

Pseudo EMI Measurement Using VNA and Optical Feeding Antenna for Site Performance Comparison among Public Testing Laboratories in Kanto-area in Japan

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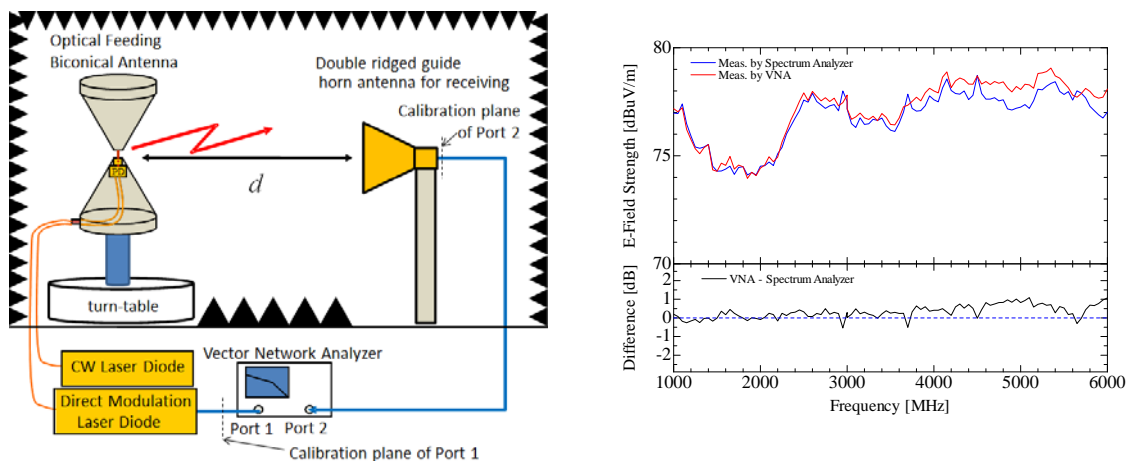
1. Introduction

Recently, site evaluation of anechoic chamber for EMI over 1GHz has attracted much attention because EU and VCCI start the regulation for EMI above 1GHz from October 2010. In the international standard, CISPR16-1-4 [1], SVSWR method has defined as a site evaluation method for EMI anechoic chamber over 1 GHz. The SVSWR method is specialized for validating the anechoic chamber hence the relationship between SVSWR and the EMI results is not clear. Therefore, the quantitative evaluation of site performance is difficult by the SVSWR.

On the other hand, round robin tests using a reference EUT have been conducted for comparing the site performance. A comb generator is generally used as a reference EUT in the round robin test for the EMI of the frequency range less than 1 GHz. As for the receiver, an EMI receiver or a spectrum analyzer is mainly used in EMI tests. However, the uncertainty of such receivers is very high. The typical uncertainties are ± 1.5 dB for the amplitude stability, ± 1.2 dB for the instability of preamp gain, ± 0.3 dB for the calibration of cable loss and pre-amplifier gain, and ± 1.0 dB for the mismatch between antenna and preamplifier according to CISPR16-4-2 [2]. Therefore, comparing the site performance using such receivers is inappropriate due to the bigger uncertainty.

For the purpose of accurate comparison of site performances and reducing the uncertainty of the measurement, we propose a pseudo-EMI measurement using VNA and optical feeding antenna in this paper.

2. Pseudo EMI measurement Using VNA and Optical Feeding Antenna



(a) Measurement Setup

(b) Electric-field strength measured by VNA

Figure 1 Measurement Setup & Electric-field strength measured by VNA

The setup for the proposed method is shown in Figure 1(a). The CW signal emitted from the port 1 of VNA modulates the optical signal generated at a direct modulation laser diode. The modulated optical signal through an optical fiber is reached to a photo-diode in the optical feeding bi-conical antenna. In the photo-diode, modulated optical signal is converted to CW microwave signal and the CW electric field is radiated from the bi-conical antenna. Another CW laser diode is used for providing DC voltage to the photo-diode. After the calibration of VNA, the electric field strength is derived from equation (1).

$$E_{3m} = F_{\text{ANT}} + S_{21} + P_{\text{OUT}} + 106.99 + 20\log(d/3) \quad (1)$$

where F_{ANT} [dB/m] is the antenna factor of the receiving horn antenna, S_{21} [dB] is the transmission S-parameter from port 1 to port 2, P_{OUT} [dBm] is the output power of port 1 of VNA, d [m] is the distance from bi-conical antenna to the receiving horn antenna aperture, 106.99 [dB] is the conversion factor from dBm to dB μ V.

