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INTERLABORATORY COMPARISON OF THE ELECTROMAGNETIC EMISSION MEASUREMENTS USING FAR AND GTEM TEST SITES UP TO 1 GHz

ABSTRACT *Electromagnetic emission limiting is one of the basic requirements in the European Directive 2014/30/EU (EMC Directive). Manufacturers often use alternative methods of measurements to make preliminary verification of emission. This paper presents and analyzes problem with comparison between measurements in different test sites: FAR (Fully Anechoic Room) and GTEM (Gigahertz Transverse Electromagnetic cell). FAR is assumed as the reference and GTEM as the alternative method. There are results of measurements carried out in Electrotechnical Institute Gdansk Branch (FAR) and Satel Sp. z o.o. company (GTEM). It is concluded that the results from these two test sites cannot be easily compared or scaled but the measurement in the GTEM was more restrictive for the tested device in wider frequency range.*

Keywords: *electromagnetic field, emission measurement, electromagnetic compatibility*

1. INTRODUCTION

Measurement of electromagnetic field emission from electric and electronic devices is a basic test to present compliance with the EMC Directive [1] which requires

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to design and manufacture an equipment, with respect to the state of art, ensuring that emission will not exceed the limits above which radio service and telecommunication devices or other equipment may not perform properly.

Manufacturer is only responsible for ensuring compliance with basic requirements. Compliance can be presented by any documented manner. One of the most popular way of compliance presentation is usage of the harmonized standards published in the Official Journal of the European Union. Emission measurement according to the standards can be measured in different sites: OATS (Open Area Test Site), GTEM (Gigahertz Transverse Electromagnetic cell), FAR (Fully Anechoic Room) and SAC (Semi Anechoic Chamber). It is allowed to measure at other sites if it can be proven that results are the same as using OATS which is the reference for all other sites. In the past a lot of researches were carried out to correlate results between OATS - FAR and OATS - GTEM and finally in the standards EN 61000-6-3, EN 61000-6-4 and CISPR 14-1 new limits for FAR are established and for measurements in GTEM it is necessary to use correction factors. Additionally, in GTEM cell, according to standards, it is allowed to measure only battery supplied devices with no cablings. Nevertheless, GTEMs are used by manufacturers for pre-compliance test during designing process. Assuming that results from GTEM and FAR are correlated with results from OATS then results from GTEM should be related with FAR.

2. PROBLEM STATEMENT

Some groups of products have to be certified because of a market requirements. It results in necessity of tests in accredited laboratory according to the standards. Before deciding to carry out a test in an accredited laboratory, manufacturers first make preliminary measurements using alternative methods in their own laboratories. One of the alternative methods is emission measurement in GTEM when device has cablings. In this way the problem is twofold. On the one hand, if manufacturer gets a positive result using alternative method, he wants to be sure that final test will also have the positive result. On the other hand, it is unwanted to waste time on reducing emission if it was increased by alternative method but not really existing. The objective of this work is to present results from FAR and GTEM and to discuss the differences and their cause.

3. METHOD

3.1. Equipment under test

New series of power supplies developed in the Satel company was selected as equipment under test for interlaboratory comparison. It was switched-mode power supply APS 412 shown in figure 1 which has 3 A maximum load current at 13,8 V.

During measurements device works at maximum power load. All interconnection wirings were connected: power cord, output cable connected to the load resistor, cable to the battery and communication cable connected to passive diode simulator.

Fig. 1. Equipment under test

Battery is typically connected close to the power supply thus connection cable was 0,2 m length, all other cables were 5 m length. Both measurements in the FAR an GTEM were carried out with the same cablings but in the FAR arranged according to the CISPR 16-2-3 [2] and in GTEM excess of cables was wound 0,15 m above floor of the cell behind tested device.

