Using Reverberation Chamber for Vehicle Radiated Emission Measurement

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***Abstract*— This paper explored the possibility to make use of a reverberation chamber for vehicle level RF emission measurement. A chamber calibration and site attenuation evaluation method is described along with a comparison of measurement results with ALSE. The RF radiated emission test of a passenger vehicle is conducted in both reverberation chamber and ALSE respectively, and the correlation between reverberation chamber and ALSE is presented.**

I. Introduction

The international standard CISPR 12 is a widely using document for vehicle radiated emission measurement. Absorber Lined Shielded Enclosure (ALSE) is often used for the purpose of vehicle certification and development test. However the tests are limited by the pre-defined vehicle positions and the results may not reflect the entire vehicle RF radiated emissions. The IEC standard 61000-4-21 describe in detail the calibration and test method of a reverberation chamber for radiated immunity and emission test, and the vehicle reverberation test chamber (VRTC) has potential for performing thorough vehicle level radiated emission measurement.

This paper proposes a method based upon the correlation between reverberation chamber and ALSE to make use of reverberation chamber for radiated emission test.

II. Chamber Calibration

A reverberation chamber is a metallic shielding enclosure furnished with a stirrer assembly to perform electromagnetic measurements. Except lower cost of construction and maintenance, an advantage of reverberation chamber is the ability to generate a statistically homogeneous electromagnetic field. The field uniformity of the ARTC reverberation chamber has been verified for RF radiated immunity test purpose. A practical method is proposed to evaluate the site attenuation characteristic of the reverberation chamber for RF radiated emission measurement purpose.

A. Setup

A test area of 5.5m(L)x2.9m(W) is defined in the ARTC reverberation chamber, as shown in Fig. 1. The Comb generator is placed one meter high at locations A1, A2, A3, A4, and A5 respectively, maintaining the stirrer rotation at speed 6 rpm, and use the Maximum Hold function to read the peak values as the settings below:

- Sweep Time: 500 ms
- Resolution Bandwidth: 120 kHz
- Video Bandwidth: 300 kHz
- Number of Sweep: 40 times
- Detector: Peak and Average

Measurement results of the 5 locations are shown in Fig. 2, and it can be seen that these five curves have similar contour. .

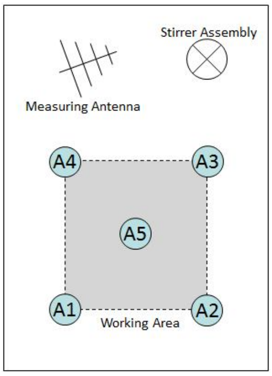

Fig. 1 Reverberation Chamber Calibration Setup

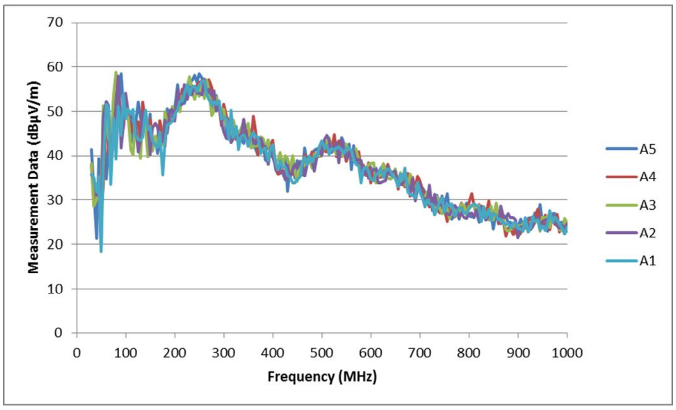

Fig. 2 Noise source measurement results

B. Site Attenuation Validation

The field uniformity of ARTC reverberation chamber has been validated for the purpose of radiated immunity test. In order to figure out possible deviation of measurement among the noise source that placed on the corners and center of the working area, the differences between A1 and A5, A2 and A5, A3 and A5, and A4 and A5 are shown in Fig. 3. If the frequency ranges with difference within ±4 dB, these ranges shall consistent with CISPR 16-1-4 Site Attenuation requirements. Based upon the results, this reverberation chamber has usable frequency range from 140 MHz to 1000

MHz. However, this chamber is still performing in the frequency range from 30 MHz to 140 MHz and the measurement data in the range is very useful as a reference purpose.