It is noted that the calibration plane of port 1 is at the output port of VNA and the calibration plane of port 2 is just before the receiving antenna input port. By the exploitation of optical feeding antenna, the optical feeding bi-conical antenna emulates a battery operated EUT and the uncertainty caused by the reproducibility of the metal cable arrangement can be removed. We call the proposed method as Pseudo-EMI measurement because this method measure the known CW signal generated from VNA in contrast to the conventional EMI measurement which measures the unknown signal emitted from EUTs.

The measured electric field by VNA and spectrum analyser is shown in Figure 1(b). We employed a double ridged guide horn antenna (Model: ETS3117) as a receiving antenna. It is noted that the resolution band width of spectrum analyser is set to 200 Hz to reduce the noise of the spectrum analyser. From the figure, the difference between the results of VNA and that of the spectrum analyzer is less than 1 dB. Therefore, the electric field strength can be measured by our proposed method using VNA and optical feeding antenna. The main cause of the difference is that the use of the indicated P_{OUT} not the measured P_{OUT} during the calculation of the electric field strength.

3. Measurement Results

3.1 Obtaining Reference Data

The reference data is required for evaluating the performance of anechoic chamber quantitatively. No reflection occurs in the ideal anechoic chamber, hence, the transmission S-parameter S_{21} is measured at reasonable-size anechoic chamber and the ideal reference S-parameter is obtained by time-domain gating [3]. The measured S_{21} for the reference data in both frequency-domain and time-domain is shown in Figure 2 (a) and 2 (b). It is noted that the amplitude of the time-domain waveform is normalized to 0 dB and the time of the peak is set to 0 ns. In the proposed system, the time-domain waveform can be calculated by the use of the phase information measured by VNA. Figure 3 shows the arrangement when the reference data is measured in an anechoic chamber. The reflection waves from the walls except the ground are received 3.4 ns after the direct wave because the reflecting object is 2 m away from the transmitting bi-conical antenna except the ground plane. Therefore, the gating width is set from -20 ns to +3.4 ns beginning at the peak time. The time difference between the direct-wave and the reflection wave from the ground is about 1.6 ns at the antenna distance equal to 4 m because the path difference is about 47 cm. Therefore the reflection wave from the ground is not removed in this time-domain gating.

