York EMC Services Ltd

AN003

Evaluation of Anechoic Chambers For EMC Measurements Using A CNE

Overview

Anechoic chambers are used for EMC testing primarily for radiated emissions (RE) and radiated immunity (RI) in the frequency range from 30MHz to 1GHz with extensions to 18GHz, or even 40GHz becoming more frequent.

The chamber performance is dependent on a number of parameters as discussed below. In order to calibrate a chamber there are strict measurement procedures that should be followed, however it is possible to evaluate the chamber performance by a simple and quick measurement using a Comparison Noise Emitter (CNE).

This application note presents results for three chambers and clearly demonstrates the usefulness of the CNE for quickly evaluating chamber response. It also gives the reader an indication of what to look for when analysing the results.

Review of the CNE

The CNE is a continuous broadband noise source, there are three models available with a usable output from 9kHz to 7GHz, applications include:

- As a reference source for Radiated and Conducted measurement systems:
    - Daily pre-test checks
    - Long term performance monitoring
    - Cable position investigation
- Investigation of measurement environments such as Open Area Test Sites (OATS), Anechoic Chambers, Screened Rooms, GTEM Cells.
- Characterising filter performance
- Measuring cable losses

The units are battery powered so they can be operated without interconnecting cables affecting the measurements. Table 1 below describes the models available.

	CNE III 9kHz to 2GHz Conducted and radiated output
	CNE V 150kHz to 1GHz Conducted and radiated output
	CNE VII 1.5GHz to 7GHz Radiated output only

Table 1—CNE Descriptions

Review of EMC Chambers

Anechoic chambers used for EMC measurements can be divided into two major groups:

- Pre-compliance – testing is for pre-compliance or research and development
- Full compliance – testing to the requirements of standards

The physical size of the chamber determines whether it is possible to be fully compliant for emission measurements. A minimum height of 6m is required to achieve full compliance for most RE standards. Many chambers are limited in height by the building structure they are housed in, and it is common to find chambers up to 3m in height, commonly referred to as compact chambers. These chambers can be fully compliant for RI measurements and are therefore found in accredited test laboratories where the RE measurements are made on an OATS. In this scenario the test chamber is generally used for pre-compliance RE testing or initial RE testing to determine the test plan for the OATS, it is therefore important to know the chamber characteristics even if full compliance is not achievable.

Review of absorber technology

An anechoic chamber used for EMC measurements consists of an RF shielded room with RF absorber materials installed on the four walls and ceiling and possibly on the floor. There are 3 basic types of absorber:

- Ferrite tiles – Useable frequency range 30MHz to 1GHz. Space efficient but heavy and cannot be used for high frequencies.
- Hybrid absorber – Useable frequency range 30MHz to 18GHz. This combines ferrite tiles with microwave pyramidal foam. The foam must have a good impedance match with the ferrite.
- Microwave pyramidal absorber – Useable frequency range 100MHz to 18GHz. Low frequencies are limited by the depth of the absorber, for example, a depth of 2.4m is required at 30MHz.

Review of the CNE Response

The broadband nature of the CNE output makes it ideal for observing any reflections in the chamber's response and it becomes a useful tool for enabling a quick measurement to determine the acceptable frequency range of the chamber.

The CNE output can be measured with or without an antenna; that is conducted or radiated. The conducted output is simply the CNE connected directly to a receiver as shown in figure 1. The radiated test set-up on an OATS is shown in figure 2. Typical plots for both tests are shown in figures 3 and 4 respectively. Measurements were made using a Rohde and Schwarz ESVS30 Receiver with a Resolution Bandwidth (BW) of 120kHz.

