 897.6 MHz**.** Note that the variations of radiated power shown in Fig. 3 have contributions from both the measurement method and the antennas under test. The observed variation of radiated power from different antenna samples, as shown in Fig. 2 , will be discussed in relation to N_{ind} – which is related to uncertainty of measurement. If we denote the standard deviation of observed values $s_{dB,obs}$, the standard deviation of the chamber statistics $s_{dB,RC}$ and the standard deviation of antenna efficiency $s_{dB,Ant}$ – we can relate them by the expression:

$$s_{dB,obs} = \sqrt{(s_{\mathrm{dB,RC}})^2 + (s_{dB,Ant})^2} \tag{4}$$

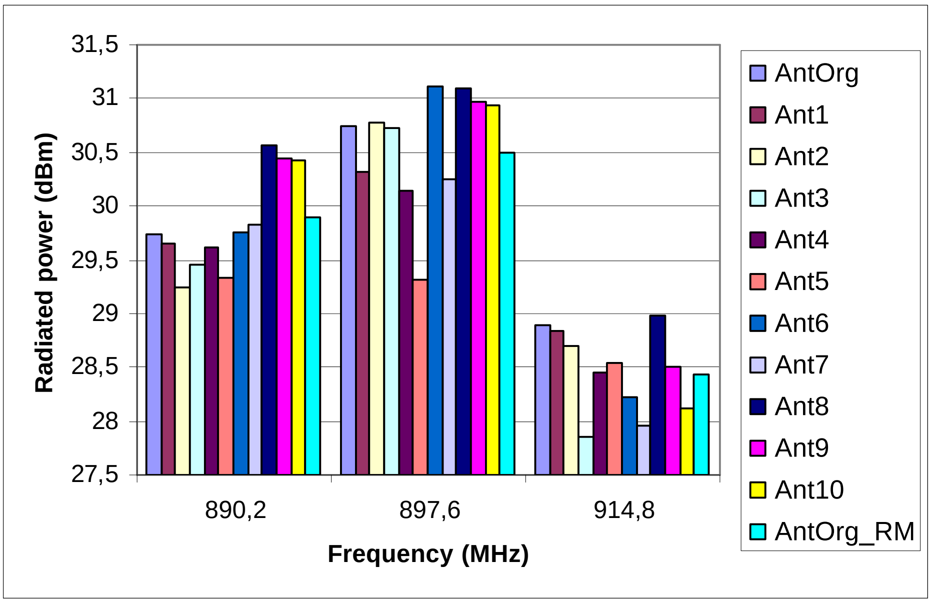

Figure 2: Radiated power of a GSM phone with 11 different antenna samples

The standard deviations of observations ($s_{dB,obs}$) was computed for the different antennas tested at the different frequencies in Fig. 2 and the number of independent samples N_{ind} (250) was used (assumed to be constant at low/mid/high channels) together with Eqs. (1-4), to estimate the standard deviation of the antennas under test ($s_{dB,Ant}$). The results are shown in Table 2.

Table 2: Standard deviation of antenna samples

f (MHz)	890.2	897.6	914.8
$s_{dB,RC}$ (dB)	0.28	0.28	0.28
$s_{dB,obs}$ (dB)	0.45	0.47	0.36
$s_{dB,Ant}$ (dB)	0.35	0.38	0.23

RADIATED RECEIVE MEASUREMENTS IN DYNAMIC PROPAGATION

A method for absolute measurements of the isotropic receiver sensitivity is presented in [6]. Relative measurement methods in dynamic propagation conditions have been investigated, with the purpose to develop a fast method of testing the receiver sensitivity through the mobile phone antenna in conditions which resembles a moving mobile phone user. This is a way to simulate the dropped call statistics measured in field trials in a real network. The radiated receive measurement setup is similar to the radiated transmit setup and the phone is set in call mode on a platform stirrer. The output power from the basestation simulator is lowered until the selected test criterion is reached. In the first kind of tests, the used criteria was that the reported bit error rate from the phone should exceed 12.8 %. The second test a criterion was to find the threshold output power from the basestation simulator for dropping the call. The call was required to survive for 10 seconds before lowering the output power from the simulator in 1 dB steps. Both test criteria have been found to give repeatable results. The call drop threshold power was measured for one phone at two different days and the differences in dB between the two measurements are typically less than +/-1 dB. The measured call drop thresholds for dynamic propagation for 3 phones at the 900/1800/1900 MHz bands are shown in Fig. 3 below. This is a relative measurement and the path loss in the chamber (lower at the 900 MHz band) is not compensated for. At some channels, the difference in call drop threshold is larger than 7 dB and since the difference between phones is larger than the repeatability of the method (+/-1 dB); the method enables relative comparisons between different phones at different channels.

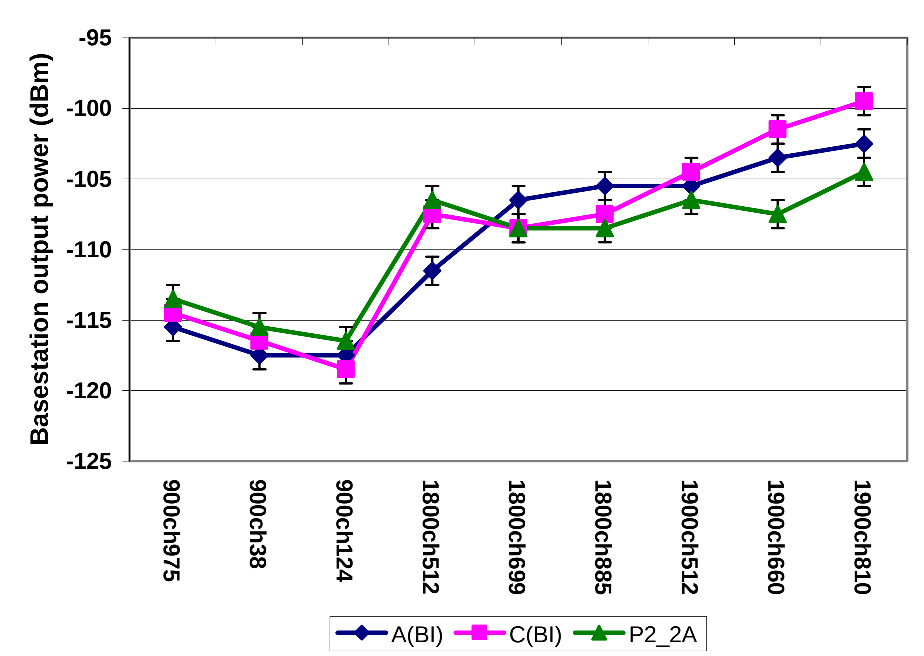

Figure 3: Call drop thresholds for 3 phones in dynamic propagation conditions for 10 seconds

DISCUSSION AND FUTURE WORK

Flextronics Design has shown that it is possible to use the reverberation chamber for absolute measurements of radiated power with an accuracy which is suitable for production sample testing. It is also shown how the chamber can be used for quick relative measurements of receiver sensitivity. Future work will include radiated transmit and receive measurements with the phone in talk position near an artificial head, as well as correlation studies between reverberation chamber and field trial results. Studies of correlation to field trials are planned in collaboration with Örebro University [7].

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