Abstract

This paper presents a feature analysis of two electromagnetic interference test facilities. The one is an anechoic chamber and the other is a reverberation chamber. And then, this paper reviews problems of the current reverberation chamber, the stirrer. In general, a reverberation chamber uses a stirrer to generate a uniform electric field inside it. However, the stirrer is a big sized unit and has rotating parts in it, which makes problems and difficulties in maintenance. To conquest these problems, this paper suggests a diffuser which is commonly used in acoustics. To study the substitution effect of a diffuser, a diffuser and a reverberation chamber for 5.0-7.0 GHz band are designed and fabricated. And then, the real measurement of electric field intensity is done to study the electromagnetic interference characteristics in a reverberation chamber with a diffuser. With the measurement results, it is show that a diffuser satisfies the international standard requirement, which means the reverberation chamber with a diffuser can be used as an official facility for the electromagnetic interference measurement.

Keywords: Electromagnetic Compatibility, Electromagnetic Interference, Reverberation Chamber

1. Introduction

Today, the wide spread use of electronic circuits for communication, computation, automation, and other purpose makes it necessary for diverse circuits to operate in close proximity. All too often these circuits affect each other adversely. Electromagnetic interference has become a major problem for circuit designers, and it is becoming more severe these days [1-17].

An anechoic chamber (an-echoic meaning non-echoing or echo-free) is a room designed to completely absorb reflections of either sound or electromagnetic waves. As shown in Figure 1, it is also insulated from exterior sources of noise. The combination of both aspects means they simulate a quiet open-space of infinite dimension, which is useful when exterior influences would otherwise give false results. Anechoic chambers, a term coined by American acoustics expert Leo Beranek, were originally used in the context of acoustics (sound waves) to minimize the reflections of a room [18]. More recently, rooms designed to reduce reflection and external noise in radio frequencies have been used to test equipment under test (EUT), antennas, radars, or electromagnetic interference.

On the other hand, the concept of a reverberation chamber was suggested by H. A. Mendes in 1968 and it has been studied to be used as a measurement facility for electromagnetic interference tests by National Bureau of Standards (NBS) [19][20]. And International Special Committee on Radio Interference (CISPR) under International Electro-technical Commission (IEC) has established various international standards related to a reverberation chamber [21][22]. Moreover, as the recent international standard expanded the regulation frequency band for electromagnetic interference to 1-18 GHz, the reverberation chamber is given much prominence today [21]. As shown in Figure 2, a reverberation chamber is screened room with a minimum of absorption of electromagnetic energy. Due to the low absorption, very high field strength can be achieved with moderate input power. Therefore, the spatial distribution of the electric and magnetic field strength is strongly inhomogeneous (standing waves). To reduce this inhomogeneity, one or more stirrers are used. A stirrer is a construction with large metallic reflectors that can rotate to different orientations in order to get different boundary conditions. The lowest usable frequency (LUF) of a reverberation chamber depends on the size of the chamber and the structure of the stirrer [19][20]. Small chambers have a higher LUF than large chambers.
**Figure 1.** Structure of an anechoic chamber

Emission = Reception = 10

**Figure 2.** Structure of a reverberation chamber

Emission = Reception – Field Strength

= 13 – 3 = 10
2. Diffuser

As mentioned above, a diffuser is commonly used in acoustics to diffuse sound waves and is made of wood. As sound waves and electromagnetic waves can be analyzed as the same in wave point of view except the only difference of the frequency band, this paper designed with Quadratic Residue Sequence theory and fabricated a diffuser that is made of metal instead of wood as shown in Figure 3 [18].

In the structure of a diffuser, the width ($W_{well}$), the depth ($d_{well}$), and the number ($N_{well}$) of the well are the main factors, and they can be determined by Equations (1)-(3).

\[
W_{well} = \frac{\lambda_{\text{max}}}{2}
\]  
\[
d_{well} = \left(\frac{S}{N_{well}}\right) \left(\frac{\lambda_{\text{max}}}{2}\right)
\]

with

\[
N_{well} = 2m \left(\frac{\lambda_{\text{max}}}{\lambda_{\text{min}}}\right), (m = 1, 2, 3, \ldots),
\]

where $\lambda_{\text{max}}$ is the wave length of $f_{\text{max}}$ and $\lambda_{\text{min}}$ is that of $f_{\text{min}}$ [22]. In Equation (3), the greater the value of $m$, the better the field uniformity in the reverberation chamber. However, when the value of $m$ is over three, the diffuser cannot be attached in the reverberation chamber because of its big size. With this reason, $m$ is set as two in this paper.