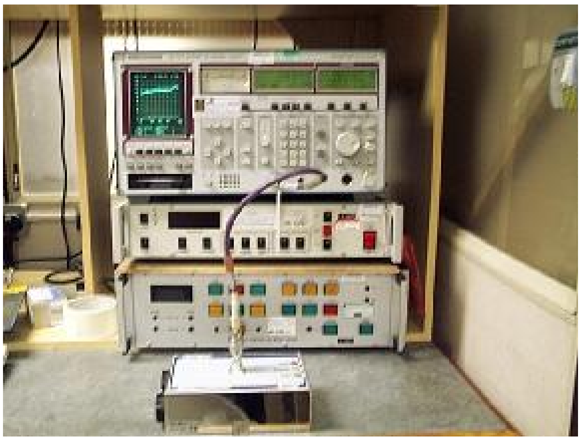

Figure 1 – CNE III Direct Output

Figure 2 – Typical Open Area Test Site

Comparing the direct result with the OATS, above 300MHz there is a good correlation between the two, the radiated results have a higher amplitude variation due to the frequency response of the transmit and receive antennas and also the effect of the ground plane reflections. Below 300MHz the frequency response of the antennas is much more dominant and introduces significant losses due to the inefficiencies of the antennas in this frequency range, particularly the CNE transmit antenna.

The response expected from a chamber should be similar to that of the OATS. If the absorber is not effective over the frequency range being tested reflections are introduced, which generate large ripples in the amplitude response making the chamber unusable.

