Improvement of Electromagnetic Field Homogeneity within EMC Immunity Testing Area

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Abstract: *To fulfill standardized requirements for electromagnetic field uniformity by radiated immunity testing floor absorbers are obviously placed between transmitting antenna and tested device. The paper analyses possibility to establish such field without the absorbers only by moving the antenna between two heights in dependence on frequency. It shows possibility of this solution with full satisfaction of uniformity requirements.*

Keywords: Electromagnetic Compatibility, Immunity Testing, Field Uniformity

1. Introduction

Within the frame of electromagnetic compatibility (EMC) two basic radiofrequency (RF) electromagnetic field tests are included. For radiated emission measurement semianechoic chamber with reflecting floor is prescribed. For radiated immunity testing anechoic resp. modified semianechoic chamber with RF floor absorbers is required, while absorbers must be placed between source antenna and equipment under test (EUT) [1]. If test laboratory has only one semianechoic chamber at its disposal, it is necessary to rearrange the configuration of floor absorbers for fully testing of each EUT. It is cumbersome and requires additional space for storage of large absorbers. So it would be beneficial to have possibility to perform immunity test within test configuration without floor absorbers. This problem was studied by several authors. Their publications deal with comparison of test results obtained in anechoic chamber and in chambers with different characteristics [2].

In the paper [3] the authors showed by only experimental measurements, that it is possible to keep the homogeneity within test area, which is named in standard as uniform field area (UFA) in required limits also without floor absorbers by changing the antenna height within the interval 1 – 2 m at 5 points. Their procedure needs computer control system, which performs relatively complicated calibration (5 times longer than standard) and it controls the antenna height depending upon frequency during the test procedure.

The presented paper analyses the possibility to ensure the UFA homogeneity by simpler way even by only two transmitting antenna heights. For this purpose we analysed the influence of transmitting antenna height upon UFA homogeneity at first by numerical simulation. Consequently we verified the obtained results by measurement in semianechoic chamber.

2. The uniform field area

Radiated immunity test standard [1] prescribes the calibration procedure for test space area. It defines the requirements for uniform field area (UFA) within which the EUT is placed. The electric field shall be calibrated over a volume or surface in front of the radiating antenna. The norm EN 61000-4-3 specifies a UFA, which is a hypothetical vertical plane of the field in which variations are acceptably small: at each frequency a field is considered uniform if its magnitude measured at 16 (4 x 4 uniformly spaced with 0,5 m distance) grid points is within -0/ +6 dB of the nominal value for not less than 75% of all grid points (e.g. if at least 12 of the 16 points of an 1.5m×1.5m UFA measured are within the tolerance) [4].

Moreover in the frequency range up to 1 GHz a tolerance greater than +6 dB up to +10 dB but not less than -0 dB is allowed for a maximum of 3 % of the test frequencies. In the calibration procedure specified in standard [1] it is stated that one has to measure the electric field at each one of the 16 grid points of the UFA at the selected frequencies. The forward power from the amplifier to the antenna shall be adjusted so that the field strength obtained is equal to the required calibration field strength E_u (electric field calibrated in the anechoic chamber). According to this procedure it is clear that the allowed tolerance of + 6 dB extendible to + 10 dB for 75% of all grid points permits a great variability of the electric field strength uniformity [4].

3. Problem description

Mechanism of EM field creation within semianechoic EMC chamber may be illustrated by figure 1. In all points within the UFA the field intensity is the result of the sum of two propagating waves – direct wave and the wave reflected from the floor.

