AUTOMATED SCAN MEASUREMENT METHOD (ASM2) FOR SHIELDING EFFECTIVENESS OF ENCLOSURES

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Abstract: In this study, automated scan measurement method (ASM2) have been used for shielding effectiveness of enclosures. The results of the measurements have been compared with the single points results obtained from the IEEE standard 299/1997

I. INTRODUCTION:

Shielding enclosures are a structure that protects its interior from the effect of an exterior electric or magnetic field. The enclosures used for testing groups of equipment, vehicles, computing systems, and smaller units whose electromagnetic emission and susceptibility require determination without disturbance from other sources.

S*hielding effectiveness* (SE) is the ratio of the signal received (from a transmitter) without the shield, to the signal received inside the shield; the insertion loss when the shield is placed between the transmitting antenna and receiving antenna by mathematical relationships defined in Table.1.

Table 1. Shielding Relations

Frequency Range	Measured quantities	SE(dB)
9kHz-20 MHz	H_1, H_2 (uA/m) V_1, V_2 (uV)	$S_H = 20\log_{10}\frac{H_1}{H_2}$ $S_H = 20\log_{10}\frac{V_1}{V_2}$
20-300MHz	E_1, E_2 (uV/m)	$S_E = 20\log_{10}\frac{E_1}{E_2}$
300-1000 MHz	E_1, E_2 (uV/m)	$S_E = 20\log_{10}\frac{E_1}{E_2}$
1.0-18GHz	P_1, P_2 (watts)	$S_H = 10\log_{10}\frac{P_1}{P_2}$

II. METHOD OF THE MEASUREMENTS

MIL-STD 285: This standard covers a method of measurement the attenuation characteristics of electromagnetic shielding enclosures used for electronic test purposes in the frequency range from 100kHz to 10 GHz [1].

Low Frequency Magnetic Field Measurement:
Measurement of the attenuation to low impedance magnetic fields shall be performed in accordance with figure 1.

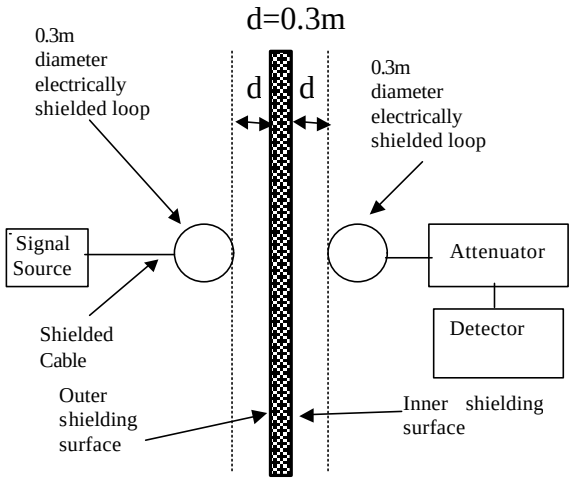

Figure 1. Schematic diagram of the low impedance magnetic fields tests.

High Frequency Electric Field Measurement:
Measurement of the attenuation to high impedance electric fields shall be performed in accordance with figure 2.

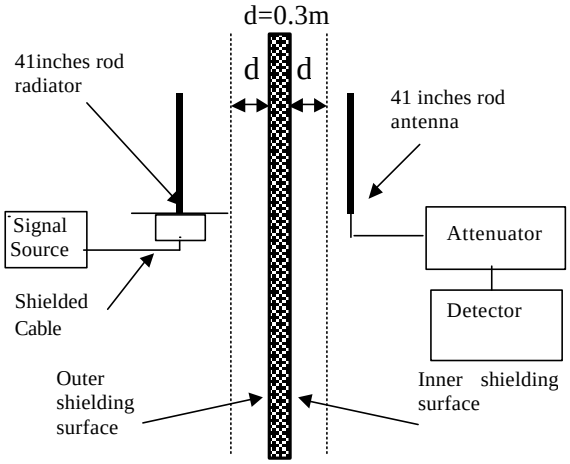

Figure 2. Schematic diagram of the high impedance electric fields tests

The test frequencies of high impedance electric field measurements are 200kHz, 1MHz and 18MHz. The test frequency of plane wave that is measured with dipole antennas is 400 MHz in accordance with Figure 2. as high impedance electric field.