3.2. Measurement in FAR

Measurement technique in FAR is described in CISPR 16-2-3 and the chamber should be validated according to the CISPR 16-1-4. Used FAR meets +/- 4dB criterion which is the maximum allowed deviation between measurement of the reference site attenuation and measurements of the site attenuation performed in the chamber. Total measurement uncertainty of used chamber is 5,3 dB including near field effects. Cables arrangement is shown in figure 2 (side view). Distance between the surface of the device and the reference point of the antenna was 3 m. According to the standard antenna location is changed depending on a EUT size and EUT is located in the way that centre of the device with cables match the center of the test volume. Measurement was made in FAR chamber which is a part of EMC laboratory of the Electrotechnical Institute Gdansk Branch. Chamber dimensions and test volume position are shown in figure 3. Antenna (BTA-L, Frankonia), receiver (ESU 26, Rohde & Schwarz) and software (EMC 32, Rohde & Schwarz) were used. Emission was measured at horizontal and vertical polarization. The results were compared with the limit from EN 61000-6-3/A1:2011 [3]. This limit is different from the limit for OATS and SAC test sites because in a FAR there are no reflections from the ground. In this approach limit is changed rather than measured value to get comparable results and the comparison is made by comparing distance between measurements and limit rather than comparison of measured field.

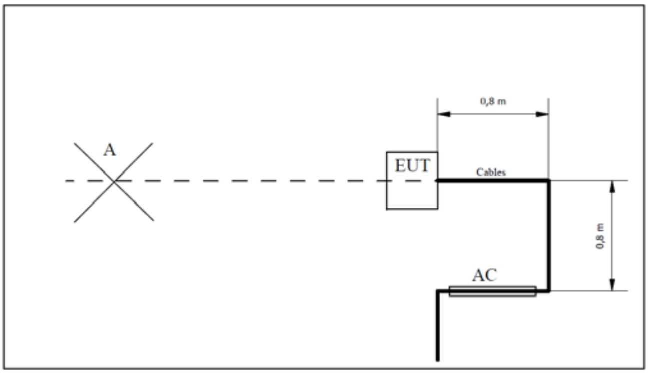

Fig. 2. Cable arrangement in FAR (A – antenna, EUT – equipment under test, AC – absorbing clamp)

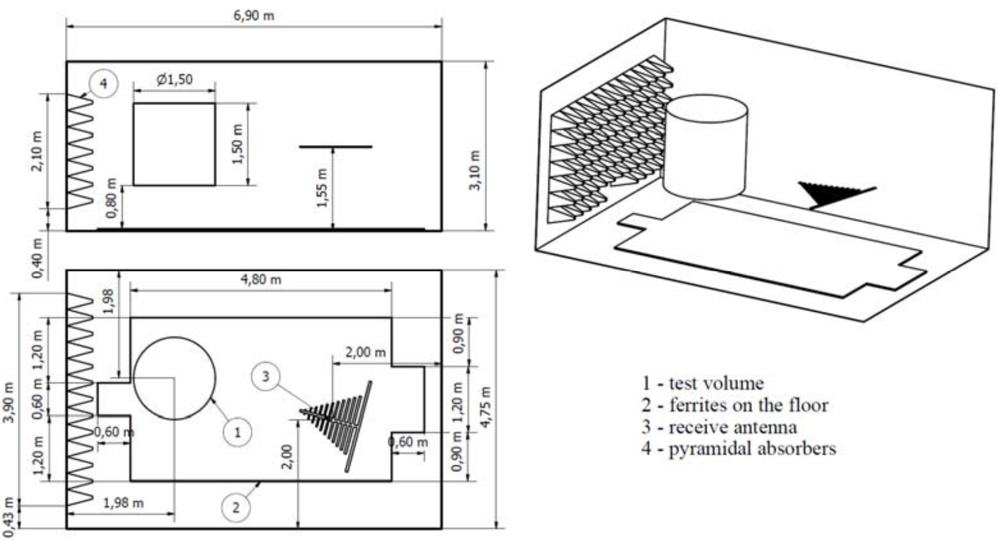

Fig. 3. Test site [4]

3.3. Measurement in GTEM

Basic measurement procedure for GTEM chambers described in standard [5], assumes taking measurements of the EUT emission in three axes, for the object being in the center of the Septum, under the assumption that the object should not be bigger than 1/3 h, where h means the height measured from the floor of GTEM chamber to Septum. Measurements were carried out in GTEM chamber (fig. 4) to determine maximum electric field strength E_{max}. Result was calculated using equation (1) which ensures correlation to OATS.

