Measurement of Semi-Anechoic Chamber Using Modified VSWR method above 1GHz

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Abstract. *Most of alternative test places as semi-anechoic chambers are designed to use them for EMI measurement in frequency range 30 ÷ 1000 MHz. Nowadays it is necessary to measure radiated emission also at higher frequencies in some cases. However, no valid standard exists to determine the process of their verification. In this paper modified site VSWR method was used to obtain behaviour and possible utilization of semi-anechoic chamber of EMC Laboratory for measurement at higher frequencies up to 10 GHz in measuring distance 1 m.*

Keywords: semi-anechoic chambers, site VSWR, verification of test place

1. Introduction

The basic standard referring verification of test places for electromagnetic interference (EMI) measurement is [1]. This standard deals with verification only in frequency range 30 MHz ÷ 1 GHz. According to [1] measured values of normalised site attenuation of the test place are compared with ideal ones. The only official document assuming a testing above 1 GHz is a technical specification [2] of ETSI, which assumes also NSA measurement but only anechoic chambers. However, at frequencies above 1 GHz directional broadband antennas shall be used, so effect of absorbers manifests itself in results at minimally 10 m measuring distance [3].

An alternative method replacing NSA measurement is described in [4]. The method is based on measurement of voltage standing-wave ratio (VSWR) that indicates differences in field distribution inside test place. This method is convenient also for anechoic chambers, but there are no measuring distance conditions. Therefore this method was used to survey properties of semi-anechoic chamber of EMC Laboratory of our university in frequency range 1 ÷ 10 GHz using some modifications.

2. Subject and Methods

Site VSWR method is based on moving transmitting source along measurement axis to sample standing wave of electromagnetic field. The VSWR value is given as ratio of maximum and minimum signal for measurement series:

$$VSWR = \frac{E_{\max}}{E_{\min}} = \frac{V_{\max}}{V_{\min}} \qquad (1)$$

where E_{max} and E_{min} are maximal and minimal value of measured E-field and similarly for values of measured voltages on receiving antenna terminals V_{max} and V_{min}. The value of VSWR determines field uniformity instead of space attenuation, while it does not depend on antenna factor and cable loss accuracies.

To verify the test place it is necessary to measure values of E-field in volume, which is bigger than $\lambda \times \lambda \times \lambda$ (λ is wavelength at given frequency). At least measurements along all axes of rectangular coordinate system shall be performed to obtain the quality of the test place. VSWR should be below 3.5 dB that is the value derived from ±4 dB NSA criterion. According to [4] this method is even better than NSA measurement because of better sensitivity of VSWR measurement, while it is simpler and less time-consuming.

At measuring distance 1 m and more, the receiving antenna is situated in far zone for frequencies above 1 GHz. Therefore, the level of measured E-field descends linearly with increasing distance from transmitting antenna. Not to influence the value of VSWR by this effect, a correction has to be applied on measured values of E-field or voltages on receiving antenna terminals. The E-field of arbitrary antenna with gain *G* supplied by power *P* in distance *d* can be computed:

$$E = \frac{\sqrt{30PG}}{d} e^{-j\beta d} \tag{2}$$

where β is the phase constant. If E_1 is the value of E-field in distance d_1, in distance d_2 its value E_2 is changed according Eq. 2:

$$E_2 = E_1 \frac{d_1}{d_2} \tag{3}$$

To apply the site VSWR method in the semi-anechoic chamber it is necessary to line the reference ground plane by additional absorbers to minimize its effect. This is suppressed also by utilization of monopole with its ground plane as transmitting antenna and therefore only effect of absorbers are surveyed.

3. Results

Such a modified site VSWR method was used to verify semi-anechoic chamber of our EMC Laboratory, which is lined by ferrite tile absorbers. Values of E-field are measured in 1 m measuring distance from centre of turntable and in 1 m height, where tested equipment is situated. Horn antenna was used as receiving antenna and tuned monopole, which has isotropic directional pattern, as transmitting one. During the measurement only the position of transmitting monopole was changed along the direction of interest. Excitation signal is obtained by means of hf generator and hf power meter is used as measuring equipment.

In order to verify our chamber in frequency range 1 ÷ 10 GHz some measurement were performed. Because during measurements at one discrete frequency the same antenna was used, it is sufficient to obtain the voltage measured at antenna terminal to know the E-field distribution. At first variation of E-field along measuring axis was measured. According to [4], values of E-field were sampled along a 40 cm long line. The measured values descent with increasing measuring distance from 1 to 1.4 m, hence correction was applied according to Eq. 3. Also these values have oscillating tendency as it is shown in Fig. 1. The measured values of voltage *V* are influenced also by attenuation and mismatching of transmission path. Maximal VSWR does not exceed 3 dB in case of all measured discrete frequencies.

To know character of standing wave in the chamber and to identify potential sources of oscillations, another measurement was performed in the same direction but only along 2λ long line. Such a measurement was realized at two frequencies 3 GHz (Fig. 2) and 10 GHz. As one can see there are two maximums and minimums within a wavelength. Hence field distribution is influenced significantly by one reflection from surrounding walls. Considering character of measured values one can account only the reflection from back wall, which is situated the closest to transmitting antenna and perpendicularly to measuring axis.

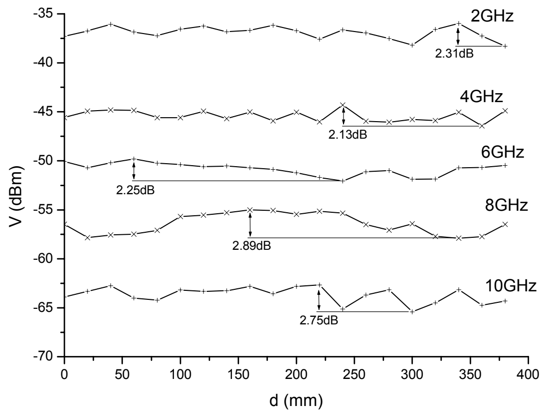

Fig. 1. Dependence of measured voltage V at antenna on raising measuring distance d for different frequencies in 1 m measuring distance.

