A SIMPLE UNQUE METHOD OF TESTING THE SHIELDING EFFECTIVENESS MEASUREMENT OF FARADAY BAG IN A SMALL RC-LIKE CAVITY

ABSTRACT

Following the conception of small electronic devices and their applications in recent times, there is the growing need to determine and test the shielding properties or shielding effectiveness (SE) of their enclosures. In this paper, we discuss how a reverberation chamber technique employing a comb generator can be used to measure the shielding SE of such enclosure. The comb generator has been a necessary test instrument for electromagnetic (EMC) test labs over the years and because of its ease of operation, it has found application in a variety of EMC test measurements such as cable loss measurement and radiation emission system test. We present here the result of testing the SE of a Faraday enclosure bag in a small RC-like cavity employing a broadband bowtie receive antenna and the same test procedure conducted at 1 meter distance from a receive antenna in a standard mode stirred reverberation chamber (MSRC). The striking positive correlation between these test results seem to suggest that SE tests of Faraday bag can be conducted in an RC-like cavity which is significantly less costly and offers a cheap alternative.

1. INTRODUCTION

Reverberation chamber has been extensively used in the past for different EMC measurements. It has been used generally for emission and immunity test measurements. It has equally been used for antenna efficiency measurements, characterization of EM environment, data cable measurements and shielding effectiveness measurements. The reverberation chamber is an electrically large, conductive enclosure used to carry out electromagnetic tests. It consists of a rectangular cavity with one or more metal mode stirrers that continuously stir the electromagnetic field to achieve field uniformity inside the chamber. Typically, the chamber is equipped with a transmit antenna that sends out the RF signal and a receive antenna that acts as a reference for most of the tests. When a transmit antenna sends out the RF signal, electromagnetic wave energy associated with the RF signal is reflected between the walls of the chamber and the mechanical stirrer up to a time when the mode of the electric field distribution inside the chamber becomes stable to satisfy the electromagnetic boundary condition. Under this condition, the equipment under test (EUT) which is subjected to the influence of the uniform distributed field energy is now completely bathed by it. The effect of the field energy on the EUT is monitored and recorded and in most cases, weighed against that measured by the reference antenna. The distinction between the RC and the anechoic chamber is that unlike the RC where the electromagnetic energy is constantly reflected by the walls, antennas, EUT, etc., the anechoic chamber has absorber materials that absorbs most of the electromagnetic wave energy.

Although the use of RC has some disadvantages, its advantages [1], as listed below, far out way the disadvantages:

1. The tests are repeatable and reproducible
2. Robust test
3. Replicates the EME close to real world (especially electronics inside cavity)
4. More field strength for less input cavity power

5. Facility cost is significantly less
6. Low uncertainties
7. Results are correlatable under certain conditions.

Existing research recognizes that nested chamber fitted with monopole probe can be used inside a large size RC for shielding effectiveness measurement. [2] Illustrated the use of the nested RC technique using frequency stirred RC to determine the SE of physically small, but electrically large enclosure and cavity. [2] Posited that the "the use of conventional paddle mode stirring in a small enclosure would be problematic, i.e. in most applications of measuring with small enclosures, it may not be possible to place a small mechanical stirrer inside the enclosures".
In this paper, we tried to overcome this problem by constructing an 812.80mm x 438.00mm x 508.00mm cavity with a handle paddle as shown in Fig 1.

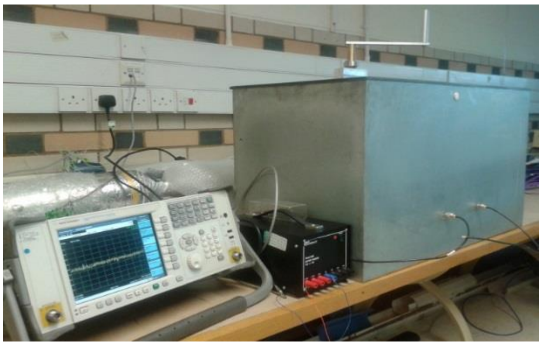

Fig 1 Showing the RC-like Cavity with hand paddle & instrument connection.

The cavity has a broadband bowtie receive antenna fitted at one of its ports. The purpose of the paper is to develop a unique method of measuring the SE of shielding bags using small and affordable cavity-styled RC. The specific objective of this study is to use a comb generator which radiates RF signal through a 2.4 GHz Wi-Fi antenna, a broadband bowtie receive antenna, an Agilent CAS N1996A Spectrum Analyser to monitor and record both the open-air and the shielded test results. The hand paddle stirrer stirred around the transmitted energy creating a statistically uniform field environment that replicates a worst case scenario in real live. The remaining part of this paper is organizes in the following way; Section 2 discusses how shielding bags provided a kind of faraday cage protection to electronic devices and looks at their advantages. Section 3 introduces the cavity-styled RC and the use of comb generator. Section 4 shows the instrument setting of the Agilent CAS N1996A Spectrum analyser and the experiment setup. Section 5 discusses the result.

