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Validity of the FAR validation using Site Reference Method

***Abstract**. Electromagnetic radiation from devices is measured in fully anechoic chambers which are validated by site attenuation measurement. Fully anechoic room was validated using Reference Site Method according to CISPR 16-1-4. Author investigate influence of the validation conditions on result of this procedure. Frequency step, antennas positioning were examined and reference measurement was analyzed.*

***Streszczenie.** Emisja promieniowana pochodząca od urządzeń może być mierzona w komorach bezodbiciowych które są walidowane poprzez pomiar tłumienia stanowiska. Podstawą niniejszej pracy jest walidacja komory całkowicie bezodbiciowej wykorzystując metodę stanowiska odniesienia zgodnie z normą CISPR 16-1-4. Autor bada wpływ różnych warunków walidacji na wynik procedury. Sprawdzono wpływ kroku częstotliwości, precyzji ustawiania anten oraz przeanalizowano procedurę wykonywania pomiaru referencyjnego. (**Słuszność metody pomiaru referencyjnego do walidacji komór FAR**)*

Keywords: anechoic chambers, attenuation measurement, electromagnetic radiation.
Słowa kluczowe: komory bezodbiciowe, pomiar tłumienia, emisja elektromagnetyczna.

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Introduction

Quality of the radiated emission measurement depends on quality of the test site and this is verified by validation procedures. The purpose of this work is to investigate potential problems during FAR (Fully Anechoic Room) SRM (Site Reference Method) validation procedure up to 1 GHz according to CISPR 16-1-4. Author is trying to improve validation conditions included in CISPR procedure. Conditions of the SRM were subjected to changes to investigate their influence on procedure result.

Survey of Related Works

Initially FARs were used as an alternative test site for OATS (Open Area Test Site) due to numerous of advantages e.g. low cost, shorter measurement time and using one facility to test immunity and emission. Additionally it was possible to get some of this benefits by simple SAC (Semi Anechoic Camber) to FAR conversion [5]. In 1991 CENELEC working group started to consider FARs as a fully compliant test site. Later FARs was introduced to be standard facility and it was necessary to describe validation procedure which ensure high quality of the measurement [3]. Few validation methods were introduced. One of them is NSA (Normalized Site Attenuation) measurement due to good agreement with theory. Second one, for small chambers, is measurement of the site attenuation compared with reference site measurement which is called reference site method (RSM) [7]. Another procedure is transducer factor measurement according to EN 61000-4-22 [8]. Nowadays CISPR considers FAR as a fully compliant facility for industrial, scientific and medicine equipment .All validation procedures mentioned above are taken into account.

A lot of researches were focused on looking for methods to correlate measurements between OATS, SAC and FAR [1], [2], [4]. This algorithms are useful for measurements according to standards where only limits for SAC or OATS are established (e.g. CISPR 22). Establishing different limits for measurement in FAR (e.g. EN 61000-6-3 or EN 61000-6-4), suitable measurement method and validation procedures it is another approach in standards to avoid correlations to OATS and ensure EMC compliance.

Problem Statement and Main Contribution

It is obligatory to validate facility, which is used for emission measurement, to perform it with good quality. So it is crucial to know if the chamber really pass +/- 4 dB criterion [7]. Validation uncertainty due to validation conditions is not stated in the RSM procedure (CISPR 16-1-4) what is the.

This work investigates what is the influence on the validation result by the selected conditions of the RSM? Hypothesis is that smaller frequency step negatively influence validation result and better precision of antennas positioning positively influence on results. In this paper there are also pointed out problems with reference measurement which influence validation result. Influence of cable positioning was not investigated because it is well known and described in CISPR [7] procedure.

This paper is based on measurements according to CISPR 16-1-4 performed to verify suitability of the FAR for emission measurement. Whole procedure of RSM were examined to find conditions affecting validation result.

Problem Solution

Method

Site reference method is described in CISPR 16-1-4. Measurements within the validated chamber are performed using small biconical transmit antenna and broadband receive antenna. Transmit antenna is placed in fifteen positions and tilted to be parallel and face the receive antenna. Receive antenna is moved to keep constant 3 m distance between antennas. Site attenuation (SA) is measured in each antenna position (0).

Measurements were made in correct and incorrect positions where ha = 0 m (0). In order to compare results maximum deviation of the SA between all 15 points was calculated.

Influence of antenna positioning precision on the validation result was considered using deviation of the SA from measurement at precise positioning. From all points one was chosen at which attenuation exceed the limit most often (point number 3, vertical polarization, 1 MHz frequency step size) then precision was changed. Angle mismatch and direction mismatch are defined in Fig.2.