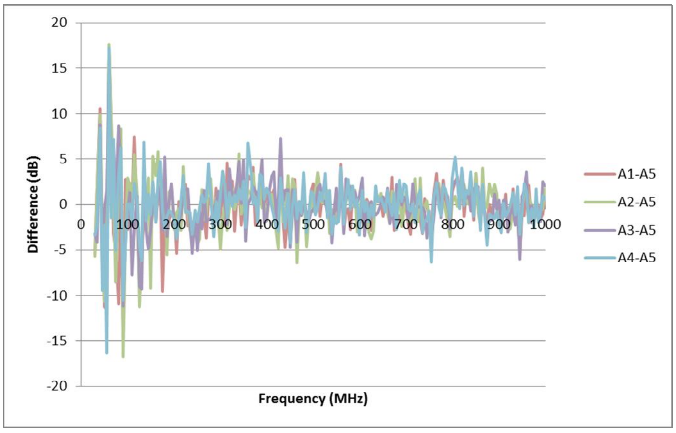

Fig. 3 Measurement difference for noise source placed at 5 locations

Since the measurement results at A5 have similar results for the average values of A1 to A5 for all point, as shown in Fig. 4, let use average data as the reference for further analysis.

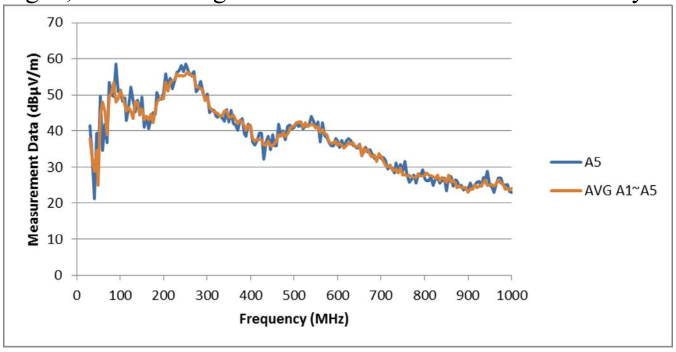

Fig. 4 Average result

C. *Correction Factor*

Assume there are correlations between the measurement results of ALSE and reverberation chamber. Place the Comb generator at the center of turntable with one meter height in the ALSE, and run the measurement as per CISPR 12 requirements. The maximum values of measurement results of both antenna polarizations are selected as the measurement data for all points, as shown in Fig. 5. Define the correction factor (CRT) as the function below:

CRT (f, dB) = Function Data (ALSE) - Function Data (VRTC)

The correction factor is plotted in Fig. 6. It may use the major points or use several linear functions and polynomial functions to represent this curve. If the vehicle measurement results at VRTC are V (f, dB μ V/m), the measurement results at ALSE are corrected by CRT (f, dB).

V (f, dB μ V/m at ALSE) = V (f, dB μ V/m at VRTC) + CRT (f, dB)

