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Subjects of discussion in radiated emission measurements above 1 GHz

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Abstract. Some emission and susceptibility EMC standards already require measurements above 1 GHz or test site validations (IEC 2006, CISPR 2006). A simple assignment of the established measurement methods below 1 GHz to the frequency range above 1 GHz bears some risks. The ratio between the physical size of the equipment under test (EUT) and the wave-length rises with frequency. This increases the electrical size of the EUT. The directivity may become larger and the radiation pattern of the EUT is getting more complex which reduces the probability to detect the maximum emission with a simple planar cut scan. To analyse these effects in more detail this paper shows radiation characteristics of an exemplary EUT. The influence of a receiving antenna height scan and the angle increment of the turntable scan on the detection of the maximum of the electrical field strength will be discussed. As a result some ideas will be given to reduce the measurement time but keeping the reliability of the measurement results constant.

1 Introduction

The use of the frequency range above 1 GHz changes the requirements upon the measurement equipment and measurement procedure. The standard limit is given for the maximum of the electrical field strength in a specified distance (1 m, 3 m) of the EUT. This is the defined measurand therefore the measurement procedure has to detect the maximum. As a result the spherical surface around the EUT has to be sampled with a sufficiently fine resolution. This is a very time-consuming procedure that is not practicable for an EMC test centre because it increases the price of the compliance test. Instead of this the cost-benefit analysis wants a high probability to detect the maximum emission with a short measurement time.

With a coarser sampling of the EUT for a measurement time reduction the probability drops to detect the maximum of the electrical field strength. To get insight into this problem the measured radiation pattern of a real EUT will be presented. These measurements confirm the results from numerical calculations done by Battermann and Garbe (2005). Furthermore the influence of an increased angle increment and the receive antenna height scan on the detection of the maximum emission will be shown that also verifies the results of Wilson (2004).

Fig. 1. 10 m semi-anechoic chamber at the Federal network agency in Kolberg with floor-absorbers to obtain fully-anechoic-room characteristics. The EUT is placed on the table.

2 Measurement setup

The measurements have been performed in a 10 m semi-anechoic chamber with foil absorbers as illustrated in Fig. 1. The measurement setup is located at the centre of the turntable. The EUT has already been used for a round robin test and it contains a comb generator with different radiating structures (slots and helix antennas) and with frequency components up to 18 GHz. In fact it is not a realistic unintentional emitter anymore because it includes efficient radiating structures but it is a fugitive emission due to a dielectric cover of the chassis. Comparisons with realistic devices proved

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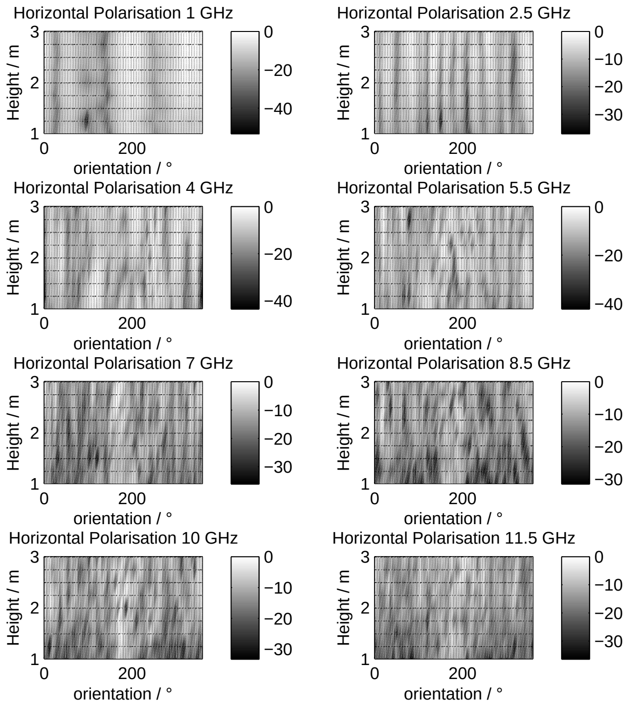

Fig. 2. Field distribution on a cylinder around the EUT in a distance of 3 m for different frequencies.