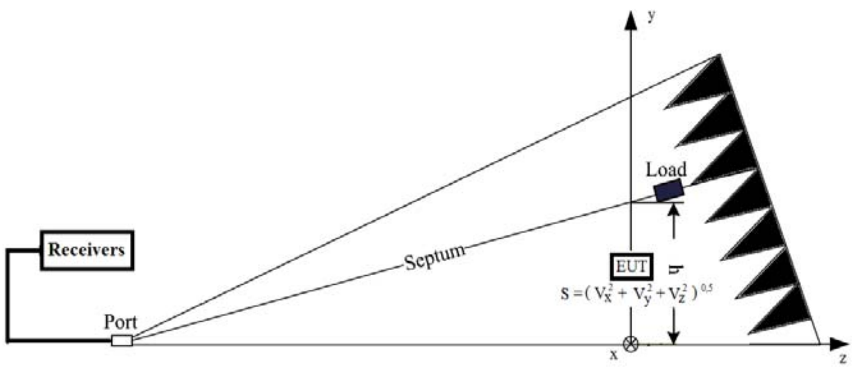

Fig 4. Schematic diagram of the emission measurements in the GTEM chamber

$$E_{\max} = g_{\max} \frac{\eta_0 k_0}{2\pi \cdot e_{0y}\sqrt{Z_c}} \cdot \sqrt{V_x^2 + V_y^2 + V_z^2} \qquad (1)$$

where:

g_{max} – factor calculated from geometry of the EUT and antenna on the OATS,
η_0 – impedance of free space, = 120 π [Ω],
k_0 – wave number amounting 2π/λ,
Z_c – characteristic impedance of the waveguide typically 50 Ω,
e_{0y} – normalized vertical electric field of the TEM mode inside the GTEM calculated from geometry of the cell and EUT position,
V_x, V_y, V_z – voltages measured at the output port of the cell.

The measurement was taken in the Satel company laboratory. The results presented in the paper have been obtained from measurements at three planes, required for the radio emission tests performed in GTEM chamber according to EN 61000-4-20 [5], emission limits were used according to EN 55022 [6].

4. RESULTS

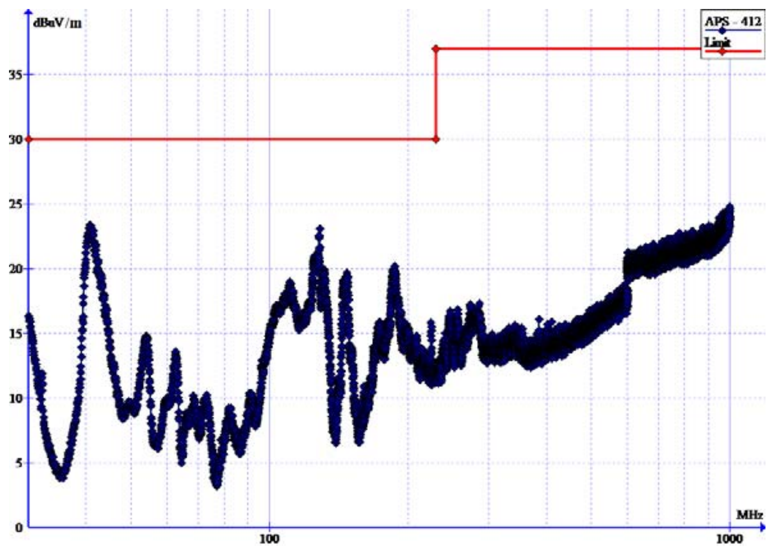

Fig. 5. APS - 412 measurements in GTEM chamber at 10 m according to [5]