2. SHIELDING EFFECTIVENESS TESTING IN RC

The whole purpose of SE testing in an RC is to block the electromagnetic field generated in the chamber with barriers made of conductive or magnetic materials from passing through the materials. SE tests can typically be carried out on gasket materials, connectors, small enclosures and electronic devices. And this can be applied across a wide range of frequencies. To reduce the coupling of noise and radio waves, shielding can be employed. The amount of reduction of the coupled signal may vary depending on the type of material used, its thickness and the frequency of concern. Shielding bags provide a kind of faraday cage protection to electronic items and ensure that devices are protected from external interferences. Such electronic devices like cell phones, computers, etc., may contain important digital information and if their security features are not enabled, stored information may be altered, deleted or extraneous data added to corrupt the device. Such device may even by tracked by unknown persons. Other benefits of using shielding bags [3] include:

- Avoids the problem of the device becoming PIN bucked
- Avoids the problem of the device becoming PUK locked
- Speeds up investigation times
- "Lab Edition" models have a window that allows user to preview evidence on suspects device, secure in the knowledge that the device is being investigated without fear of remote access
- They are re-usable and portable, etc.

Because of the importance of preserving our data and information using shielded bags, this test proposes a technique for testing the SE of existing shielding bags. The paper aims to develop a simple unique way to test the level of shielding provided by existing shielding bags.

3. METHOD

To date, various methods have been developed and introduced to measure the shielding effectiveness of materials. The method of using a small dimensioned cavity-styled RC in this study is uniquely useful because the test is easier, faster and the facility is extremely affordable.

In this section, we introduce the comb generator as the transmitter of the reference signal. The comb generator is an electronic device that generates very short, fast pulses with sharp rise and fall times [4]. The pulses are continuously repeated as frequency, which translates into a series of frequencies that are multiples (harmonics) of the fundamental frequency in the frequency domain. When the spectrum analyser is used to view the wide frequency span, the display resembles a comb: hence the name comb generator [5]. The most common use of the comb generator is as a broadband frequency synthesizer where the high frequency components of the generated signal are used as stable references corresponding to the lower energy references. In this test, the comb generator was used as a radiation emission test instrument. Unlike a typical RF signal generator that is usually bulky, requires AC power, takes time to setup and configure to desired frequency and amplitude, the comb generator is small, quick, portable and battery powered to eliminate the possibility of external cables affecting the radiated signal [6].

4. THE EXPERIMENT SETUP

Fig 1. Shows the experiment setup. It consists of a hand-held paddle that manually stirs the field energy generated by the comb generator inside the cavity.

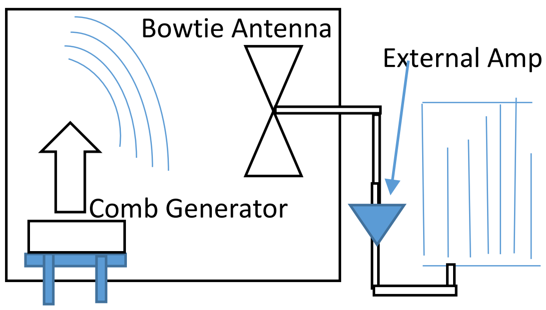

Fig 2. Setup diagram for SE test in a RC-like cavity

Spectrum
Analvser

A broadband bowtie antenna was used to monitor the energy level inside the enclosure. The bowtie antenna was connected to the signal analyser through an amplifier using BNC/SMA connector. It must be noted that the bowtie antenna was soldered at its feed point with the connector such that impedance mismatch between it and the pre-amplifier is minimized. The instrument setting of the spectrum analyser was as given below:

Specifications	
Start frequency	500MHz
Stop frequency	3GHz
Instrument attenuation	0dB
Instrument Reference level	-20dB
Resolution Band width	300Hz
Instrument Pre-amplifier	ON
External amplifier	OFF

One of the assumptions made in this experiment was to assume that the impedance of the bowtie antenna together with the line propagation losses, provided input attenuation to limit the signal power in the spectral lines of emission from the comb generator not to overload either the pre-amplifier or the spectrum analyser [7]. Finally, the faraday bag was used to completely cover the comb generator as shown in Fig 2; and the extent to which the bag could shield the energy radiating away for the comb antenna was monitored using the signal analyser.