3. Reverberation chamber

As mentioned above, this paper is to analyze electromagnetic interferences in a reverberation chamber for 5.0-7.0 GHz band and to prove the efficiency of a diffuser. A simple comparison of reverberation chambers is shown in Figure 4 and 5: (A) a reverberation chamber with a stirrer, (B) a reverberation chamber with a diffuser. In Figure 3 and 4, it can be easily seen that a reverberation chamber with a diffuser has more simple structure and much larger test space in the reverberation chamber than that with a stirrer.

International standard IEC 61000-4-3, IEC 61000-4-21, and National Bureau of Standards Technical Note 1092 require an official electromagnetic interference test facility to have the field uniformity in a reverberation chamber within ±6 dB tolerance and ±3 dB standard deviation [20-22]. Thus, this paper is to validate the effect of the diffuser with its tolerance and standard deviation. In other words, this paper focuses on whether the field uniformity in a reverberation chamber with a diffuser is within ±6 dB tolerance and ±3 dB standard deviation.
4. Measurement

In this paper, all the measurement method and procedure for analyzing the field uniformity in the reverberation chamber with a diffuser are followed by those of IEC 61000-4-3 and IEC 61000-4-21 international standards [21][22]. To validate the substitution effect of the designed diffuser, the measurement for analyzing the electric field uniformity in the reverberation chamber was done. The positions of the test volume, a diffuser, and the transmitting antenna as a source point are as shown in Figure 6. Electric field strengths are sampled at 80 test points in a test volume [23-25].

The detail structure of the test volume and test points is as shown in Figure 7. The test volume for analyzing the electric field uniformity in the reverberation chamber has five test planes, and each test plane has 16 test points. Thus, the total number of the test point is 80 (16 test points per a test plane five test planes) [24][25].
Figure 6. Measurement set up

Figure 7. Five test planes and X=70 plane
5. Measurement result

A signal generator (HP/Agilent, Model: E4433B) generated signals of 1 V at 5, 6, and 7 GHz, and the electric field strengths for each frequency is measured with an isotropic field probe (Amplifier Research, Model: FP5080).

As previously mentioned above, this paper focuses on whether the field uniformity in a reverberation chamber with a diffuser satisfies the requirement of the international standard, ±6 dB tolerance and ±3 dB standard deviation [20]. Table 1 shows the measured electric field strength in the reverberation chamber with a diffuser. Moreover, it also shows that the electromagnetic interference test requirements of NBS, the tolerance and the standard deviation, are satisfied by the diffuser.

![Figure 8. Measurement system](image)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Max.</th>
<th>Min.</th>
<th>Average</th>
<th>Tolerance</th>
<th>Standard deviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 GHz</td>
<td>63.8</td>
<td>60.9</td>
<td>62.3</td>
<td>2.9</td>
<td>5.9</td>
</tr>
<tr>
<td>6 GHz</td>
<td>63.1</td>
<td>60.2</td>
<td>61.6</td>
<td>2.9</td>
<td>5.9</td>
</tr>
<tr>
<td>7 GHz</td>
<td>62.7</td>
<td>59.9</td>
<td>61.3</td>
<td>2.8</td>
<td>5.7</td>
</tr>
</tbody>
</table>

6. Conclusion

With the measurements, the sampled data of the electric field strength were analyzed to investigate the electric field characteristics inside a reverberation chamber. The measurement results show that the field uniformity in the reverberation chamber with a diffuser meets ±6 dB tolerance and ±3 dB standard deviation of field uniformity characteristics, and this means that the requirement of NBS for the field uniformity condition at 5, 6, and 7 GHz was obtained by the fabricated diffuser.

7. Acknowledgement

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8. References


