Testing of EMC Properties of Electrical Devices Equipped with Wireless Communication

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Abstract. *The paper is focused on finding the optimal measurement setup for measuring radiated emissions of devices using wireless transmission paths. The priority is to ensure the full functionality of equipment under test while functionality of measuring system is not affected. A model of the measurement site for analysis of these conflictions was created in numerical simulator and the simulation results were verified by measurements.*

Keywords: EMC, Radiated Emission, Antenna, GSM

1. Introduction

Nowadays, except of common cable transmission paths (LAN, USB, RS485) modern electrical devices have increasingly used wireless transmission paths, as: Wireless LAN (Wi-Fi, WiMAX), PAN (Bluetooth), WAN (2G/3G mobile networks), satellite navigation (GPS) and many others [1]. Electromagnetic compatibility (EMC) properties of equipment under test (EUT) need to be verified in its typical operation condition [2]. Then modification of the measurement procedure is required and an anechoic shielded chamber, as site for radiated emission measurement, hast to be equipped with a new apparatus that enable wireless data transfer from/to the EUT.

This paper focuses on finding the optimal radiated electromagnetic (EM) emissions measurement arrangement which keeps full functionality of the EUT so the measuring system operates without a failure. We created a model to analyze effect of auxiliary devices (used for the wireless transmission) on the measurement process. The model was created in numerical simulator FEKO. Simulated results were verified by measurements.

2. Measurement setup

Shielded chamber prevents the wireless communication in principle. Also due to filtering requirements in wide frequency range the chamber complicates a wire data transfer between devices located inside and outside (because signal filters has to be a part of a measurement chain). The standard measurement methodology requires that the EUT was placed on a measuring table or on the floor of the shielded chamber. Measuring antenna is located in a distance of 3 or 10 m from the EUT [3]. The antenna and the EUT are located in the two foci of imaginary ellipse, creating an obstruction-free area, which defines a minimum area free from scatterers of electromagnetic field (Fig.1). Wireless communication of the EUT requires creating a connection which provides bidirectional data transmission between the EUT and auxiliary equipment situated outside the shielded chamber. In our case we tried to find a solution of a connection between the EUT and mobile phone/data networks. Technical realisation for other wireless networks is similar.

WAN (World Area Network) connection to the EUT needs a communication system (outside shielded chamber) consisting of GSM antenna and repeater that receives and amplifies properly signal of nearby base stations. This signal is applied through coaxial cables and feedthrough filter to the GSM antenna inside the chamber. Location of the GSM antenna inside the chamber and GSM signal level have to choose to enable EUT a reliable communication, while the measuring antenna should receive GSM signal of sufficiently low level (ideally less than relevant limit level, but definitely cannot exceed maximal input power of a measuring preamplifier). High level of signal can cause a disruption of proper function of the measuring preamplifier and then a degradation of the measurement.

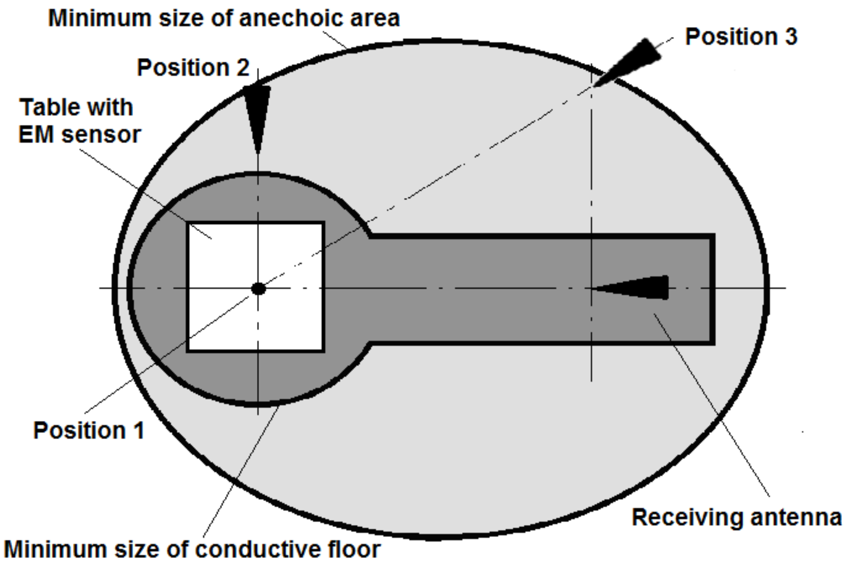

Fig. 1. Setup modifications for radiated emissions measuring

Several GSM antenna locations may be chosen in a shielded chamber (8.5×4.5×4.5 m): These locations have to fulfill following requirements: minimal interference with the obstruction-free area, antenna main lobe cannot direct to the receiving antenna and also a convenient connection of GSM signal to the antenna.

Our experiments were performed with only vertically polarized GSM antenna which was situated in the following three positions (Fig.1): advantage (+) / disadvantage (–)
1 – A rod antenna 10 cm long (located in a cylindrical hollow in a reference ground plane under the measuring table together with power plugs and signal connectors. The antenna is practically connected to one of the RF connector, other side of this connection is outside the chamber (+). Although the antenna is non-directive (–), its location, partially embedded in the floor, helps to reduce effect of the antenna presence on measuring antenna (+).
2 – Directional antennas (YAGI GSM-900, Log-periodic (LP) 300-1000 MHz or HORN 1-18GHz) are perpendicular to the main axis of the chamber, in height of the measuring table, tip of the antenna is situated 1 m from the table. This represents a suitable location because of the antennas directivity (+), the antennas are partly situated in the obstruction-free area (–, however in the larger chamber it is not a problem).
3 – The antennas (YAGI, LP and HORN) are oriented obliquely toward the main axis of the chamber (directed to the table centre) and distance between tips of GSM antenna and the receiving antennas about 150 cm. Such a position is less convenient due to patterns of the antennas (–), however the antennas are outside the obstruction-free area (+).