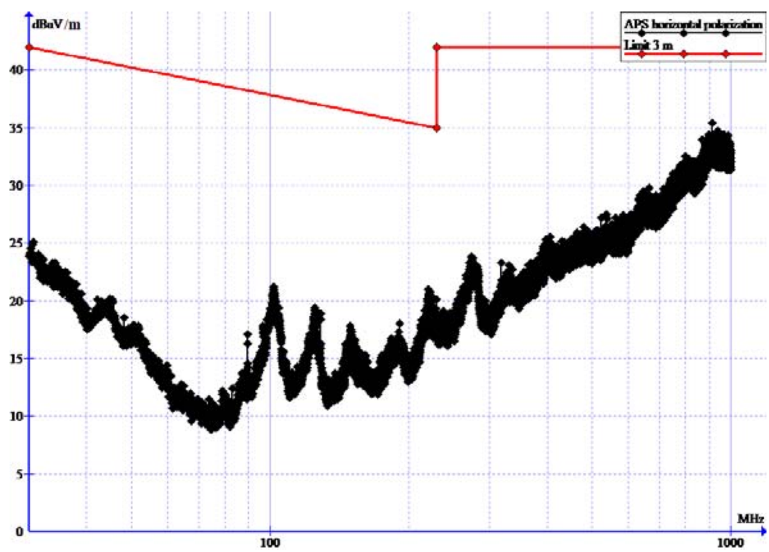

Fig. 6. APS - 412 measurements in FAR chamber at 3 m horizontal polarization

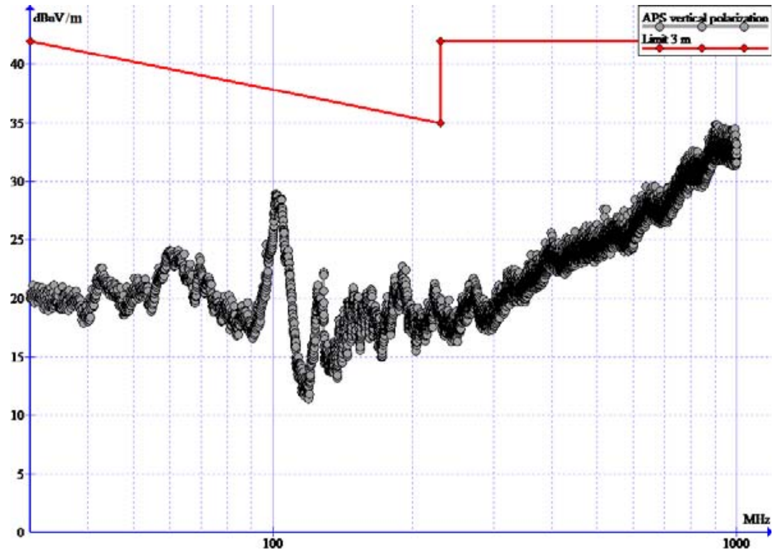

Fig. 7. APS - 412 measurements in FAR chamber at 3 m vertical polarization

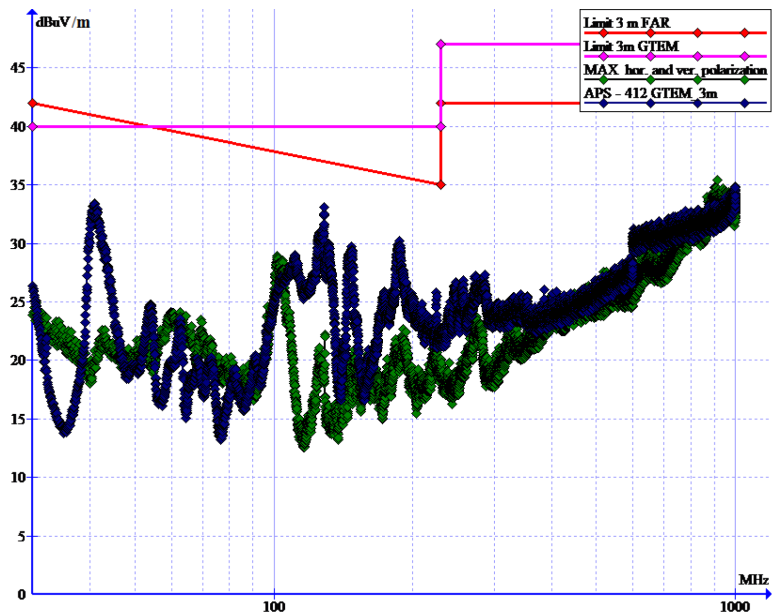

Fig. 8. Comparison measurements of APS - 412 in FAR (for max. emission at horizontal and vertical polarization) and GTEM chamber for 3 m

5. CONCLUSION

Figure 8 shows that the measurements in GTEM chamber and those taken in FAR chamber differ significantly. They point out the necessity of caution approach while measuring in GTEM chamber. For example the differences between measurement and limits at 40 MHz is 8,77 dBμV/m and 21,7 dBμV/m in GTEM and FAR respectively.

This indicates the lack of possibility of direct comparison of the results obtained in both measurement configurations. Important information obtained by the company laboratory is the direct information about the need of having a considerable reserve below the limits in the range of 10 dBμV/m. It is well known that results from different test sites are comparable when the device has no cablings [3] thus it is concluded that presented differences result from cabling influence and it follows necessity of conservative approach during evaluation of emission if there is possibility to connect numerous different types of cables with different arrangement. Additionally difference between results may results from over simplification, because calculations for GTEM assumes that EUT has the same properties as simple dipole source. Future work will be related to improvement of the cable decoupling method to get more comparable results. Positive and important information obtained by testing in GTEM chamber is the knowledge that the tested object meets the emission requirements, despite not full decoupling of the cables and usage of the alternative test site.