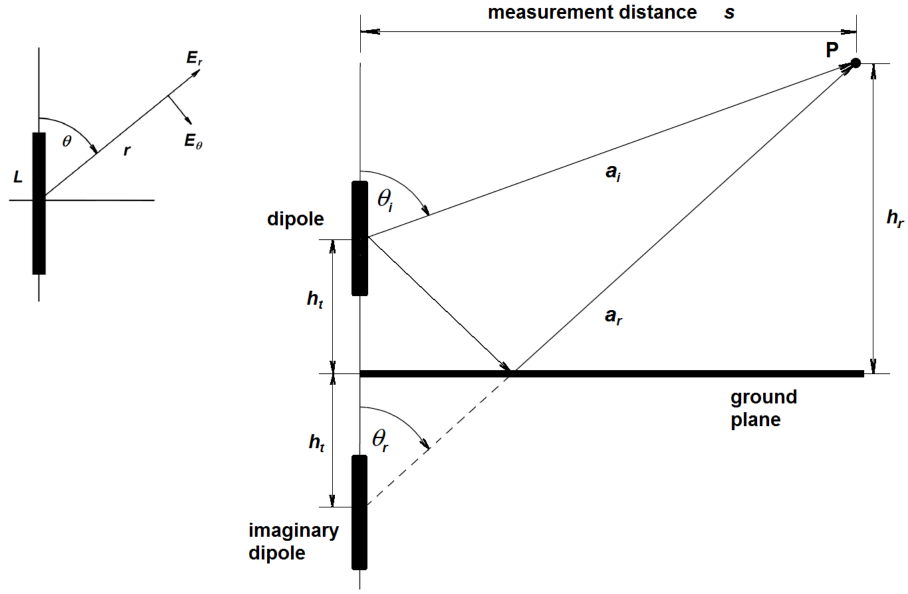

Fig. 1. Wave paths with ground plane reflection

The intensity of electric component of electromagnetic field at the observation point may be expressed as the sum of direct wave intensity and reflected wave intensity multiplied by the reflection coefficient ρ:

$$E = E_d + \rho E_r \tag{1}$$

There are several factors influencing the resulting intensity. Generally the intensity of the wave is indirectly proportional to the length of propagation path of the wave i.e. distance between field source and observation point. So the reflected wave has significantly lower intensity than direct one. Then the reflection coefficient is negative for horizontal wave propagation and positive for vertical one. And the phase shift between waves significantly affects the resulting intensity. Two factors, propagation length and phase shift, are dependent upon antenna height. Due to the described interference of both waves the field intensity is significantly dependent upon frequency and as the propagation distance differs between UFA points, the field homogeneity is expressively changing up to more than 20dB at some frequencies.

4. Creation of simulation model

It is advantageous to use numerical simulation tools to study the influence of transmitting antenna position upon EM field homogeneity in UFA. They allow simpler analysis mainly in cases of complicated configurations. We used software system FEKO based on method of moments. The walls of chamber covered by RF absorbers where modeled by open area space border as well as the chamber ceiling, the conducting floor by perfectly conducting space border.

5. Evaluating procedure

The principle of evaluating procedure was based upon the fact that although the UFA homogeneity is rapidly changing it is possible that minimum homogeneity for all antenna heights is lower than limit value of 6 dB. So we performed homogeneity analyses by numerical simulation in frequency bands 80 - 1000 MHz and 1000 - 3000 MHz with 2 MHz frequency step. The antenna height was changing in the range 1 – 2,1 m with 10 cm step. For each antenna position and each frequency point we stored the EM field intensity values in all 16 points prescribed by the standard. Then the dependence of UFA homogeneity upon frequency was calculated for each antenna height.

On obtained data file the searching procedure could start. It takes all combinations of two antenna heights and searches the minimal homogeneity at all frequencies. Then it counts the frequency points for which the homogeneity is more then 6 and less than 10 dB. If the homogeneity is more than 10 dB, the combination is consider unacceptable.

On the basis of the result obtained by described procedure we performed verification of simulation results by measurements at chosen antenna heights within semianechoic chamber of our EMC laboratory. The measurements were executed by automatic software system fully complying standard requirements for UFA calibration and immunity test performance. The obtained results were then processed by the same procedure as the simulation results.

The results of the whole process are shown in following figures. In figure 2 the simulated and measured values of homogeneity are shown for frequency range 80-1000 MHz and horizontal antenna polarisation. It is evident from presented figures, that required homogeneity is reachable by combination of two antenna heights – 130 and 200 cm. This combination allows to reach the best UFA homogeneity, when the 6 dB limit value was excessed less than 0.7 dB only in 1,73 % of total number of frequency points. By verification measurement the 6 dB value was crossed by maximum 0.7 dB in 1,96 % of number of frequency points.

