

Design of a Biconical Antenna with Cylindrical Loads for EMI Test Site Validation above 1 GHz

Sungsik Kong^{1,2} · Jaehoon Choi²

Abstract

In this paper, a biconical type antenna is proposed for EMI test site validation above 1 GHz. To achieve broadband and omni-directional radiation patterns required by international standard(CISPR), the proposed antenna consists of general bicones with cylindrical loads and adopts side feeding method to minimize the influence on H-plane pattern due to feeding cable, balun, and connector. The radiation patterns of the fabricated antenna are measured and the results are compared with CISPR criteria and commercial antenna in our interest frequencies. Although the proposed antenna has a few problems in frequency range of 1 GHz to 2 GHz, it has relatively better performance than commercial antenna.

Key words : Biconical Antenna, EMI, CISPR, Site Validation, Omni-Directional Radiation Pattern.

I. Introduction

With the rapid progress of information society in recent years, information technology equipment(ITE) with clock frequency above gigahertz such as personal computer is spreaded and used extensively. On the other hand, unwanted electromagnetic waves from these electronic equipment cause to interference for short range and low power radio services such as personal communication system, and malfunction for other electric and electronic equipment.

In order to solve these problems, the international special committee on radio interference(CISPR) of the IEC has conducted several projects which are establishing limits, measurement methods, receiver specifications, and EMI test site validation above 1 GHz since 1999. These projects almost finished and published to international standards. In particular, the project for EMI site validation above 1 GHz concluded with some problems which are criteria of transmitting antenna for site validation, validation procedure and acceptance criteria^{[1]-[7]}.

In this paper, we investigated the trends for transmitting antenna for EMI test site validation above 1 GHz, and fabricated the broadband antenna agreed with CISPR standard. And the fabricated antenna was measured and analyzed its properties such as radiation patterns and VSWR.

condition. A few studies have been conducted to minimize the influence of reflections upon the received signal, for example an anechoic chamber^[8]. If the test site is not designed to provide fully anechoic conditions like free space, for example semi-anechoic chamber and open area test site, use of absorbing material to cover part of the metal ground plane is required.

Therefore, to provide illumination of all reflecting surface during the validation test, and to simulate the possible low directivity antenna gains exhibited by many equipment under test, the antenna used as a transmit source shall be linearly polarized and shall have a dipole-like radiation pattern^{[9],[10]}.

Radiation patterns of the transmitting antenna required by CISPR 16-1-4 Ed.2^[8] show illustrated in Fig. 1 and Table 1. The E-plane pattern of the antenna must not enter the forbidden area symmetrical to the main lobe directions on both sides of the pattern where amplitude is less than -3 dB for $\pm 15^\circ$ and the H-plane pattern of the antenna must not exceed the deviation from the $\pm 135^\circ$ as shown in Fig. 1 and Table 1. And the plot (solid lines) on the E-plane and H-plane pattern is for an antenna that meets the requirements. The shaded areas represent the maximum permissible deviations. The solid lines meet the requirements because the radiation pattern does not enter the shaded regions.

