Experimental Evaluation of the Validation Method using Broadband Antenna for Radiated Emission Test Site

Kunihiro Osabe*[1] Takeshi Yamanaka*[2] Jiro Kawano*[3]

*[1] Panasonic Mobile Communications Co., Ltd.
600 Sedo-cho, Tuzuki-ku, Yokohama 224-8539 JAPAN

*[2] Akzo Nobel K. K.
1 Sunayama, Hazaki-cho, Kashima-gun, Ibaraki 314-0255 Japan

*[3] Voluntary Control Council for Interference by Information Technology Equipment
2-3-5 Azabudai, Minato-ku, Tokyo 106-0041 JAPAN

Abstract: Experimental comparison of the various validation methods (CISPR16-1, ANSI C63.5 revision, Dual AF method) using the broadband antenna of Biconical, Logperiodic and Full-range type was performed at seven radiated emission test sites. With regard to each method, it was compared with the NSA value measured by a pair of dipole antenna and verified the method of test site validation. As the result, it was concluded that, even if it is used broadband antenna, the NSA calculation up to 300MHz should be considered the influence of mutual impedance coupling of antennas and of the ground plane.

Key words: EMI, NSA, Broadband Antenna, Radiated Emission Test Site

1. Introduction

The both site attenuation measurement using a pair of dipole antenna and a pair of broadband antenna have been performed at seven radiated emission test sites. It was started from the site attenuation measurement ($V_{direct} - V_{site}$) using a pair of dipole antenna with the same geometric condition as the broadband antenna measurement of 1m and 2m height of transmitting antenna with horizontal polarization, and the height of 1m and 1.5m with vertical polarization. To get the reference value (NSA_{ref}) including the correction factor (ΔNSA) to consider the influence of mutual impedance coupling of antennas and of the ground plane, it was calculated in each test site by the following formula.

$$NSA_{ref} = V_{direct} - V_{site} - AF_{dip/tx} - AF_{dip/rx} \cdots \Delta NSA \quad (1)$$

$AF_{dip/tx}$: Antenna Factor of a transmitting antenna

$AF_{dip/rx}$: Antenna Factor of a receiving antenna

Both antennas were calibrated at 2m height above the ground.

ΔNSA was calculated with the same geometric condition as the broadband antenna measurement of 1m and 2m height of transmitting antenna with horizontal polarization, and the height of 1m and 1.5m with vertical polarization.

After that, each test site conducted the site attenuation measurement using the broadband antenna (Biconical antenna for 30MHz to 300MHz, Logperiodic antenna for 300MHz to 1GHz and Full range brodaband antenna for 30MHz to 1GHz). The measurement values of site attenuation are shown SA_{bca}, SA_{lpa} and SA_{frb}. These antenna factors have been shown AF_{bca}, AF_{lpa} and AF_{frb}.

And the NSA value based on CISPR16-1 ($NSA_{bca\text{-}cis}$), Draft of ANSI C63.5 revision ($NSA_{bca\text{-}ansi}$) and the method of Dual AF ($NSA_{bca\text{-}daf}$) were calculated and compared to the NSA_{ref} value. Then, it could be compared with same geometric condition. The result is shown to the following clauses.

2. Evaluation between 30MHz and 300MHz (Biconical antenna)

The validation methods using a pair of biconical antenna (Schwarzbeck: BBA9106) as a broadband antenna based on CISPR16-1, Draft of ANSI C63.5 revision and the method of Dual AF have been experimentally compared with the reference NSA value based on the dipole antenna measurement between 30MHz and 300MHz. The result is shown to the following clauses.

2-1. Evaluation based on CISPR16-1 [1]

The transmitting and receiving biconical antenna each was calibrated at 2 meters above the ground based on the Standard Antenna method. After that, the NSA value was calculated with the following equation.

$$NSA_{bca\text{-}cis} = SA_{bca} - AF_{bca/tx} - AF_{bca/rx} \quad (2)$$

The difference $D_{bca\text{-}cis}$ between $NSA_{bca\text{-}cis}$ and NSA_{ref} was evaluated to the following formula.

$$D_{bca\text{-}cis} = NSA_{bca\text{-}cis} - NSA_{ref} \quad (3)$$

The evaluation results are shown in Figure 1a and Figure 1b.