Influence of frequency step was considered using maximum deviation from reference measurement (RM) at horizontal polarization. Maximum frequency steps are in the Table 1. as specified in the standard. Results were analyzed above 110 MHz because deviation from RM at lower frequencies depends on near field effects and imperfection of reference measurement.

In order to verify measurements, reference measurement is required. This part of procedure is performed in quasi free space conditions which are achievable by placing antennas 4 m above ground covered by absorbers. It is required by the standard that all fifteen measurements must be within the +/ 4 dB range from reference site attenuation. Problems with this measurements will be described by the brief analysis.

Table 1. Maximum frequency step

Frequency range [MHz]	Frequency step [MHz]
30 – 100	1
100 – 500	5
500 – 1000	10

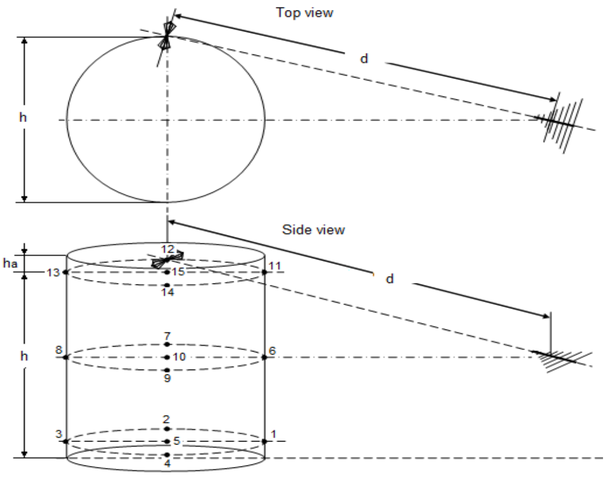

Fig. 1. Antennas positions (d = 3 m, h = 1,5 m, h_a = 0,16 m) [7]

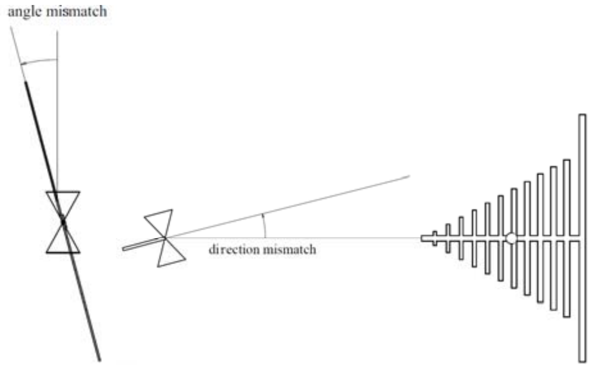

Fig. 2. Angle mismatch and direction mismatch definition

Implementation

Measurements were carried out in FAR built in 1997 in Electrotechnical Institute, Gdansk Branch. Walls and ceiling are completely covered by ferrite absorbers but floor is covered partially. It has been proven that partially covered floor is enough to pass +/- 4 dB criterion [6]. Back wall is additionally covered by pyramidal absorbers. All dimensions are shown on Fig. 4. Placement of the test volume with antenna positions was selected due to practical reasons. It ensures ease of receiving antenna movement and access to the tested device and cablings.

Cables position affect the results [7], thus cablings in validated FAR was placed in a defined manner at all measurements, in order to minimalize cables influence. It is not possible in small chamber to maintain cables 2 m straight behind the antennas as mentioned in CISPR procedure. Cables were positioned horizontally behind the antennas and then fasten to the walls and leaded on the walls on the shortest path to the connector.

Reference measurement was carried out in SAC chamber in Wroclaw University of Technology. Test distance was 3 m and antennas were placed 4 m above ground covered by absorbers. Cables were oriented horizontally behind antennas for a 2 m distance and then dropped on the ground.

Test site diagram and used equipment are described in Fig. 3. Software used to control equipment and store data was MC 32 from Rohde & Schwarz. The same devices (listed in Fig. 3.) were used during measurements in FAR and reference measurement apart of cablings. CISPR procedure ensures SA measurements without cables attenuation.