II. Antenna Performance Requirements by CISPR

The EMI test site above 1 GHz relies on reflection

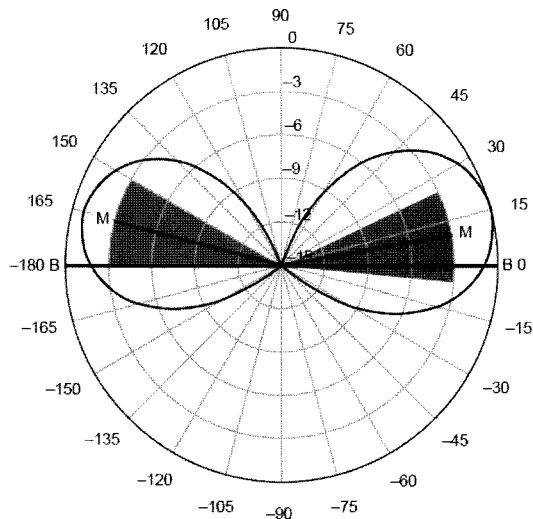
III. Design and Fabrication of Antenna

3-1 Antenna Design

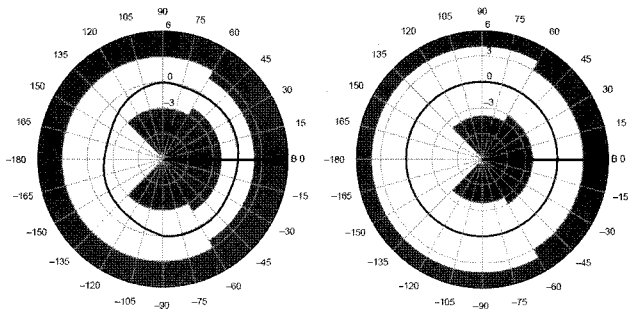
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(a) E-plane in the frequency range of 1 GHz to 18 GHz



(b) H-plane in the frequency range of 1 GHz to 6 GHz (c) H-plane in the frequency range of 6 GHz to 18 GHz

Fig. 1. Radiation patterns of the CISPR antenna.

Table 1. The forbidden areas of H-plane as frequency range.

Angle range	1 GHz to 6 GHz	6 GHz to 18 GHz
-60° to 60°	±2 dB	±3 dB
-60° to -135° 60° to 135°	±3 dB	±4 dB
-135° to -180° 135° to 180°	<+3 dB	<+4 dB

The biconical antenna can be used to achieve broadband and omni-directional radiation pattern characteristics^[11]. We designed the biconical type antenna with cylindrical loads and cones for broadband EMI site validation. In order to obtain the optimized structure, a try and error by using commercial electromagnetic wave simulation software, HFSS^[12] was applied by changing the parameters as shown in Fig. 3. Table 2 shows the optimized parameters of the proposed antenna. For omni-directional radiation pattern of the antenna, the side feeding method for minimizing the influence on H-plane

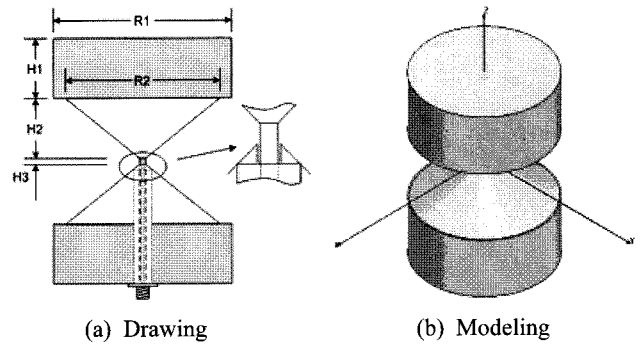
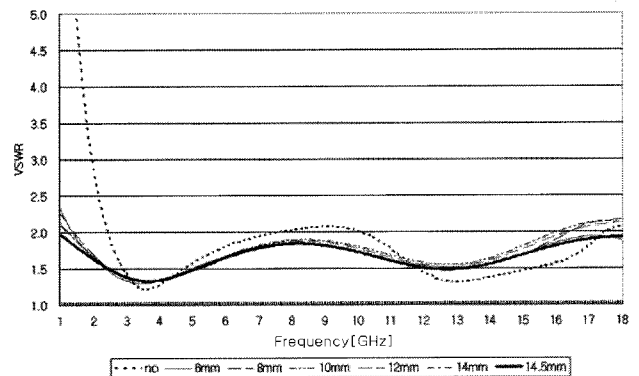
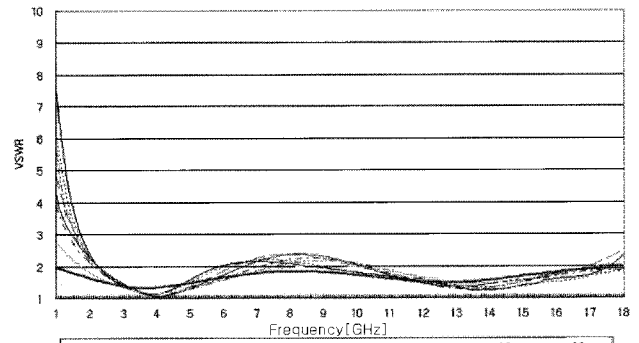