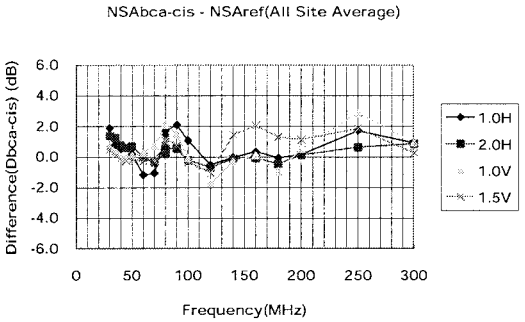


Figure 1a : 3m distance measurement

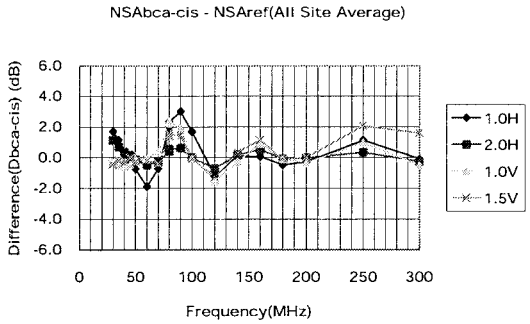


Figure 1b : 10m distance measurement

Figure1: Difference between $NSA_{bca\text{-}cis}$ and NSA_{ref}

2-2. Evaluation based on the draft of ANSI C63.5 revision [2]

The 12th edition draft to the U.S. National standard ANSI C63.5 revision in its finalization process has been proposed correction factors for calculating the NSA values.

Based on the draft, the antenna calibration was conducted by the Standard Site Method (three-antenna method) with 10m antenna-to-antenna distance. And the measured value was converted to free space antenna factor. After that, the NSA value incorporated the Geometry Specific Correction Factor (GSCF) was calculated with the following equation.

$$NSA_{bca\text{-}ansi} = SA_{bca} - AF_{fs/tx} - AF_{fs/rx} - GSCF \quad (4)$$

The difference $D_{bca\text{-}ansi}$ between $NSA_{bca\text{-}ansi}$ and NSA_{ref} was evaluated with the following formula.

$$D_{bca\text{-}ansi} = NSA_{bca\text{-}ansi} - NSA_{ref} \quad (5)$$

The evaluation results are shown in Figure 2a and Figure 2b.

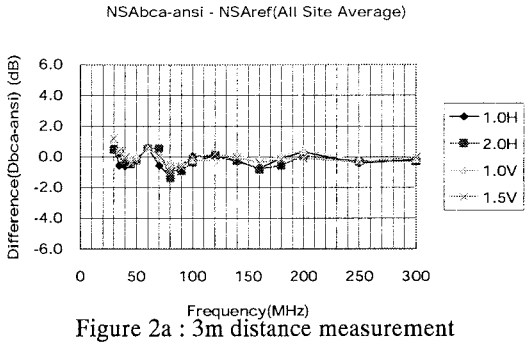


Figure 2a : 3m distance measurement

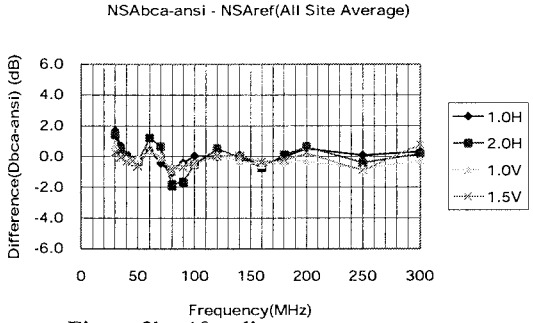


Figure 2b : 10m distance measurement

Figure2: Difference between $NSA_{bca\text{-}ansi}$ and NSA_{ref}

2-3. Evaluation based on the Method of Dual AF [3]

The method of Dual AF has been proposed to get the dual antenna factor, which is total antenna factor of transmitting and receiving antennas with test site validation condition each. According to this method, the Dual antenna factor of both transmitting and receiving biconical antenna used to this evaluation was calibrated on the CALTS. After that, the NSA value incorporated the Dual AF was calculated with the following equation.

$$NSA_{bca\text{-}daf} = SA_{bca} - DAF_{bca/tx+rx} \quad (6)$$

The difference $D_{bca\text{-}daf}$ between $NSA_{bca\text{-}daf}$ and NSA_{ref} was evaluated with the following formula.

$$D_{bca\text{-}daf} = NSA_{bca\text{-}daf} - NSA_{ref} \quad (7)$$

The evaluation results are shown in Figure 3a and Figure 3b.