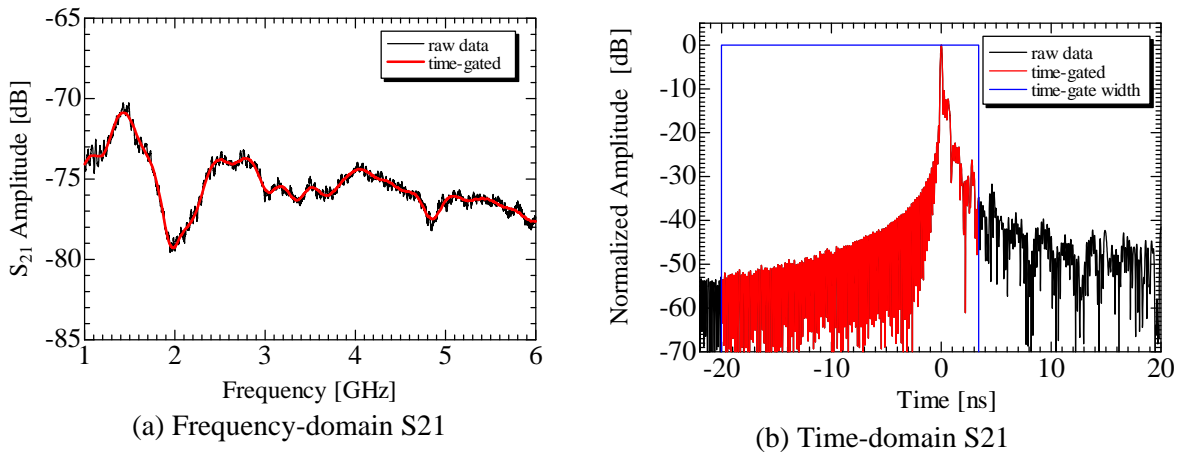


Figure 2: Measurement Results of Reference Data

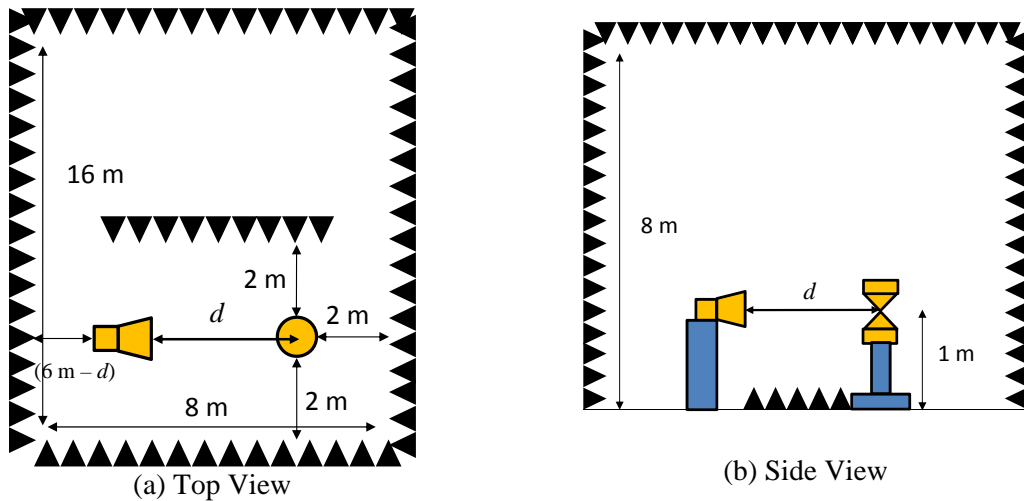


Figure 3: Setup for Reference Data Measurement

The electric field strength calculated by the equation (1) after time-domain gating is shown in Figure 4. The $d = 4.0$ m corresponds to the diameter of 2.0 m turntable. The $d = 3.75$ m and $d = 3.6$ m correspond to the diameter of 1.5 m and 1.2 m turntable, respectively. The differences of each electric field strength are caused by the ground reflected wave varying by the antenna distance d . The quantitative evaluation of the performance of the anechoic chamber is achieved by comparing the above reference electric field strength to the electric field strength measured at the target anechoic chamber.

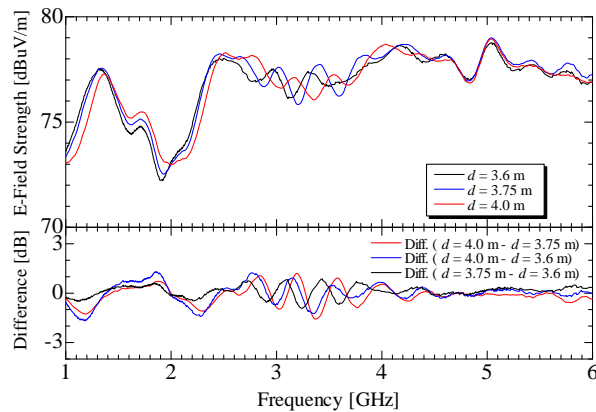


Figure 4: Reference Electric Field (at $d = 3.6$ m, 3.75 m, and 4.0 m)

3.2 Example of Evaluation of Site Performance

The example of evaluation of site performance using the proposed method is shown in Figure 5. The overlapping part of the time-gated reference waveform and the measured waveform is almost same. Therefore, the reflection wave from the anechoic chamber is almost included after the time of 3.4 ns. The difference of the electric field strength measured at target site and the reference electric field strength is distributed from -2.0 dB to 1.5 dB in the frequency range from 1 GHz to 6 GHz. According to these figures, we can judge the site performance quantitatively and can compare the site performance to other sites.