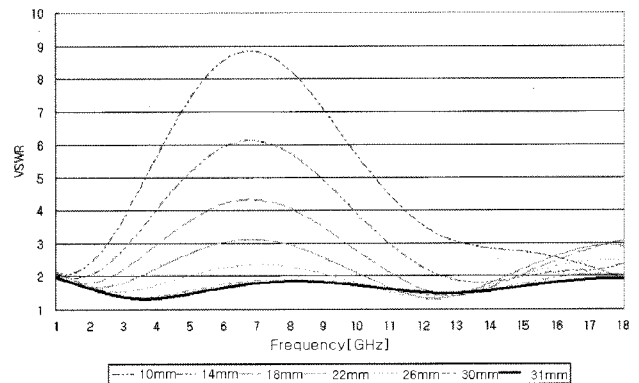
Fig. 2. Geometry of the proposed antenna.



(a) Height, H1 of cylindrical loads



(b) Diameter, R1 of cylindrical loads



(c) Diameter, R2 of cones

Fig. 3. Simulated VSWR of the proposed antenna.

Table 2. Optimized parameters of the antenna.

	Diameter [mm]		Height [mm]	
	R1	33	H1	14.5
Cylindrical load	R2	31	H2	15
Cone	-	-	H3	1

pattern due to feeding cable, balun, and connector is employed from lower cone to upper cone.

3-2 Antenna Fabrication and Measurements

Fig. 4 and 5 show the picture and VSWR of the fabricated antenna. The measured VSWR of the antenna has properties below 2 almost our interest frequencies except for 1 GHz. And the radiation patterns as shown in Fig. 6 have omni-directional patterns required by CISPR. These are radiation patterns of E- and H-plane at 2 GHz, 4 GHz, 16 GHz, and 18 GHz. Fig. 7 is the radiation patterns in the frequency range of 1.6 GHz to

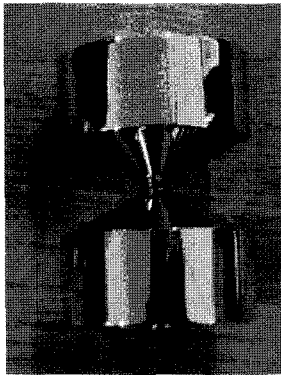


Fig. 4. Picture of the fabricated antenna.

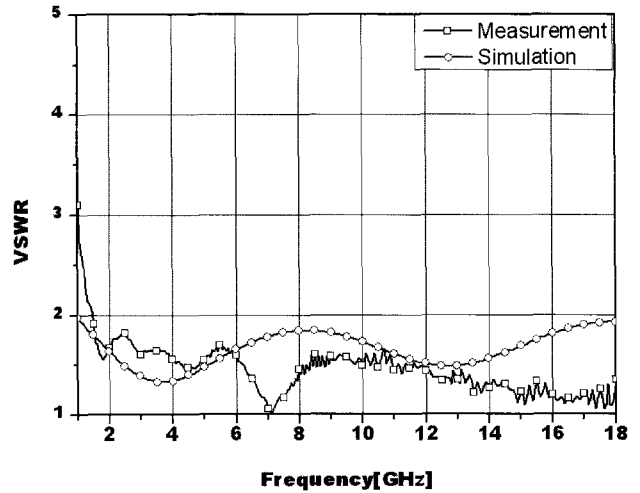


Fig. 5. VSWR of the proposed antenna.