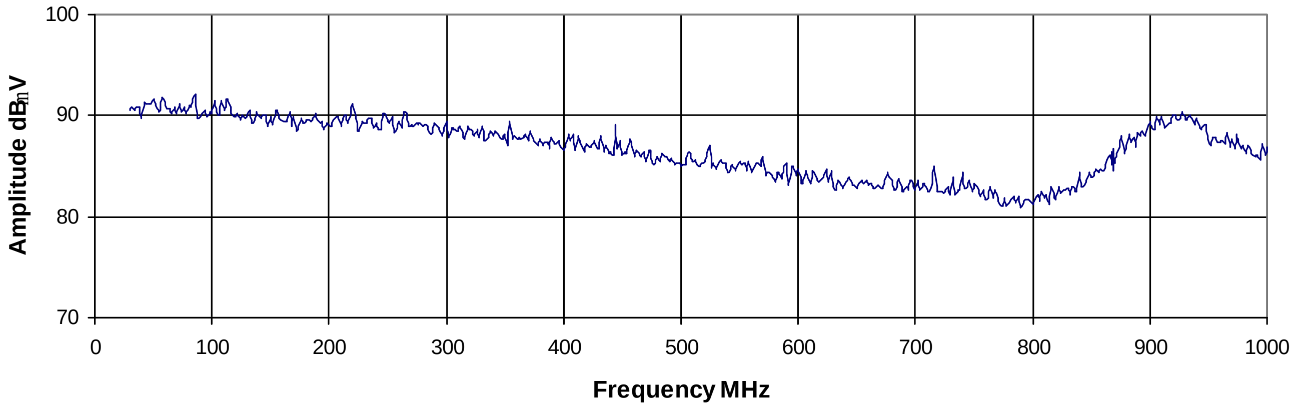

Figure 3 - CNE III Direct Output

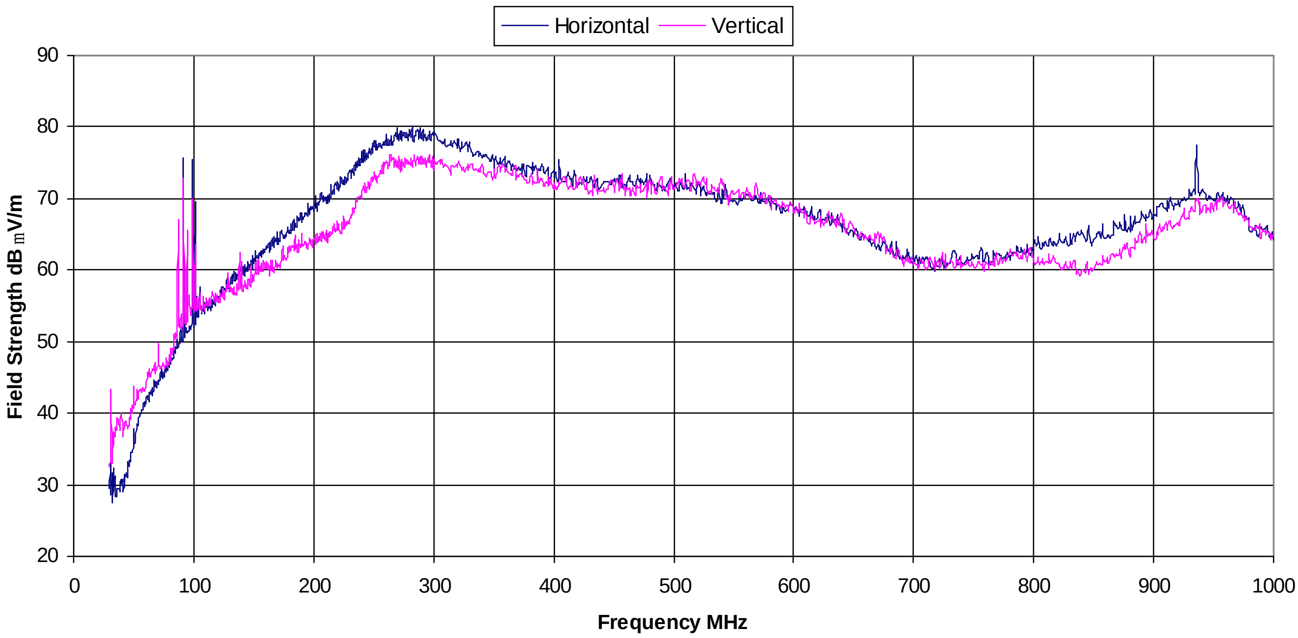

Figure 4 - CNE III Radiated Output @3m on an OATS

Chamber performance using a CNE

Three chambers were measured for the purpose of evaluation, table 2 lists their absorber type and size. All measurements are made at a 3m test distance.

The following section shows the results for the various chambers, the vertical plots only have been presented since the horizontal and vertical plots should be the same if the chamber is fully anechoic.

Chamber reference	Absorber	Size m (L, W, H)
Ch A	Ferrite tiles	7.0, 3.5, 3.0
Ch B	Hybrid absorber	6.7, 3.5, 4.0
Ch C	Pyramidal foam	7.0, 4.0, 2.8