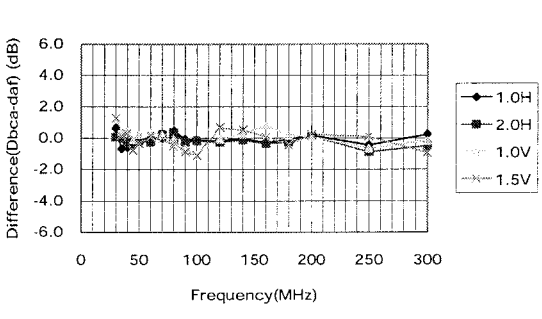


Figure 3a : 3m distance measurement

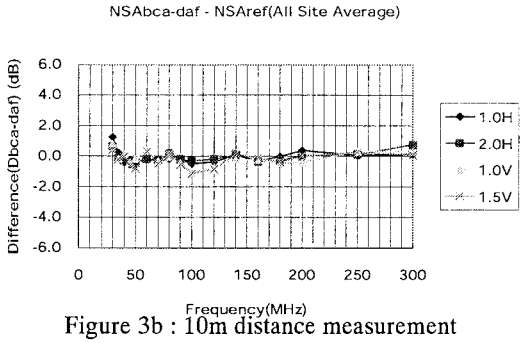


Figure 3b : 10m distance measurement

Figure3: Difference between $NSA_{bca-daf}$ and NSA_{ref}

With regard to the above validation methods using a pair of biconical antenna, the following correlation results were found.

1) The site validation method based on the CISPR16-1 causes more than 2dB difference in some frequencies and conditions comparing with the reference NSA value based on the measurement using a pair of dipole antenna.
2) The method of ANSI C63.5 draft may fall into almost within ±2dB difference.
3) And the method of dual AF may fall into almost within ±1dB difference.

3. Evaluation between 300MHz and 1GHz (Logperiodic antenna)

The validation method based on CISPR16-1 using a pair of logperiodic antenna (Scwarzbeck: UHALP9108A) as a broadband antenna has been experimentally compared with the reference NSA value based on the dipole antenna measurement between 300MHz and 1GHz.

As the NSA value above 300MHz by using a dipole antenna has not incorporated the correction factor, NSA_{ref} was calculated with the following equation.

$$NSA_{ref}=V_{direct} - V_{site} - AF_{dip/tx} - AF_{dip/rx} \quad (8)$$

The transmitting and receiving logperiodic antenna were calibrated at 2 meters above the ground based on the Standard Antenna Method. After that, the NSA value was calculated with the following equation.

$$NSA_{lpa-cis}= SA_{lpa} - AF_{lpa/tx} - AF_{lpa/rx} \quad (9)$$

The difference, $D_{lpa-cis}$ between $NSA_{lpa-cis}$ and NSA_{ref} was evaluated to the following formula.

$$D_{lpa-cis} = NSA_{lpa-cis} - NSA_{ref} \quad (10)$$

The evaluation results are shown in Figure 4a and Figure 4b.

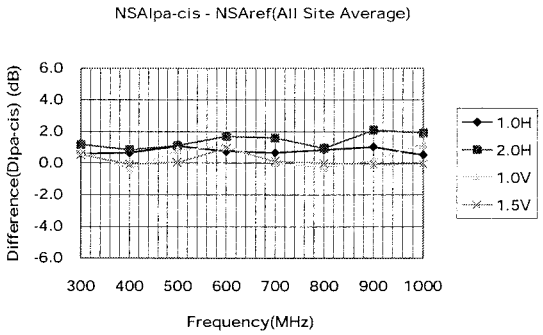


Figure 4a : 3m distance measurement

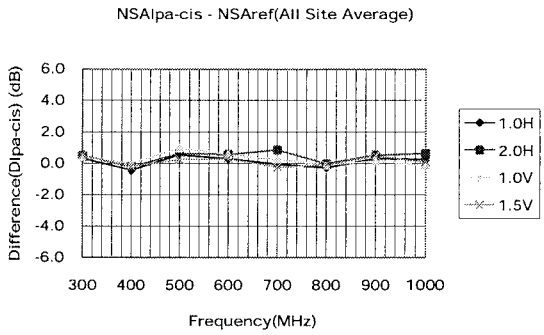


Figure 4b : 10m distance measurement

Figure4: Difference between $NSA_{lpa-cis}$ and NSA_{ref}

The broadband antenna method using a pair of logperiodic antenna based on the CISPR16-1 may fall into almost within ±2dB. It may be possible to calculate the NSA without any correction factor. However, with regard to the site validation of 3 meters distance measurement, the difference became about 2dB in the higher frequency area. In case of the 10 meters distance measurement, it became better result within ±1dB.

4. Evaluation between 30MHz and 1GHz (Full-range broadband antenna)

One type of full range broadband antenna (Schwarzbeck:VULB9168) was used for the site validation measurement and the antennas were calibrated based on the Standard Site Method.