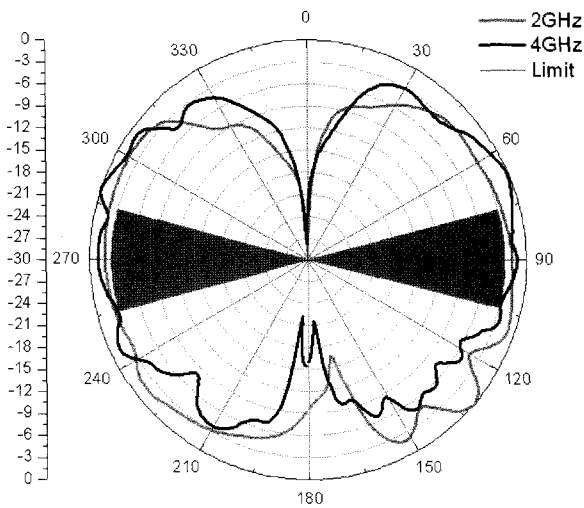
1.9 GHz with some problems which are unsatisfied CISPR criteria, although it has omni-directional radiation patterns.

Consequently, the measured results of the proposed antenna have relatively better performance than commercial antenna^{[13],[14]} which was developed by Schwarzbeck as shown in Table 3.

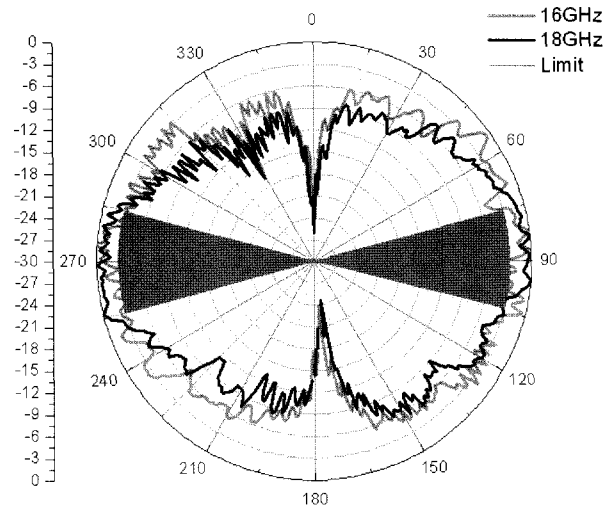
IV. Conclusions

The radiation patterns of transmitting antenna could be affected by accuracy, uncertainty and reproducibility for EMI test site validation from some papers^{[15],[16]}.

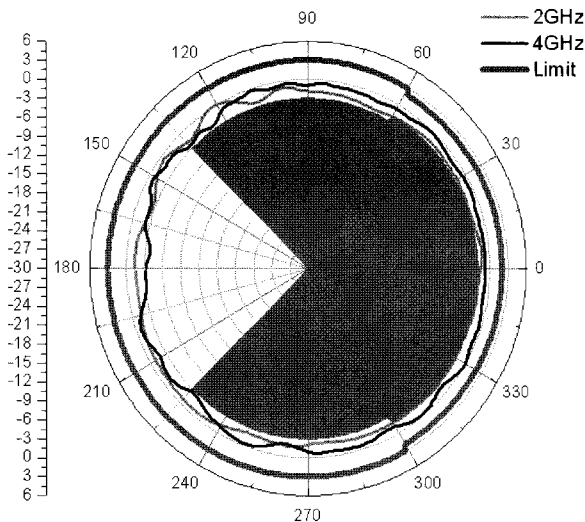
Although the proposed antenna in this paper has a few problems in frequency range of 1 GHz to 2 GHz, it has relatively better performance than commercial antenna. The proposed antenna offers a large bandwidth