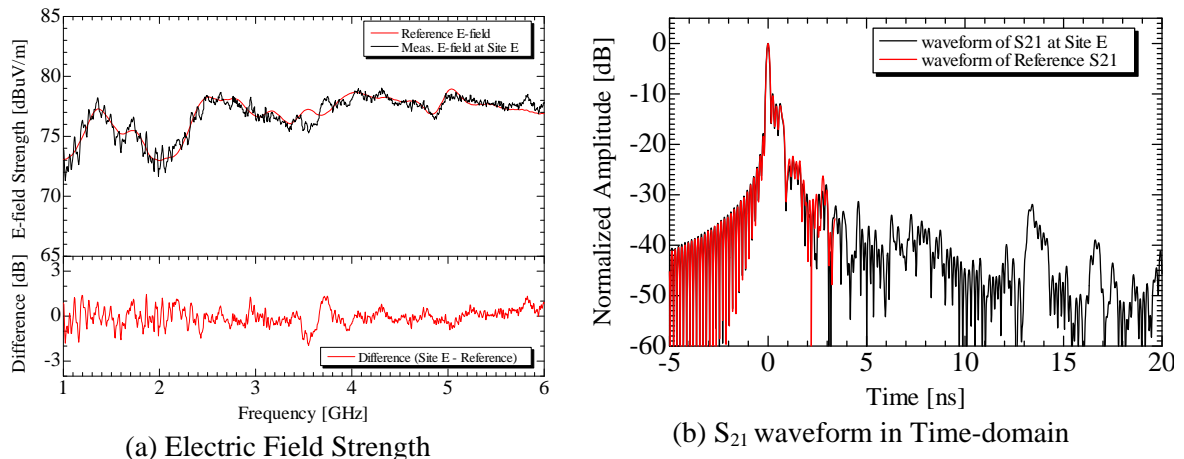


Figure 5: Measurement results of Site E

4. Comparison Results of All the Participating Sites

Table 1: Difference between reference E-field and E-field measured at each site (unit: [dB])

Distance	$d = 4.0$ m						$d = 3.75$ m	$d = 3.6$ m		
Site Name	A	B	C	D	E	F	G	H	I	J
Max.	+2.2	+2.9	+2.3	+3.2	+1.5	+4.1	+2.6	+5.1	+2.8	4.6
Min.	-4.3	-3.8	-3.5	-3.3	-2.0	-2.8	-3.5	-2.4	-5.1	-6.1
Max. - Min.	6.5	6.7	5.8	6.5	3.4	6.8	6.1	7.4	7.8	10.7

We conducted the proposed measurement of the site performance in 10 public testing and research laboratories in Kanto-area in Japan from October to November in 2011. The maximum and minimum differences of the electric field between the target site and the reference data are listed in Table. 1. Although the SVSWR measured at these sites is all less than 6 dB, the difference shows a bit higher value than the estimated value when the SVSWR is less than 6 dB. The 6 dB SVSWR is corresponds to the ± 3 dB error in the electric field strength.

5. Conclusions

We proposed the pseudo-EMI measurement using VNA and optical feeding bi-conical antenna. The proposed method is very useful for the performance comparison of EMI anechoic chamber. This is because the proposed method can calculate time-domain waveform for the reference data and can quantitatively evaluate the site performance by observing the deviation from the time-domain gated reference data.

Acknowledgments

We would like to thank all the public testing and research laboratories in Kanto area for their contributions.

References

- [1] CISPR 16-1-4, "Specification for radio disturbance and immunity measuring apparatus and methods –Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment –Radiated disturbances", Edition 2.1, 2008-01.
- [2] CISPR 16-4-2, "Specification for radio disturbance and immunity measuring apparatus and methods –Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty", Edition 2.0, p.52, 2011-06.
- [3] A. V. Oppenheim, and R. W. Schaffer, "Digital Signal Processing", Prentice-Hall, 1975.