IEEE STD 299/1997

This standard provides uniform measurement procedures for determining the effectiveness of electromagnetic (EM) shielding enclosures at frequencies from 9 KHz to 18 GHz (extendable down to 50 Hz and up to 100 GHz)

Tablo 2. Standard Measurement Frequencies

Frequency	**Antenna type (IEEE299)**	**Antenna type ASM2**
Low range[a]		
9-16kHz	Small Loop	
140-160kHz	Small Loop	
14-16MHz	Small Loop	
Resonant range[a]		
20-100MHz	Biconic	Biconic
100-300MHz	Dipole	Biconic
High range[r]		
0.3-0.6GHz	Dipole	Log-Per
0.6-1.0GHz	Dipole	Log-Per
1.0-2.0GHz	Horn	Horn
2.0-4.0GHz	Horn	Horn
4.0-8.0GHz	Horn	Horn
8.0-18.0GHz	Horn	Horn
[a] Actual test frequencies shall be according to the approved test plan.		
[b] A single frequency in each band is recommended, but actual test frequencies shall be according to the approved test plan.		

The method of measurement [2] is to place an electromagnetic field source (transmitter) outside the shielding enclosure to be evaluated, to place a detector inside the enclosure, and to make provision for simulating removal of the enclosure. The detailed procedures are divided into three ranges, denoted as low frequency, resonance, and high frequency. Recommended test frequencies and the used antenna types in IEEE 299 and ASEM2 are defined in Table 2.

Low Range Measurement (9 KHz-20 MHz)

The measurements shall be made in accordance with Figure 3, with the transmitting and receiving loops each spaced by 0.3m from the respective shielding barrier and coplanar in a plane perpendicular to the wall, ceiling, or other surface being measured. Low frequency measurements, one loop (typically the transmit loop) shall be maintained in a fixed position and second loop (typically the receive loop) shall be reoriented and displaced (physically swept at least one –fourth the seam length on either side of the exact coplanar location) to seek a worst –case measurement; the maximum indication of the detector reading shall be used for determining the SE.

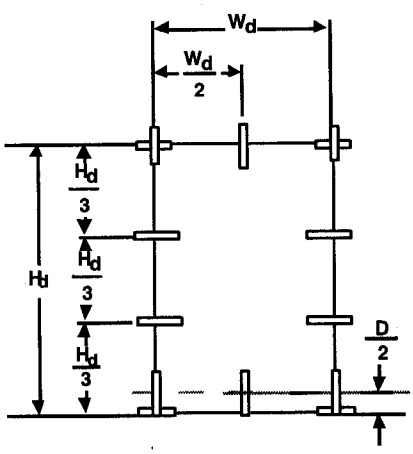

Figure 3a Single-panel entry door measurements

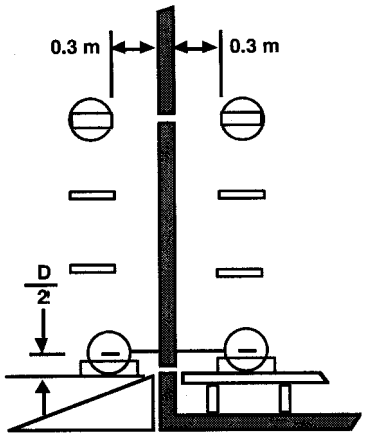

Figure 3b Door measurements

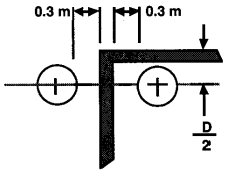

Figure 3c. Partially accessible corner seam measurements

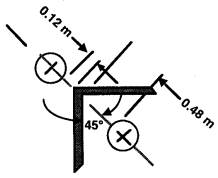

Figure 3d. Fully accessible corner seam measurements

Midrange Measurement (20MHz-300MHz)

The midrange (resonant frequency) procedures directly measure the effect of electromagnetic sources at positions over all accessible surfaces of enclosure.
Signal sources, measuring equipment, and arrangement shall be in accordance with the following sub clauses and Figures 4

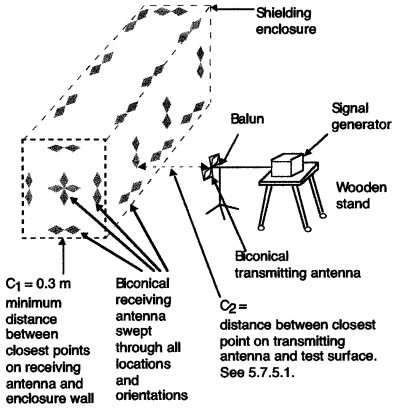

Figure 4. Resonant range measurements setup (horizontal transmitting antenna orientation), 20MHz-100MHz

High-Range Measurements (300MHz-1GHz)

The high-frequency procedure directly measures the effect of high frequency sources at positions over all accessible surfaces of the enclosure. The sources of electromagnetic fields shall be dipoles, biconical antennas, horns, yagis, log periodic, or other linear antenna types. In the range 300MHz to 1 GHz an electric dipole whose overall length is 1/2λ is required.