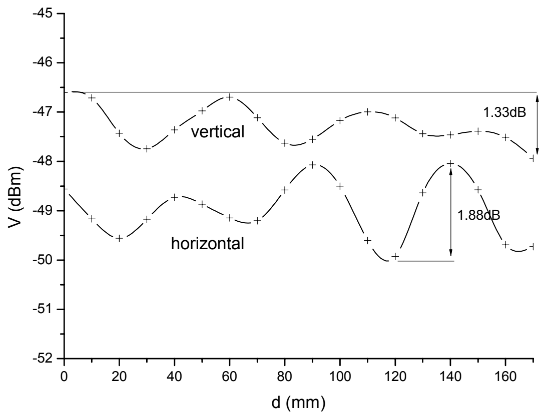

Fig. 2. Dependence of measured voltage V at antenna on raising measuring distance d for both polarisations of antennas at 3 GHz.

The same measurements were performed also for horizontally polarized antennas. As one can see in Fig. 2, in comparison to vertically polarized wave the standing wave of horizontally polarized E-field is moved in volume of the chamber due to different conditions. On the other hand values of VSWR are very similar, so in next only vertically polarized wave are surveyed.

Also properties of field standing wave in other directions were surveyed. The transmitting antenna was deflected perpendicularly to measuring axis within the range $<+\lambda; -\lambda>$ in horizontal and $<0; 4\lambda/3>$ in vertical direction. Chosen ranges of antenna movement represent the maximal dimensions of potentially tested device. Results of measurement, which was performed for three frequencies, are present in Tab. 1. The values VSWR obtained in this manner are lower than in previous analysis. This confirms the idea about influence of reflection from the closest wall. The measured values of E-field at horizontal deflection are not symmetrical due to non-symmetry of the analysed test place equipped by measuring equipments.

Table 1. VSWR values of analysed fields at deflection of monopole from measuring axis

Deflection	in horizontal direction			in vertical direction		
f (GHz)	2	5	10	2	5	10
VSWR (dB)	1.8	1.7	1.3	1.76	0.93	2.52

As was mentioned in previous the only influencing estimate effect is undesired reflection from the back wall. It is because used absorbing material – ferrite are not designed to work in such high frequencies. Therefore this wall was lined with additional pyramidal foam absorbers to suppress this reflection. As it is shown in Fig. 3 and Fig. 4, pyramidal absorbers help us to minimize the values of site VSWR. Their influence is more significant at higher frequencies, at frequency 10 GHz additional absorbers suppress site VSWR from 2.81 dB to only 1.05 dB (Fig. 4). It is because resonant frequency of used ferrite tile absorbers is at value of 160 MHz [5], which is far from analysed range of frequencies.

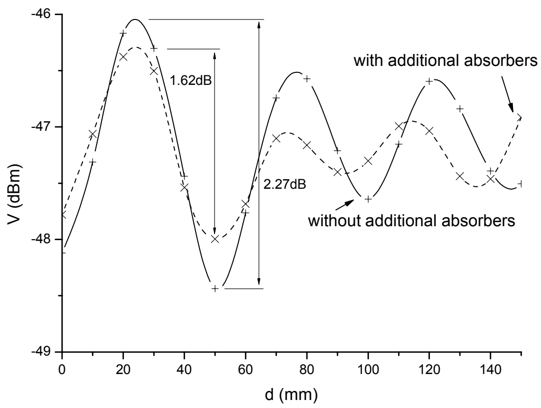

Fig. 3. Influence of additional absorbers on site VSWR at 3 GHz.

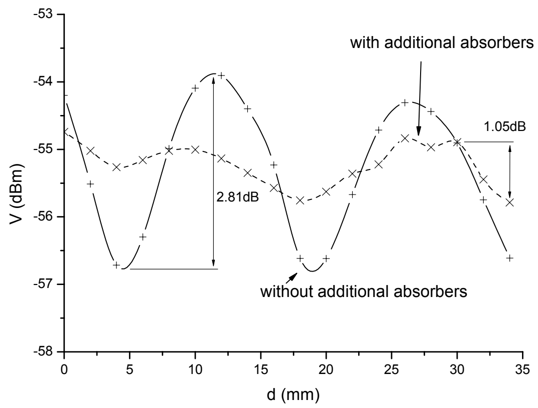

Fig. 4. Influence of additional absorbers on site VSWR at 10 GHz.

4. Discussion

The semi-anechoic chamber of EMC Laboratory was build for EMI measurements in frequency range 30 ÷ 1000 MHz. Modified site VSWR method was used to obtain overview about possible extension of operation frequency range up to 10 GHz. It is known that ferrite absorbers used in analysed chamber are not intended to use them at higher frequency up to 1 GHz. In spite of this fact, it is possible to use this test place for measuring also in frequency range 1 ÷ 10 GHz and in measuring distance 1 m, because values of site VSWR does not exceed 3 dB in all realized measurements. It is evident from the measured values that E-field distribution is influence especially by undesired reflection from the nearest wall that is perpendicular to the measuring axis. Resulting from performed analysis, using additional pyramidal foam absorbers on mentioned wall leads to reduction of site VSWR to only 1.5 dB.

Acknowledgements

This research was financially supported by the project VEGA VG 1/3101/06 and by the Ministry of Education of the Slovak Republic under grant 2003SP200280202.

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