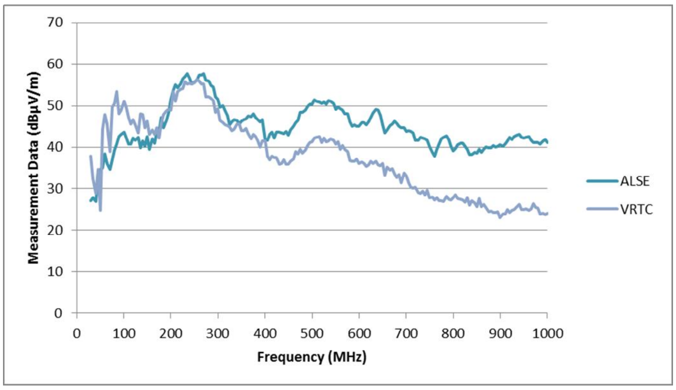

Fig. 5 Comb signal measurement results

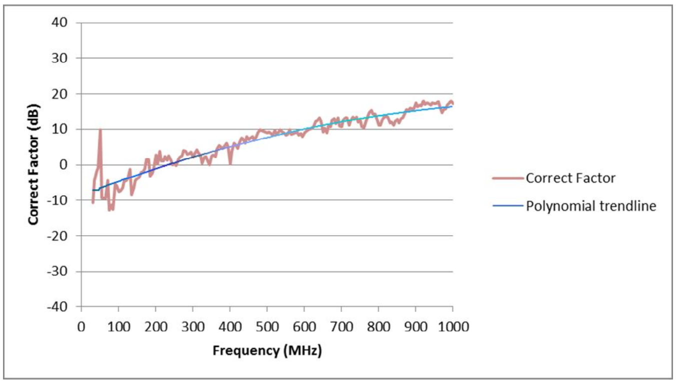

Fig. 6 Correction Factor

III. VEHICLE RADIATED EMISSION MEASUREMENT

The radiated emission measurements for a passenger vehicle are conducted in both VRTC and ALSE with the same vehicle configurations, as shown in Fig. 7 and Fig. 8. The measurement results of VRTC are corrected by correction factors. The results are compared and shown in Fig. 9. This plot shows high correlation between the ALSE and corrected VRTC measurement results, and most part of the peaks appear on curves of both chambers with certain amount of difference in amplitude. It is possible to find a boundary for all points that depicts the potential deviation between the measurement results of ALSE and VRTC for future study.

L (f) < V (ALSE) – V(VRTC) < U (f)

where

V (ALSE) is V (f, dB μ V/m at ALSE),

V (VRTC) is V (f, dB μ V/m at VRTC) corrected by CRT,

L (f) is lower boundary at frequency f,

U (f) is upper boundary at frequency f.

Fig. 7 Vehicle test in reverberation chamber

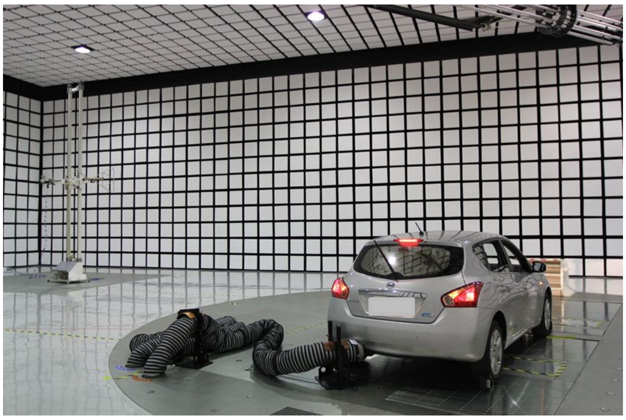

Fig.8 Vehicle test in ALSE

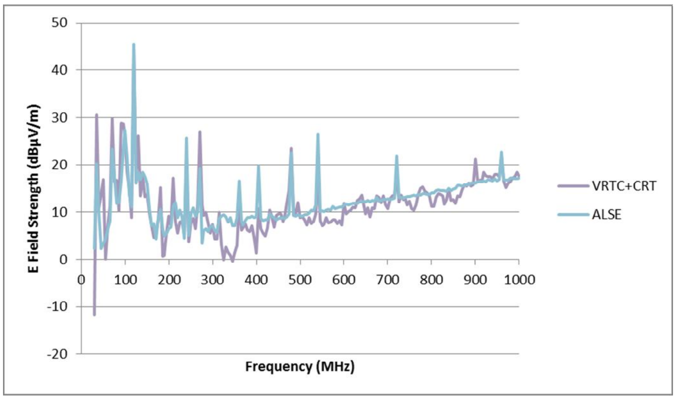

Fig. 9 Vehicle test results

IV. Conclusions

This study shows high correlation of the radiated emission measurement results between ALSE and vehicle reverberation chamber. The site attenuation characteristic of VRTC is within ±4 dB from 140 MHz to 1000 MHz and make it reasonable for radiated emission test purpose. A method based upon the correlation between ALSE and VRTC is established and the vehicle measurement results at ALSE are expectable via correcting the results at VRTC by correction factors. Instead of four complete scans (H/V polarization, Left/Right side) in ALSE, only one sweep through all frequency points with continually stirrer rotation is needed for VRTC test. The test procedures are much simplified for VRTC test than ALSE test. The test results of a passenger vehicle demonstrate the practical correlation between ALSE and VRTC test results, and a boundary for better correlation can be found in future study.

References

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