Table 2

Test Set-Up

The test set up for measurements up to 1GHz is shown in figure 5

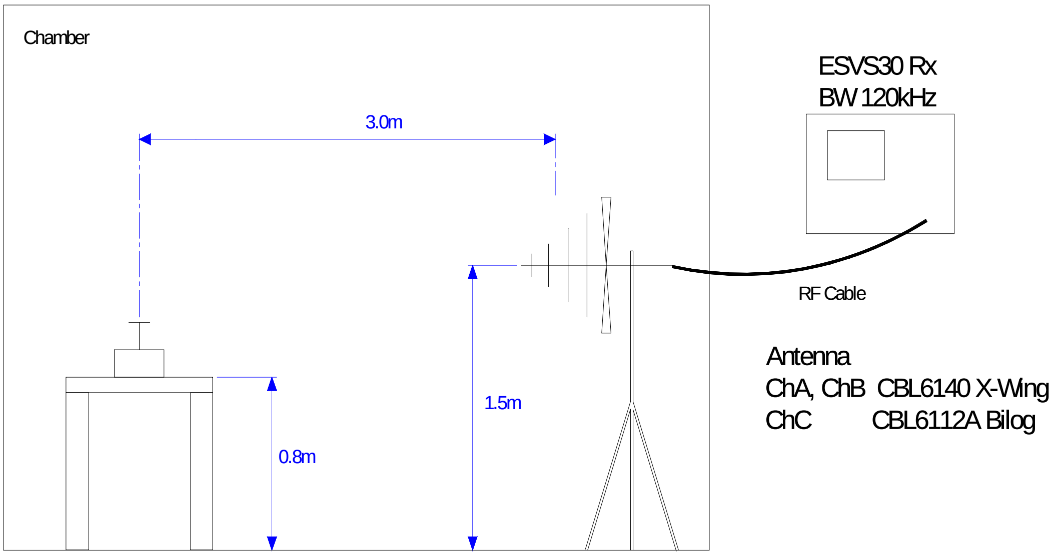

Figure 5 - Test Set-Up for 30MHz to 1GHz

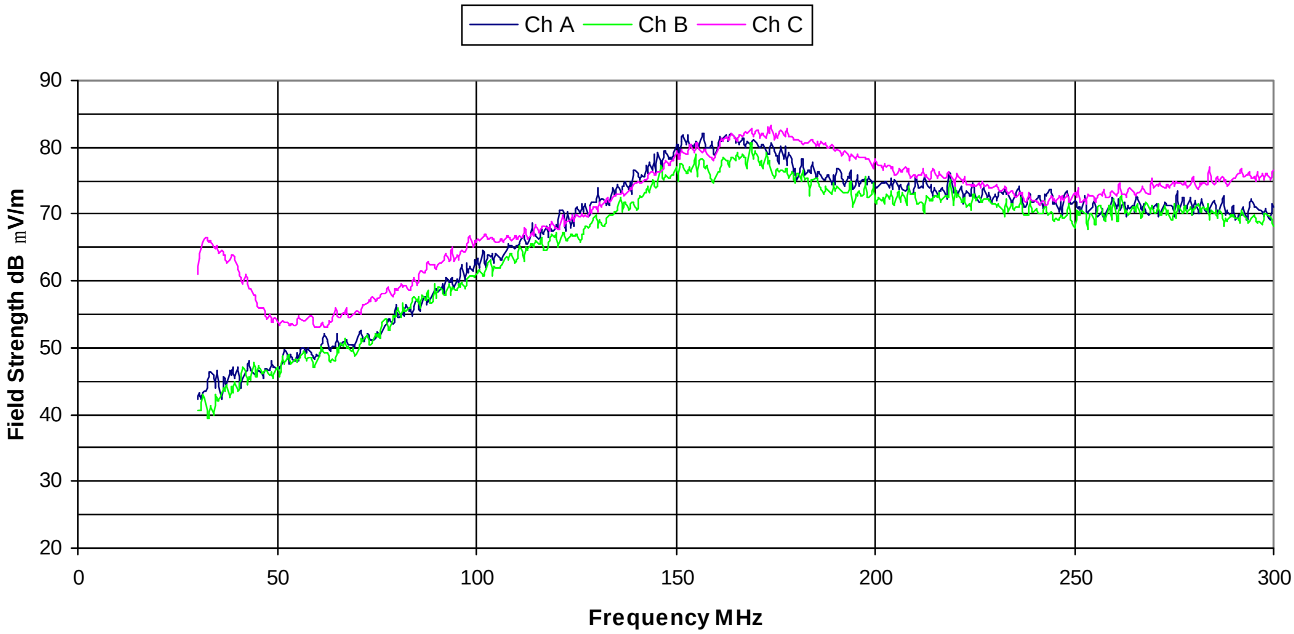

Figure 6 - 30MHz to 300MHz

30MHz to 300MHz

Figure 6 shows the results for the three chambers, Ch A & Ch B are very comparable in this frequency range. There is an unusual response from Ch C below 100MHz due to the inefficiency of the pyramidal absorber at these frequencies thus this chamber is not recommended for use below 100MHz.

30MHz to 1GHz

Ch A has a higher ripple content compared to the other two chambers due to the ferrite tiles being less absorptive than the hybrid or pyramidal foam, however there are no sharp resonances and therefore the response of all three chambers is probably acceptable. **Note**: this only applies above 100MHz for Ch C, see figure 7.