LITERATURE

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PORÓWNANIE MIĘDZYLABORATORYJNE POMIARÓW EMISJI ELEKTROMAGNETYCZNEJ W KOMORACH TYPU FAR ORAZ GTEM W PAŚMIE CZĘSTOTLIWOŚCI DO 1 GHZ

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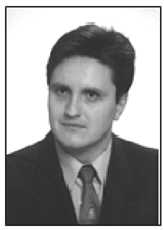
STRESZCZENIE *Ograniczanie emisji elektromagnetycznej jest jednym z podstawowych wymagań dyrektywy europejskiej 2014/30/EU (Dyrektywa EMC). Przedsiębiorstwa często wykorzystują alternatywne metody pomiaru przy wykonywaniu wstępnej weryfikacji emisji. W publikacji przedstawiono i przeanalizowano różnice i problemy związane z porównywaniem wyników uzyskanych na różnych stanowiskach pomiarowych: w komorze całkowicie bezodbiciowej FAR (ang. Fully Anechoic Room) oraz w komorze GTEM (ang. Gigahertz Transverse Electromagnetic cell). Pomiary w FAR przyjęto za metodę referencyjną, natomiast pomiary w komorze GTEM są metodą alternatywną. W opracowaniu przedstawiono wyniki badań, które zostały wykonane w Gdańskim Oddziale Instytutu Elektrotechniki (FAR) oraz w firmie Satel Sp. z o.o. (GTEM). W wyniku badań stwierdzono, iż porównanie obydwu metod jest zadaniem trudnym. Jednakże należy pamiętać, że pomiary wykonywane w komorze GTEM są bardziej restrykcyjne dla testowanych urządzeń, w szerszym zakresie częstotliwości.*

Słowa kluczowe: *pole elektromagnetyczne, pomiary emisji, kompatybilność elektromagnetyczna*



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