Fig. 3: Showing the comb completely covered by the Faraday bag

TEST 1

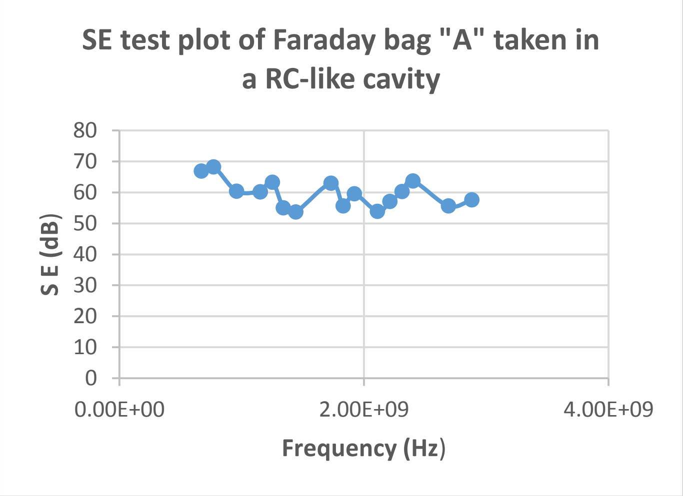

Fig 3: Showing test result of test of Faraday bag “A” in RC-like cavity

TEST 2

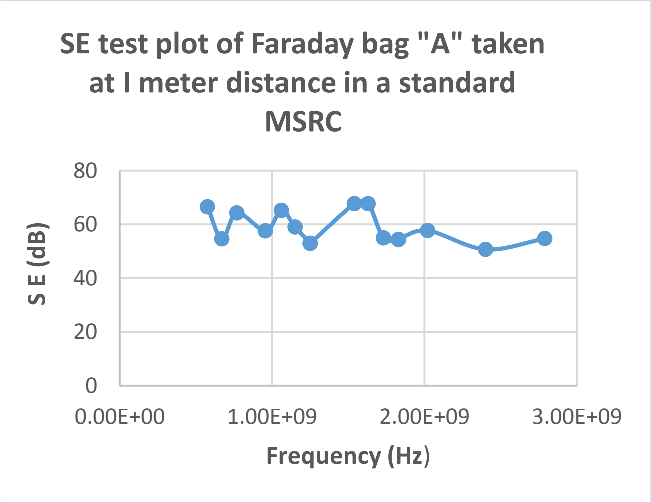

Fig 4: Showing test result for Faraday bag “A” at 1 m distance in standard chamber

TEST 3

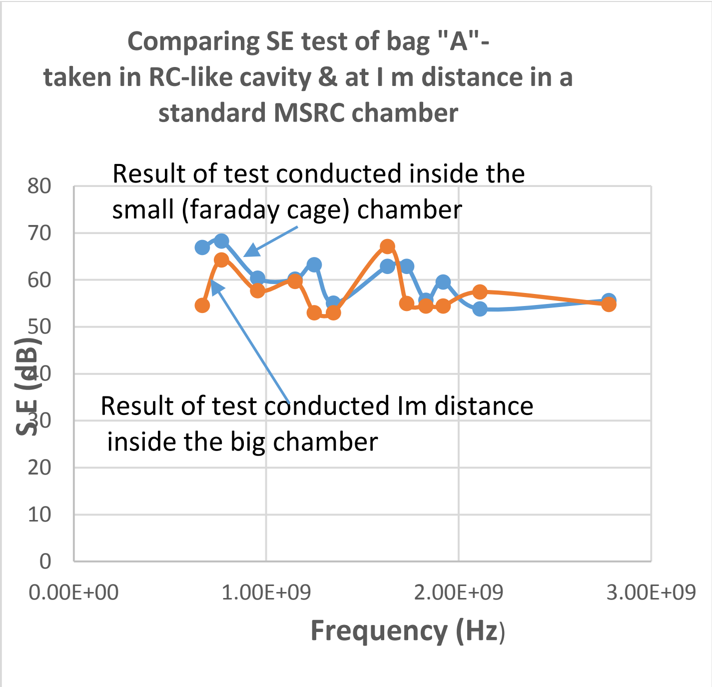

Fig 5: Shows result of comparing Test 1 & 2.