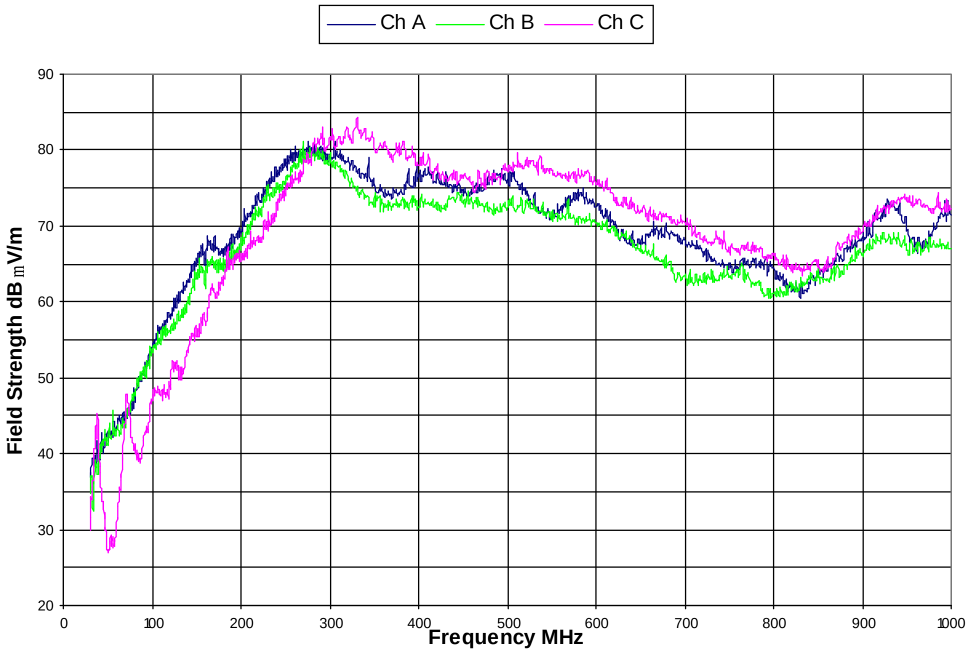

Figure 7 - 30MHz to 1GHz

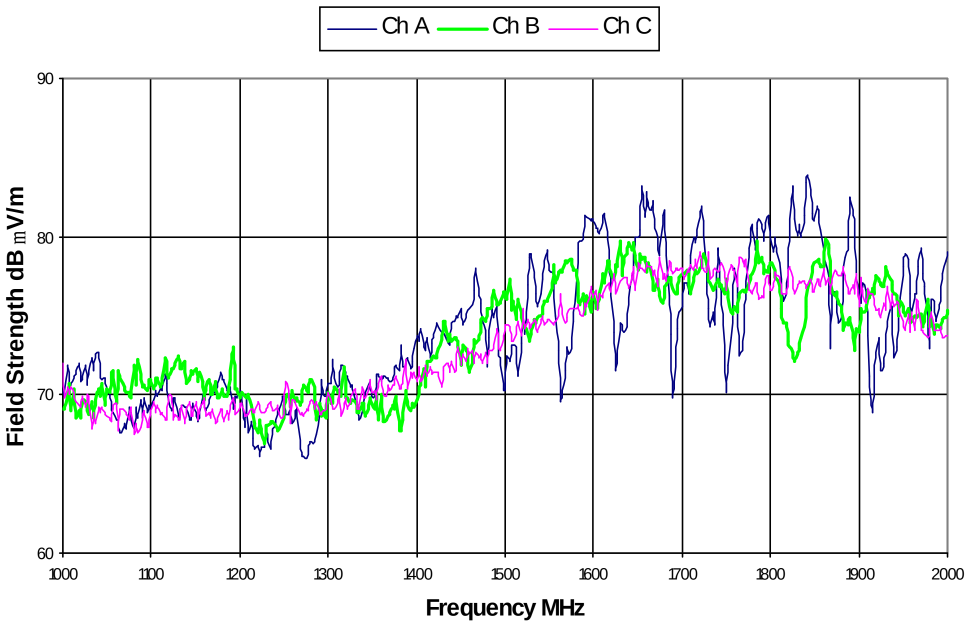

Figure 8 - 1GHz to 2GHz

1GHz to 2GHz

Above 1GHz the ripple in Ch A response is much more dominant due to the inefficiency of the ferrite tiles in this frequency range and therefore this chamber is not recommended for use above 1GHz. Ch B is starting to show an increase in the ripple but it is within an acceptable level. Ch C has a relatively smooth response and is a good choice in this frequency range.

Measurements made with HP8594E spectrum analyser, RBW 100kHz, VBW 10kHz. Rx antenna: EMCO double ridged waveguide horn.

1GHz to 7GHz

The ripple which was seen in figure 8 for Ch B appears to improve again above approximately 2.5GHz. It is unlikely that this is due to a poor match between the ferrite tiles and the hybrid foam but may indicate a low carbon content in the foam itself. In comparison Ch C still displays a relatively smooth response. Ch A was not measured over this frequency range.