3. Modeling and measurement

The aim of modeling is to determine level of the GSM signal caused by various position and types of the GSM antennas in the position of receiving antenna if level of the GSM signal in the table centre is 1 V/m. This value were chosen in order to verify the experiment by measuring with omni-directional sensor of EM fields placed on the table, because the value of 1 V/m is a minimal value reliably measured by the sensor. We focused on frequencies of 900, 1800, 1900 and 2100 MHz, which corresponds with GSM 900, GSM 1800, UMTS up-link and down-link frequencies. EM numerical simulator FEKO was chosen to search optimal GSM antenna position. Used model includes a reference ground plane with same dimensions as the chamber has and with the hollow in the table position. Hybrid absorbers of the chamber were replaced by the open space and a wooden table, which has not significant effect on the propagation of EM waves was omitted to simplify the model [4]. For calculation purposes, several numerical methods were necessary to use because the model is very large in terms of the GSM signal wavelength. Properties (near field, radiation pattern, etc.) of the antennas were calculated using method of moments, while propagation of EM waves over the conducting plane was calculated by means of physical optics [5]. Typical distribution EM field generated by the rod antenna at frequency of the GSM-900 is shown in Fig. 2. To speed up a calculation in case of the HORN antenna EM field source the factory radiation pattern was used and then it was verified by measurements.

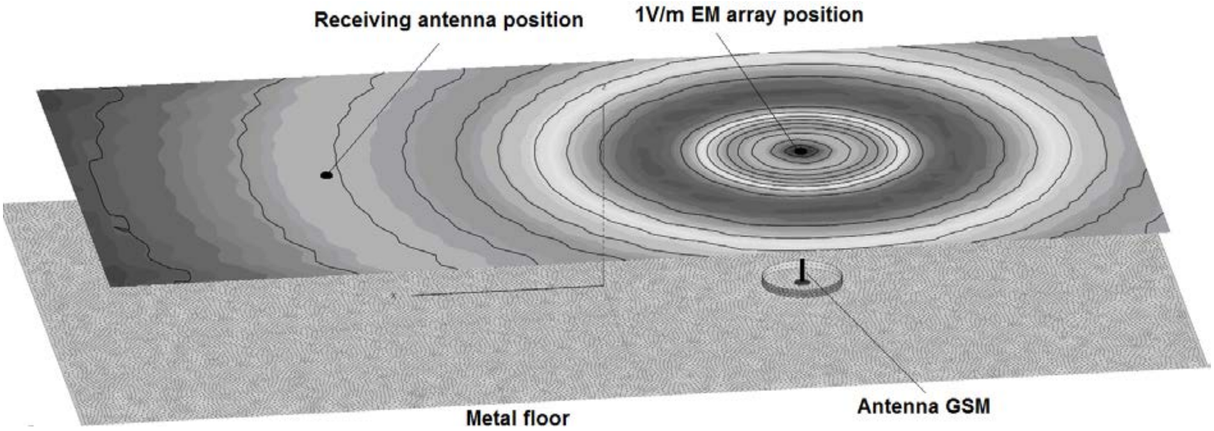

Fig. 2. EM field distribution when rod antenna is used for the GSM-900.

As the lowest signal peak value necessary for reliable function of most devices with GSM or UMTS interface, value of 60 dBμV/m was experimentally determined. Then all simulated as well as measured signal levels at the receiving antenna were recalculated so that these values correspond to real GSM or UMTS operation in the shielded chamber.

4. Results and discussion

All the measured E_{meas} and simulated E_{sim} levels of EM fields at the position of the measuring antenna are summarized in the following table. The values of EM field in a position of the receiving antenna may slightly exceed the limit values prescribed by general EMC standards, however, there is no risk of preamplifier saturation or the measurement distortion at these levels.

Comparison of the EM field values in a position of the receiving antenna shows that position 2 and using HORN or YAGI antenna best suit for GSM field excitation. We observed the GSM levels exceeding the limit values significantly in position 3, so this position is unacceptable. The rod antenna (at position 1) radiation slightly exceeds the limit receiving antenna, but configuration 1 is a very practical solution. However it is necessary to be careful with output level of the GSM repeater, mainly not to exceed the input power of the antenna's preamplifier.

ROD	**position 1**			
f [MHz]	900	1800	1900	2100
E_{sim} [dBμV/m]	59	58	62	55
E_{meas}[dBμV/m]	60	43	63	50

YAGI	**position 2**	**position 3**	**LP**	**position 2**	**position 3**
f [MHz]	900	900	F [MHz]	900	900
E_{sim} [dBμV/m]	26	45	E_{sim} [dBμV/m]	26	45
E_{meas} [dBμV/m]	29	41	E_{meas} [dBμV/m]	29	41

HORN	**position 2**				**position 3**			
f [MHz]	900	1800	1900	2100	900	1800	1900	2100
E_{meas} [dBμV/m]	41	41	41	41	55	53	56	58

5. Conclusions

Optimal measurement setup was searched for coexistence of wireless data transmission system and measurement system for radiated emission. Simulated and measured results of the EM field levels are in quite good agreement. The differences may be caused by imperfection of the model, which is always a compromise solution (of model perfection and computing power demand). Presented model may be even in this simplified form used for mapping the distribution of EM fields generated by GSM antennas in shielded enclosures. This fact enables (for various configurations of the EUT and selected GSM antennas) to determine EM field at the receiving antenna and to gain important information for the chamber arrangement. In addition, obtained information can be used to adjust the optimum GSM signal level in the GSM signal path.

Acknowledgements

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