TEST 4

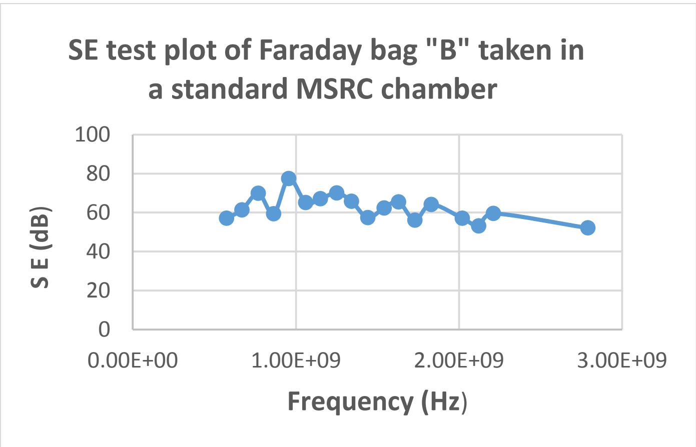

Fig 6: Showing test result for Faraday bag "B" in a standard RC

TEST 5

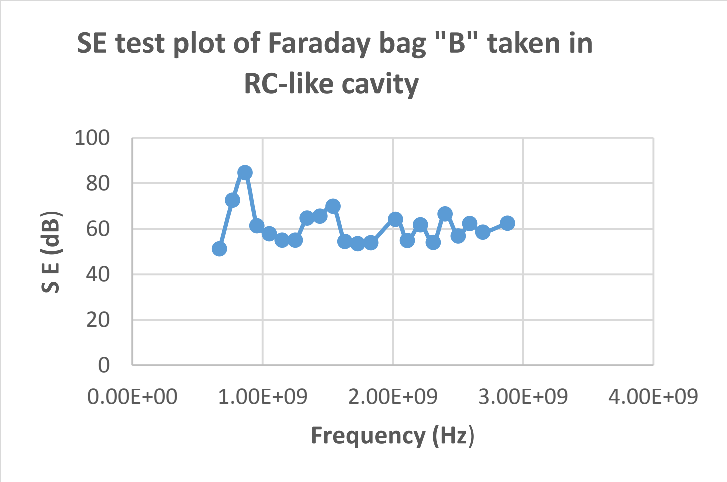

Fig 7: Showing test result for bag "B" in RC- like cavity

TEST 6

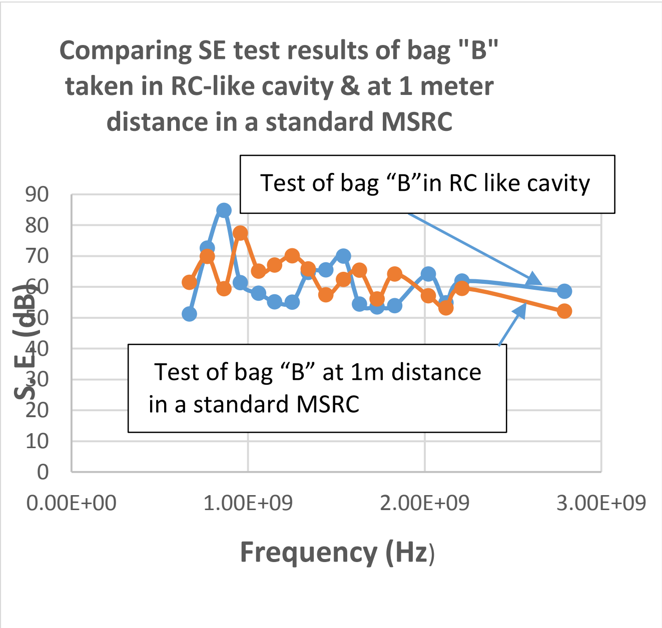

Fig 8: Showing result of comparing Test 4 & 5

5. RESULTS & DISCUSSION

Fig 3 presents the SE plot of the Faraday bag from the experiment as shown in shown in Fig 2.

Fig 4 shows the SE plot of the same Faraday bag from the experiment shown in Fig 2 and conducted at 1 meter distance in a standard mode stirred reverberation chamber.

In fig 5, the result of the correlational comparison between Fig 3 and Fig 4 is shown. One possible implication of studying fig 3 and fig 4 would seem to suggest that SE of the faraday bag tested in this experiment is between 52.02dB – 53.84dB. From the chart, it can be seen that there was a significant positive correlation between the result obtained in the small cavity and the result obtained at 1 meter distance inside the standard reverberation chamber.

The correlation in this result is most striking because when the test was repeated with same faraday bag of smaller dimension (about 1.5ft x 1ft x), the results were almost the same as shown in fig 8.

Comparing fig 6 and fig 7, the graphs maintained almost the same trend in their “peaks” and “valleys”.

However, this type of test result has not previously been described. Despite these promising results, some questions remain to be answered namely understanding the rational for choosing the peaks above the instrument noise floor in the experiment and setting their threshold in the plot.

6. CONCLUSION

This experiment was undertaken to design a simple but unique method of testing the shielding effectiveness measurement of Faraday bags in a small RC-like cavity using a comb generator RF signal.

The outcome of this work has shown that the cavity styled RC can be used to measure SE of enclosures.

When the SE test of same type of Faraday bag but with different dimensions was taken, no major significant difference in the result was shown. The second major finding of this experiment is that repeating this experiment with the same instrument setting and using an external amplifier, no significant difference could be found when the test was conducted at 1 meter distance in a standard RC. Taken together, these findings suggest that SE of Faraday bags can be measured in a small RC-like cavity. This work will obviously serve as a base for future studies of using the small RC-like cavity for SE measurement of other enclosures.

7. REFERENCES

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