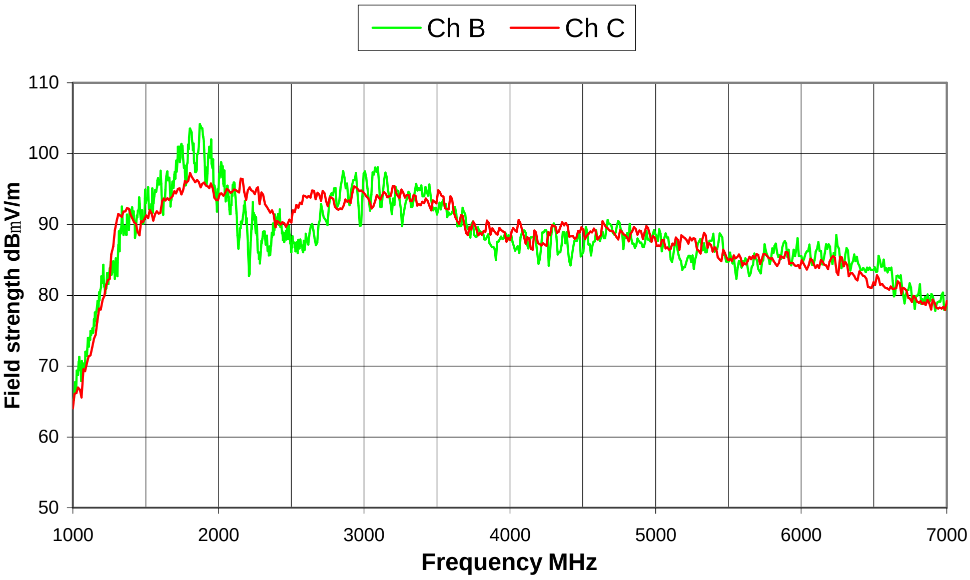

Figure 9 - 1GHz to 7GHz
Measurements made using MS2663B spectrum analyser, RB/VB 1MHz

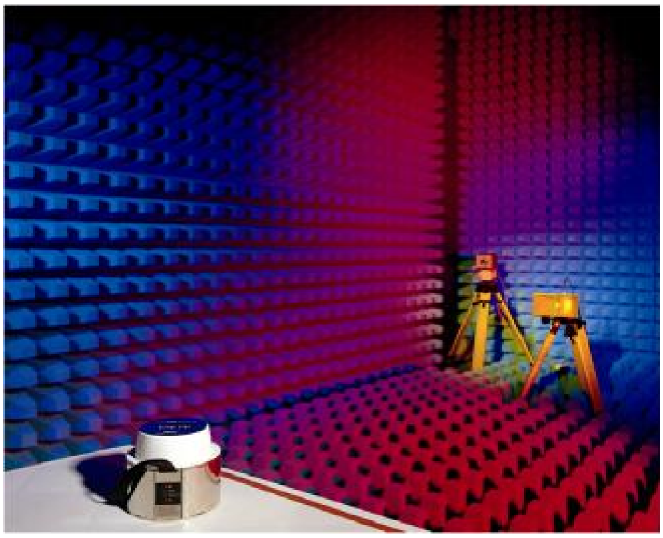

Figure 10 -1 to 7GHz Test Set-up

Standards

Radiated emission requirements are covered by CISPR 16-1, this defines the Normalised Site Attenuation (NSA) validation method and criteria. This method is well known for being probably the most difficult criteria for any given chamber to pass. The NSA level of the site must be within +/-4dB for measurements to be considered comparable to an OATS, however this method requires a ground plane for the frequency range 30MHz to 1000MHz and a height scan from 1 to 4m.

The standards do not currently have procedures for validating sites above 1GHz, although CISPR 16-2 is intended to cover this frequency range; in practice, chambers designed for working above 1GHz will often be validated using the Free Space Transmission Loss method. This method is essentially the NSA method with a few changes. The floor is fully or partially lined, antennas are calibrated in free space, the receive antenna is at a fixed height and the measured results are normalised to theoretical free space.

Conclusions

The results presented demonstrate the ease with which a CNE can be used to quickly verify the chamber characteristics. Although the chambers used in this article are all fully lined compact chambers the same technique can be used for partially lined screened rooms and GTEM cells.

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