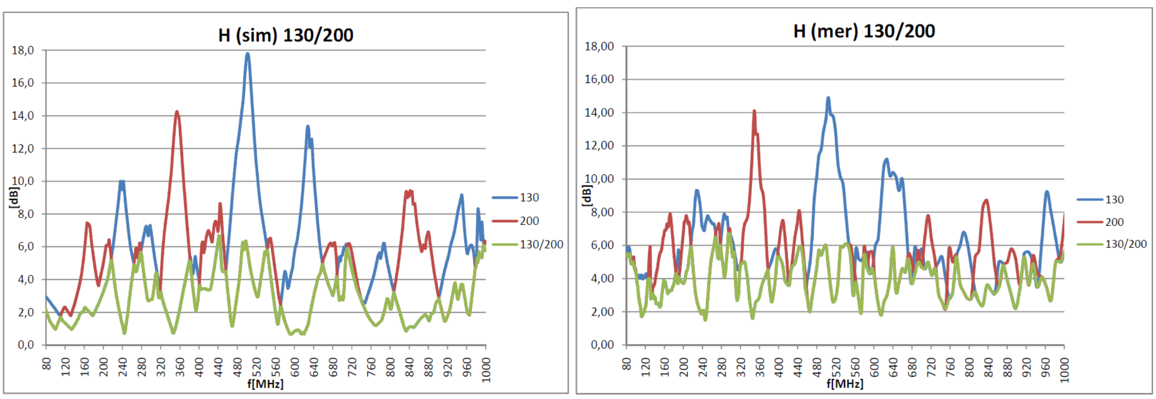

Fig.2. Simulated and measured results for frequency band 80 - 1000 MHz and horizontal antenna polarisation

Similar analysis was performed also for vertical antenna polarisation. In this case the situation is much better as the floor reflection coefficient is positive. Our simulations showed that all heights above 140 cm comply with requirements of standard. By the measurements all heights above 180 cm were conforming. Both simulated and measured results for 190 cm antenna heights are presented in figure 3.

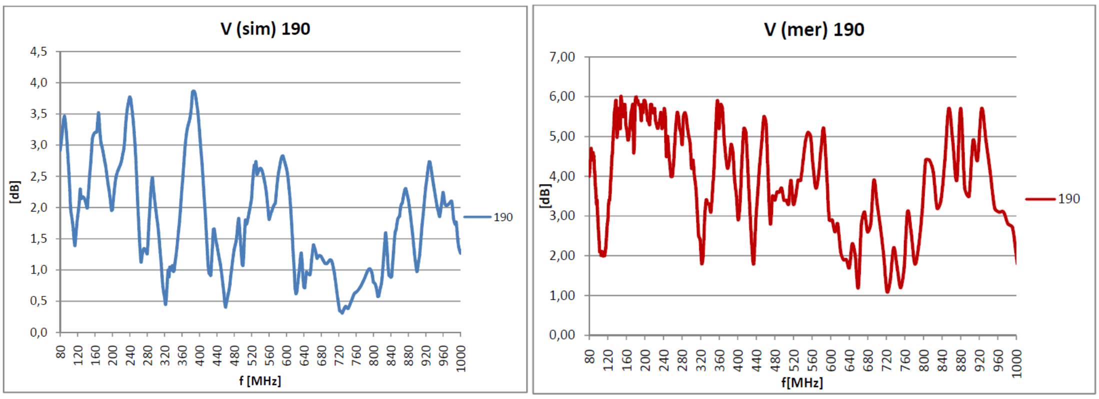

Fig.3. Simulated and measured results for frequency band 80 - 1000 MHz and vertical antenna polarisation.

The analysis in 1-3 GHz range was performed by simulation. For horizontal polarisation the homogeneity was conforming by combination of 190 and 200 cm antenna heights, when the limit values 6 dB was exceeded by maximum 1,2 dB only for 1,24 % of frequency points. For vertical polarisation all heights above 110 cm are complying.

6. Conclusions

The paper showed that it is possible to fulfill the requirements of EM field immunity test standard [1] without floor absorbers placed between transmitting antenna and EUT by using only two antenna heights. This allows to make EMC testing arrangement less time consuming so more effective. After including the algorithm for controlling the designed procedure into the whole software system the realisation of our technique does not need any additional test operator activity.

Acknowledgements

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