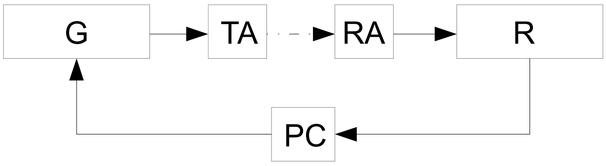

Fig. 3. Test site diagram (G – RF generator: SML R&S; TA – transmit antenna: BBHA 9120D Schwartzbeck; RA – receive antenna: BTA-L Frankonia; R – EMI Receiver: ESU 26 R&S; PC – personal computer

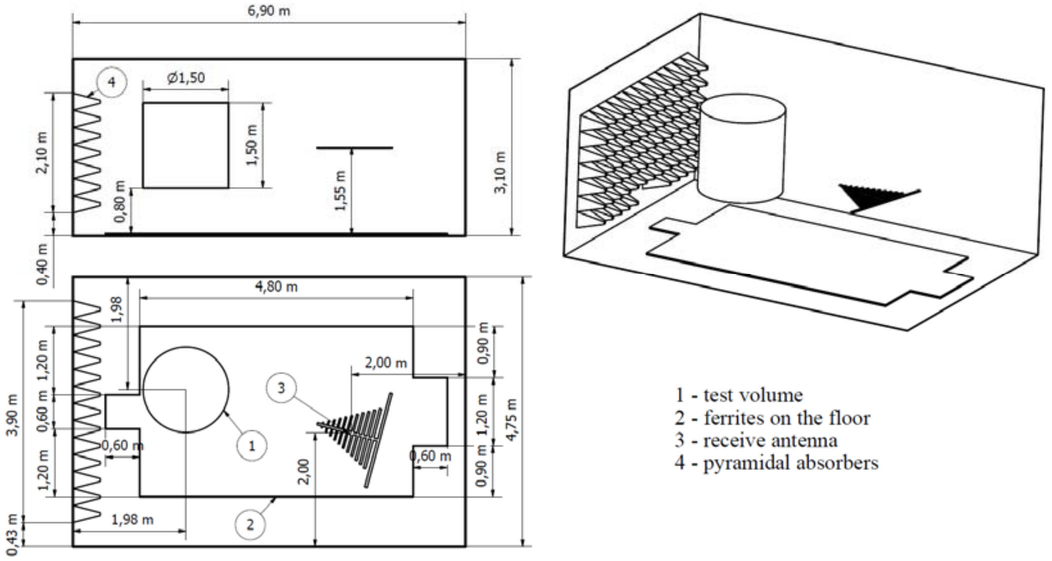

Fig. 4. Test facility

Results

- Correct and incorrect positioning of the antennas:

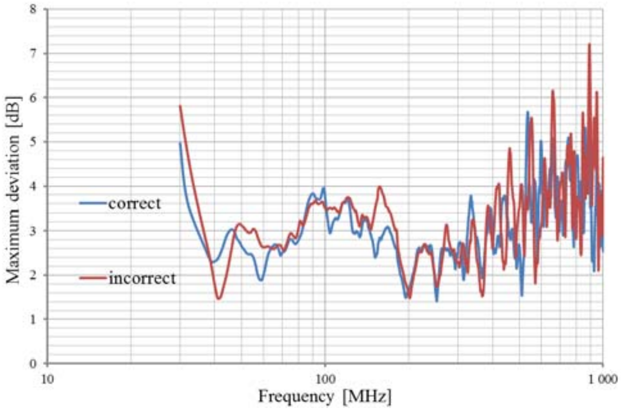

Fig. 5. Vertical polarization

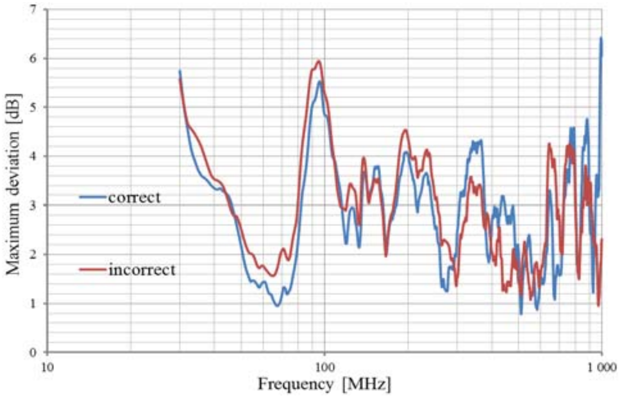

Fig. 6. Horizontal polarization

- Precision antennas positioning:

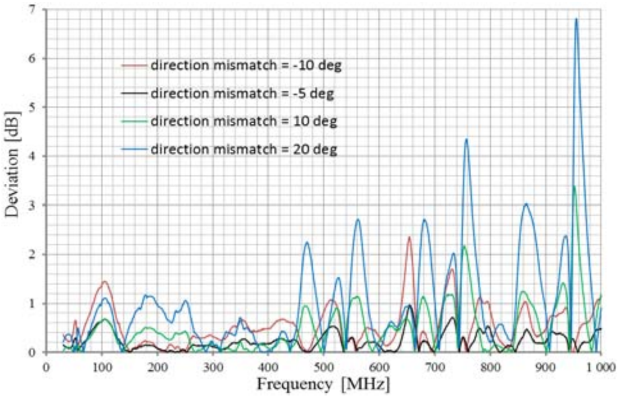

Fig. 7. Direction mismatch influence

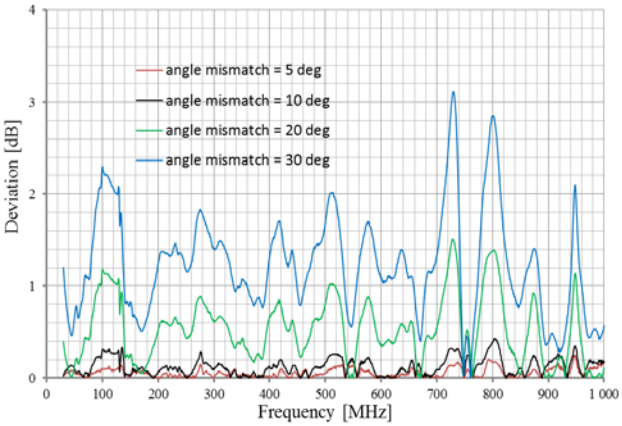

Fig. 8. A mismatch influence

- Freguency step size influence

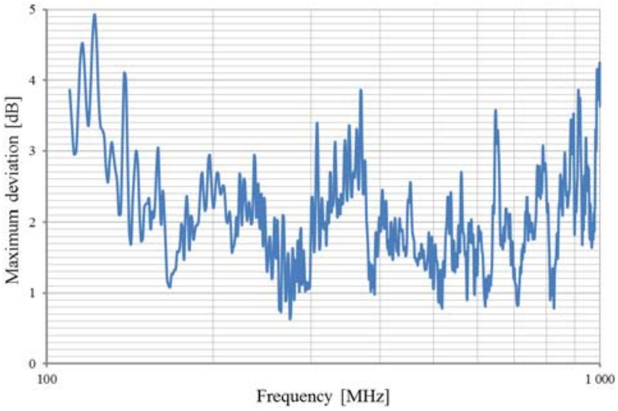

Fig. 9. Maximum deviation from RM; 1 MHz frequency step size

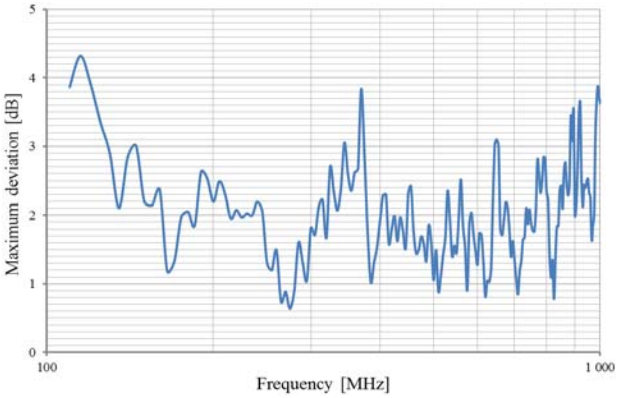

Fig. 10. Maximum deviation from RM; 5 MHz frequency step size

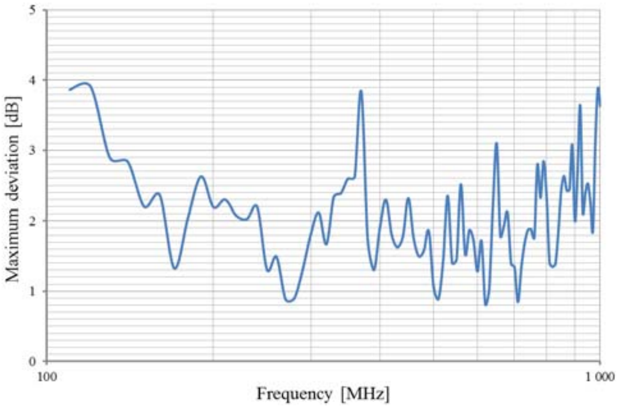

Fig. 11. Maximum deviation from RM; 10 MHz frequency step size

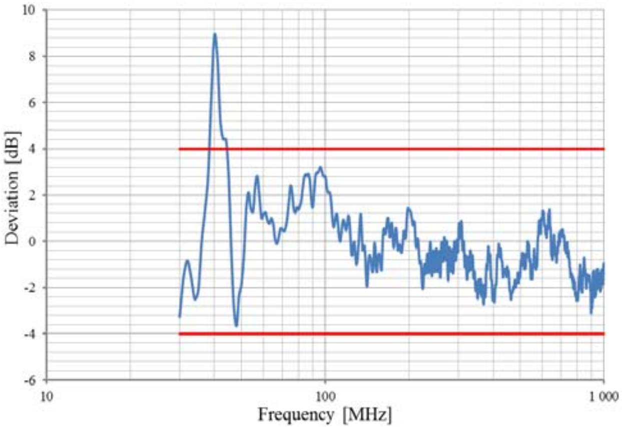

Fig. 12. Deviation between calculated NSA (equation 1) and theoretical NSA (equation 2)

Analysis of results

The results given in section above shows influence on validation by specific parameters.

When transmit antenna is positioned incorrect (ha = 0 in Fig. 1) then results are different as shown in Fig. 5 and Fig. 6 but influence of this mistake on result of validation cannot be clearly inferred. In this case maximum deviation at vertical polarization and correct positioning is less than maximum deviation at incorrect positioning but it is adversely at horizontal polarization.

More time consuming is antennas positioning and as shown in Fig. 7 and Fig. 8 it is important to make it precisely. Making -5 degrees of direction mismatch results with 0,96 dB maximum change in site attenuation. When transmit antenna is positioned vertical (-10 deg. direction mismatch) the maximum change in site attenuation is 2,37 dB. Site attenuation measurement is not so sensitive to angle mismatch. Maximum change in measurement equal 0,43 dB occurs with 10 deg. angle mismatch.

In figures Fig. 9, Fig. 10 and Fig. 11 there are results of maximum deviation from reference measurements depending on frequency step size. At 1 MHz frequency step size there are four frequency ranges where limit is exceeded so result of validation is negative. At 5 MHz frequency step size only at one frequency maximum deviation exceed the limit. Changing frequency step size at 10 MHz then the result of validation become positive. Because of that facts it is reasonable to perform validation procedure with constant 1 MHz frequency step size. Increasing frequency step size makes validation easier to be passed but reduce time of measurement. Note that all measurements in one antenna position with 1 MHz frequency step size and 100 ms dwell time takes less than 2 minutes when control software is used.