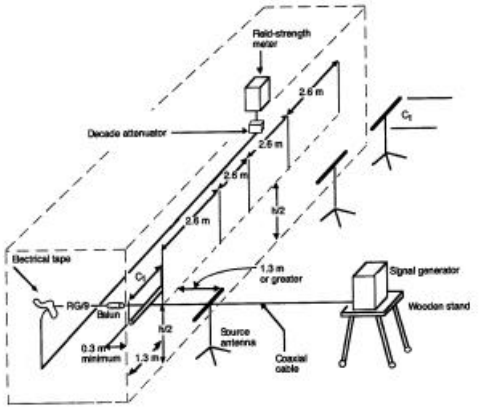

Figure 5. Measurement Setup for frequencies≤1GHz

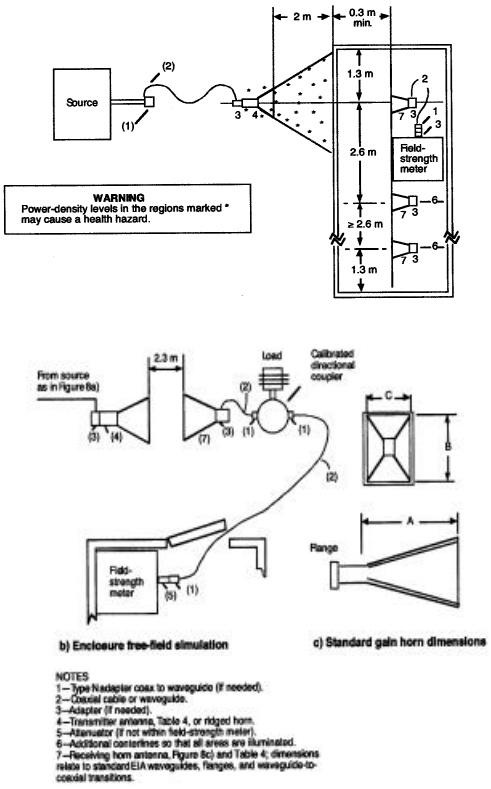

Figure 6. Reference and measurement setup for frequencies >1GHz

Automated Measurement System:

The traditional measurement systems do not allow us to scan a particular frequency range. In this study, a synchronous wireless test system has been used for the effectiveness measurements of enclosures through the shielding enclosures in TUBITAK-EMC Laboratory [3]

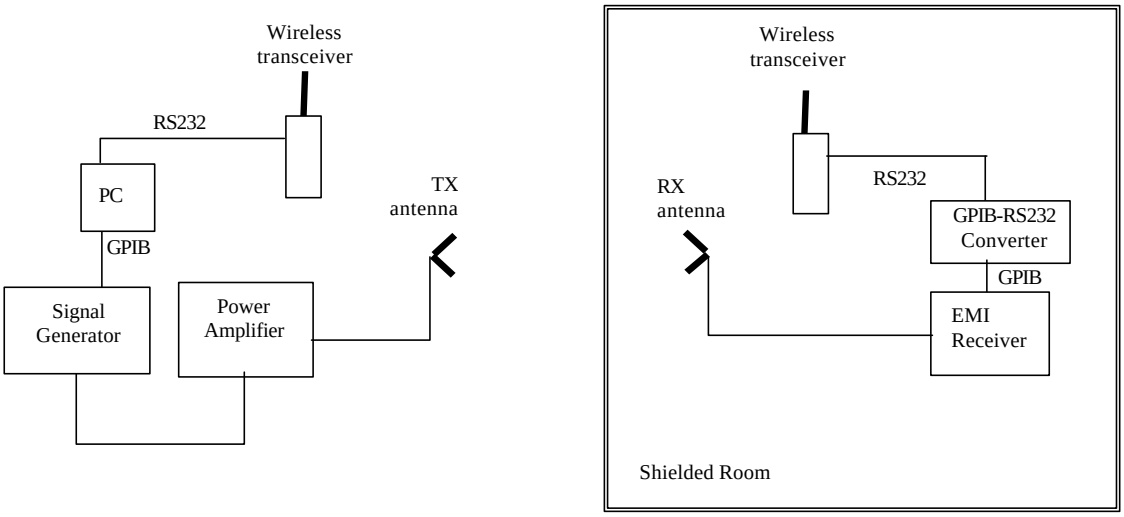

Figure 7. Automated Measurement Setup

The measurement setup shown in Figure 7 can be used the shielding effectiveness of the enclosures. This setup allow us measuring any enclosures automatically by a spread spectrum wireless control system which used for RS232 serial communication for data transfer. Equipment used for this setup is given Table 3.