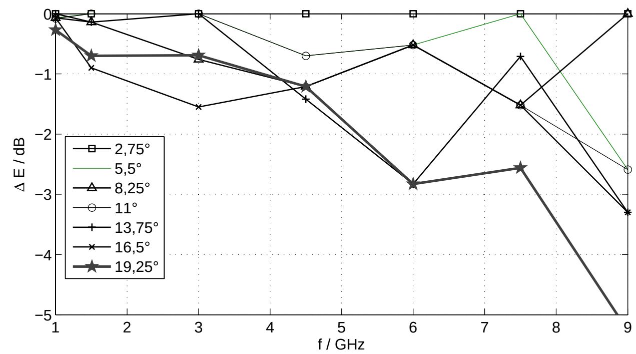

Fig. 3. Deviation against the detection of the maximum electrical field strength with a reduced angle increment.

that the emission is typical for a device with emissions above 1 GHz.

Floor absorbers (VHP 8 NRL) are used to provide fully anechoic room characteristics (FAR). The setup fulfils the Site-VSWR criterion of 6 dB (IEC, 2006). The receive antenna is a V-type logarithmic periodic antenna R & S HL050 that is used in combination with a high power pre-amplifier. The ESIB 40 EMI Receiver (with integrated pre-amplifier) is connected with 5 m Suhner Sucoflex 104. The measurement system is controlled with the ESK1 Software but the complete data analysis is performed offline. The depicted electrical field strength (Fig. 2) is calculated with respect to the antenna factors, distance correction and system attenuation and normalized to the maximum.

3 Measurement of the field distribution around the EUT

The cylindrical surface around the EUT with a radius of 3 m and a height of 2 m (starting at 1 m above the ground level) has been scanned. The resulting field distribution that is normalized to the maximal electrical field strength is depicted in Fig. 2. The height of the cylinder is mapped on the ordinate and the angle of the turntable scan is on the abscissa. Up to about 5 GHz it is possible to separate minima and maxima but this is impossible for higher frequencies. The reason for this is the integration over the radiation pattern of the antenna. As a result it is not reasonable to perform a very detailed scan of the EUT because the spatial resolution is already limited by the antenna.

Furthermore the question arises: “Which physical quantity is the reason for the disturbance?” It could be the electrical or magnetic field strength or even power density. From this point of view it is necessary to clarify the appropriate measurand. It is still not safeguarded that the disturbance model below 1 GHz is also valid above 1 GHz. The power-density may be a more reasonable measurand than the electrical field strength (Garbe, Battermann, 2007).

Besides this it is visible that the maximum of the emission is not always at the circumference of the planar cut at a height of 1 m. Therefore a height scan would be necessary or at least a reduction of the used limit. This effect is also shown by Wilson et al. (2002).

4 Influence of the angle increment of the turntable

With a coarser angle increment of the 360° turntable scan the probability is getting lower to detect the maximum. This is depicted in Fig. 3. It shows the deviation against the finest resolution of 2,75°. At lower frequencies the deviation is quite small. This agrees very well with theory because the electrical size of the EUT is small and therefore it has a neglectable directivity. The electrical size ka of the EUT is defined by the wave number k and the radius a of the minimum sphere that fully encloses the test object. With increasing frequency the deviation is getting larger and at 8 GHz with an increment of 19,25° the 360° turntable scan will deliver a maximum of the electrical field strength that is about 3,5 dB below the maximum obtained with the finest angle increment. In general the deviation is getting larger with increasing frequency.

The result shows a good possibility to reduce measurement time. If the standard limit of the emission test would be reduced by 3.5 dB for a measurement at 8 GHz it would be possible to reduce the measurement time by a factor of approximately 7 (in one polarisation). With a larger reduction of the limit the number of samples could also be decreased. The theory is also given by Wilson (2004) for a non intentional transmitter.

5 Conclusions

The higher directivity of the EUT with increasing frequency requires a more detailed sampling around the EUT. Instead of this time consuming approach it is also possible to take into account a reduced standard limit as already pointed out by Wilson (2004) if the measurement should be based on a smaller number of samples. A very detailed scan in only one plane is not reasonable because the spatial resolution is already limited by the antenna as shown in Fig. 2. It makes more sense to distribute the samples around the surface of the EUT. The necessary number of samples depends on the size of the EUT und the frequency under consideration.

Furthermore it should be taken into account that it is necessary to analyze the disturbance model above 1 GHz to check if the electrical field strength is the real disturbance quantity for this frequency range (Garbe, Battermann, 2007).

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