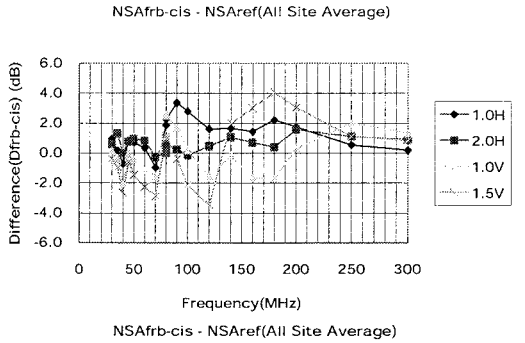
The NSA value was calculated with the following equation.

$$NSA_{frb-cis}= SA_{frb} - AF_{frb/tx} - AF_{frb/rx} \quad (11)$$

The difference, $D_{frb-cis}$ between $NSA_{frb-cis}$ and NSA_{ref} was evaluated to the following formula.

$$D_{frb-cis} = NSA_{frb-cis} - NSA_{ref} \quad (12)$$

The evaluation results are shown in Figure 5a and Figure 5b.



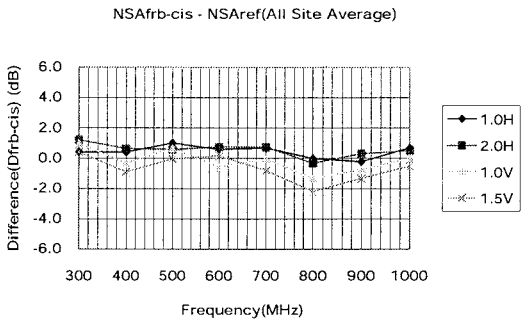
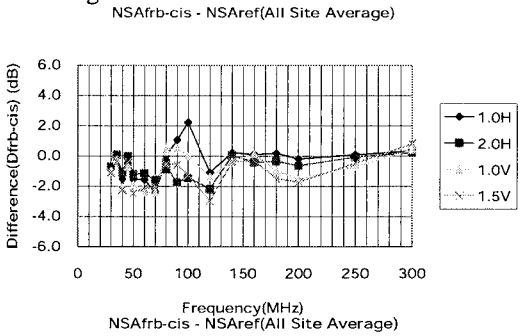


Figure 5a : 3m distance measurement



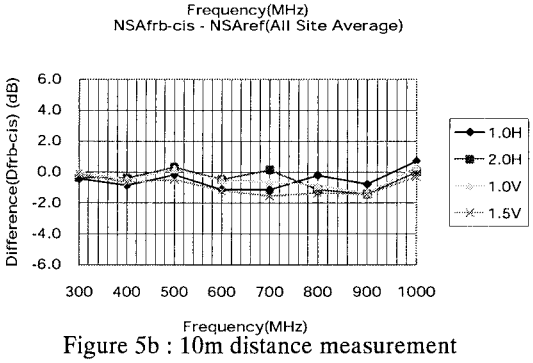


Figure 5b : 10m distance measurement

Figure5: Difference between $NSA_{frb\text{-}cis}$ and NSA_{ref}

It was found that the NSA by using a pair of full-range broadband antenna causes more than 2dB difference in many frequencies and measurement conditions, specially the 3 meters distance measurement.

From this result, it is not appropriate for the test site validation to use the full-range broadband antenna.

5. Conclusion

Various test site validation methods using broadband antenna were evaluated comparing with the reference NSA value measured by a pair of dipole antenna in a whole frequency range from 30MHz to 1GHz. The following conclusions were achieved.

1) With regard to the validation methods using a pair of biconical antenna, the validation method based on the CISPR16-1 causes more than 2dB difference comparing with the reference NSA value based on a pair of dipole antenna. To reduce the difference, it is recommended that the NSA calculation should be consider the correction factor or the antenna calibration should be included the influence of mutual impedance coupling of antennas and the ground plane, such as the method of dual antenna factor measurement.
2) With regard to the validation above 300MHz using a pair of logperiodic antenna, it is possible to calculate the NSA without any correction factor. However, it should be noted that the validation result for 3 meters distance measurement site has about 2dB difference in the higher frequency area.
3) It is not appropriate for the test site validation to use the full-range broadband antenna. However, it is necessary to study the use of dual antenna factor method, as one possibility.

6. Acknowledgment

All experiments in this paper were conducted and reported with the cooperation of VCCI technical subcommittee members. We would like to express special thanks for their effort.

Reference

[1]CISPR Publ. 16 part 1-1999: "Specifications for Radio Disturbances and Immunity Measuring Apparatus and Methods - Part 1- Radio Disturbance and Immunity Measuring Apparatus"

[2]ANSI C63.5/D12 dated August 27, 2001: "Draft Standard - American National Standard for Electromagnetic Compatibility— Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration of Antennas (9 kHz to 40 GHz)"

[3] W. Muellner, H. Garn: From NSA to Site-Reference Method for EMC Test Site Validation; 2001 IEEE EMC International Symposium