Table 3. Equipments for ASM2

Device	**Model**
Receiver	HP 7402A
Signal Generator	R&S SMY01
Amplifier	AR 10W
Biconical antennas	Schwarzbeck 1643-1644
Log-Per antennas	Schwarzbeck 217-218
Wireless control system	FreeWave WDT
Personel Computer	HP notebook

III. MEASUREMENTS:

In this section results that obtained by IEEE 299 single frequency method and ASM2 are given in graphical representation. IEEE 299 reference and attenuation measurements setup has been used in ASM2.
In ASM2 equipment has been controlled by a computer program which has written in Lab Windows CVI that based on C++ programming language. Start frequency, stop frequency, number of steps and transmitted power can be set upon request. Reference and atenuation data is recorded and SE is calculated automatically by this program.

Figure 8. Shielded room in TUBITAK-EMC Lab.

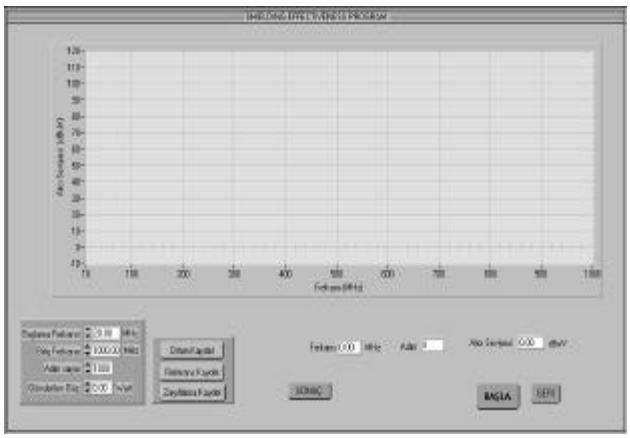

Figure 9. User Interface of ASM2 Computer Programme

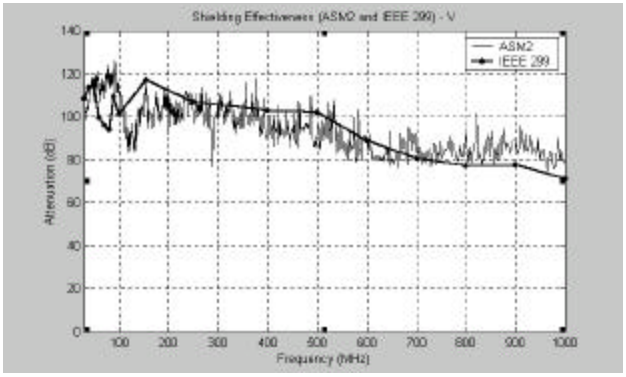

Figure 10. Shielding effectiveness results of the shielded room in TUBITAK-EMC Laboratory for the frequency range from 30 MHz to 1GHz (Vertical Polarization)

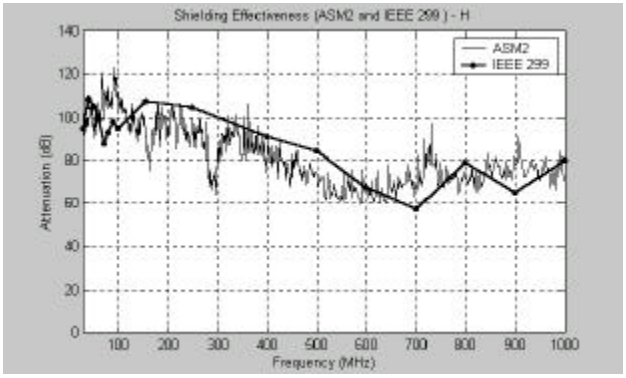

Figure 11. Shielding effectiveness results of the shielded room in TUBITAK-EMC Laboratory for the frequency range from 30 MHz to 1GHz (Horizontal Polarization)

IV. CONCLUSION

- Shielding effectiveness of the shielded room in TUBITAK has been measured by using two different methods.
- ASM2 has been introduced for attenuation test which has used a wireless data transceiver to obtain synchronized frequency steps.
- ASM2 has been carried out by a computer program written in LAB-Windows CVI programming language.
- Two methods have been compared and the best agreement has been obtained.
- It has been seen that ASM2 is a useful and reliable method for shielding effectiveness measurements especially in all frequency range of IEEE 299 method.
- Resonance effects of the enclosures have been observed by this method.

References:

[1] MIL-STD 285 " Attenuation Measurements For Test Purposes, Method of MIL-STD285, 1956 Washington 25, D.C

[2] IEEE STD 299-1997 "IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures" 1997,USA

[3] P.Karacagil, S.Seker, F.Üstüner, N.Ari "Theoretical and Experimental Shielding Study of Offices" *14th International Wroclaw Symposium and Exhibition on "Electromagnetic Compatibility*" June 23-25, 1998