Calculated NSA (NSA_{calc}) derived from reference measurement is compared with theoretical NSA (NSA_{theo}) in Fig. 12. Calculated NSA and theoretical NSA are defined as follow:

$$NSA_{calc} = SA_{ref} - AF_T - AF_R \quad (1)$$

$$NSA_{theo} = 20log(\frac{5Z_0 d}{2\pi}) - 20log(f_m) \quad (2)$$

where: SA_{ref} – side attenuation from reference measurement, AF_T – antenna factor of the transmit antenna, AF_R - antenna factor of the receive antenna, Z_0 – 50 Ω reference impedance, d – distance between the phase centers of antennas, f_m – frequency.

Reference measurement is hard to made outdoors using low power transmit antenna because of ambient signals, thus measurements were carried out in 10 m SAC. In order to verify if this reference site satisfies quasi free space conditions result was recalculated (equation (1)) and compared with theoretical NSA. Result of this comparison depends on uncertainty of the antenna factors, generator stability and accuracy of the EMI receiver. Deviation from theoretical NSA at frequencies less than 110 MHz depends also on near field effects. At 40 MHz deviation from NSA is 8,5 dB (Fig. 5) and it cannot be explained by previously mentioned conditions. This deviation is probably caused by reflections from walls. Because of this result, validation of the FAR was made above 110 MHz. Reference measurement enable to avoid uncertainties related to antennas calibration and near field effects but there are problems with verification of the reference measurement.

Conclusion

This paper shows importance of the conditions included in SRM validation procedure. It was concluded that 10 MHz frequency step size is not enough to detect all frequencies at which limit is exceeded and precision of the antennas tilting and positioning influence on repeatability of the measurement. Result of reference measurements and problems with determining if this measurement is correct are analyzed. Future work should be concentrated on precise description of the reference measurement verification. It is also needed to examine validation procedures when test volume is placed on the floor.

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