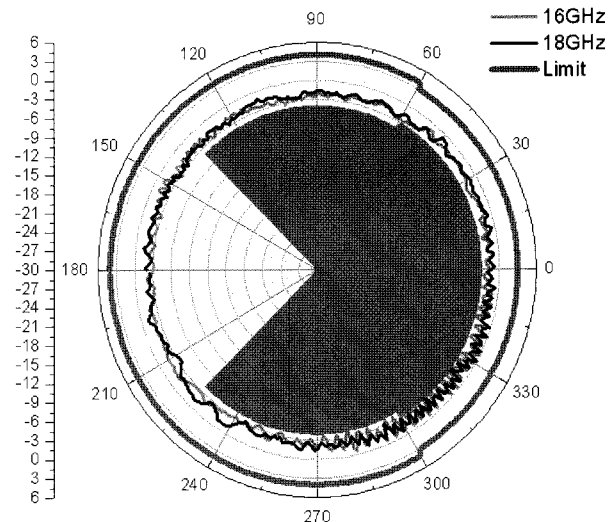
(a) E-plane at 2 GHz and 4 GHz



(b) E-plane at 16 GHz and 18 GHz

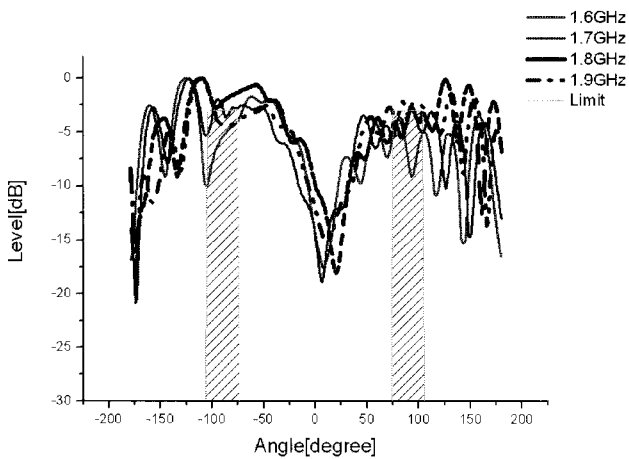


(c) H-plane at 2 GHz and 4 GHz

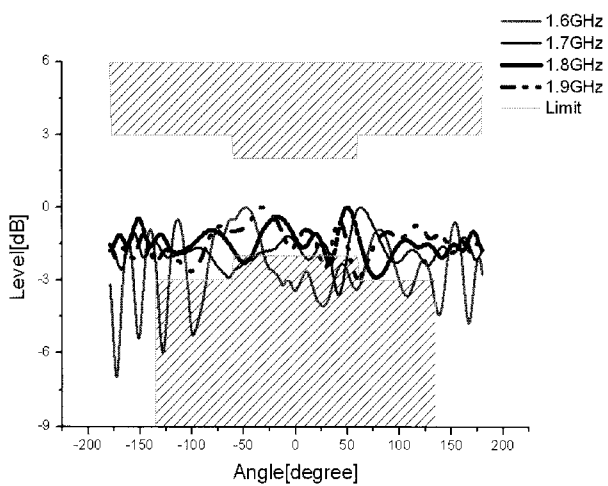


(d) H-plane at 16 GHz and 18 GHz

Fig. 6. Radiation patterns of the fabricated antenna.



(a) E-plane



(b) H-plane

Fig. 7. Radiation patterns of the proposed antenna in the frequency range of 1.6 GHz to 1.9 GHz.

Table 3. Comparison of performance between the proposed and commercial antenna.

	Proposed Ant.	Commercial Ant.
Bandwidth [VSWR ≤ 2]	97 %	30 %
Beamwidth at 2 GHz [E-plane]	105°	82°
Beamwidth at 18 GHz [E-plane]	41°	40°

of 97 % as well as wide beamwidth of 105° at 2 GHz and 41° at 18 GHz. To solve the problems for radiation patterns of the proposed antenna below 2 GHz, we received some advice for measurement method of radiation pattern by using optical antenna measurement system^[17] from Dr. M. Alexander of NPL(national physics laboratory of United Kingdom) at 2006 CISPR working group meeting. This will be the interesting subject for the next study. In the future, we will validate for EMI test site above 1 GHz by using the improved antenna and the commercial antennas.

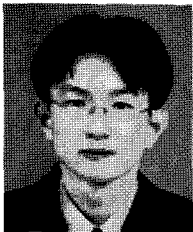
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