The Influence on Characteristics of the Antennas Caused by Short Pins of Biconical Antennas

#Mio Nagatoshi [1], Masanobu Hirose [2], Satoru Kurokawa [2] and Hisashi Morishita [1]
[1] Department of Electrical and Electronic Engineering, National Defense Academy
1-10-20 Hashirimizu Yokosuka 239-8686 Japan, e-mail: g46005@nda.ac.jp
[2] Advanced Industrial Science and Technology, Tsukuba, Japan

1. Introduction

Today, popularization of electronic equipment causes various problems with unexpected electromagnetic waves from the equipment. For these problems, the interference waves from 30 MHz to 1000 MHz should be measured by antennas. This measurement is called Electromagnetic Interference (EMI) measurement. Standard antennas for EMI measurement are half-wavelength dipole antennas. Recently, a biconical antenna which is one of broadband antennas is used for automatic EMI measurement. For the difference between radiation patterns of a half-wavelength dipole antenna and a biconical antenna, two measured electric fields are different [1]. Biconical antennas have various types. We call a metal bar from a center conductor to an outside element, a short pin. The biconical antenna having a pair of the short pins has various combinations of directions of right and left short pins. Depending on the number of pairs of the short pins or directions of the short pins, the structures of the biconical antennas are different and the characteristics are different.

In this paper, we demonstrate the influence on the antenna characteristics cased by the short pins of biconical antennas, using a simulation soft FEKO.

2. Simulations and Results

2.1 Simulation models

Fig.1 shows the configurations of a biconical antenna. In Fig.1 (a), the number from ①to④ and ⓐ express the positions of the short pins. Table 1 shows respective positions of the short pins. The model 1 antenna has no short pin. The model 2 antenna has six pairs of the short pins. Fig. 1(b) shows the model 3 antenna having one pair of the short pins placed on ZY plane. The directions of the short pins of the models (4 to 7) antenna are different. Comparing respective radiation patterns, we obtain the influence on the patterns caused by the difference of the short pin position .

Fig.2 shows the arrangement of a transmission antenna and a receiving antenna calculating the transmission characteristic of two model 4 antennas. The transmission antenna and the receiving antenna are placed symmetrically to the ZY plane. The feed point of the transmission antenna and the load point of the receiving antenna are a port1 and a port2, respectively. The distance between the port1 and the port2 is r m. When the distance r varies from 3 m to 50 m, we calculate S_{21} to compare the transmission characteristics of these antennas. The transmission characteristic of dipole antenna is also calculated. The length of the dipole antenna is 129.5 cm, which is the same as the span of the biconical antennas. The dipole antenna resonates at about 110 MHz. Comparing all transmission characteristics of the biconical antennas with the dipole antenna, we obtain the influence on the transmission characteristics caused by the short pins position.

2.2 Simulation Results

Fig.3 shows the radiation patterns of all antennas at 300 MHz. Fig.3 (a) shows the patterns of the models (1 to 3). Fig. 3 (b) shows the patterns of the model 4 and 5 and Fig.3 (c) shows the patterns of the model 6 and 7. In Fig. 3(a), these radiation patterns are symmetrical to the x and y axes. The structures of these antennas are symmetrical to the YZ and ZX planes. Therefore these current distributions are symmetrical to the x and y axes. However the radiation patterns of Fig.3 (b) and Fig.3 (c) are not symmetrical to the x and y axes because the structures of these antennas are not symmetrical. The radiation pattern of the model 4 becomes sharp in the direction of the short pins. Fig.4 shows the current distribution of the model 4 antenna and the current on the short pins is stronger than outside elements. Radiation patterns of No5 and No6 antenna are the same as No4. The pattern of the model 7 has point symmetry because the current distribution is balanced to y axis due to directions of the short pins are opposite each other. The No4 antenna has the maximum difference between the gains at ϕ =0deg. and ϕ =180deg.of all antennas. The difference is about 2[dB]. The current distribution on the short pins affects the radiation pattern of the biconical antennas.

From Friis transmission formula, the ideal (far-field) ratio of the received power and the input power is given by

$$\frac{P_{rec}}{P_{in}} = (1-|\Gamma_r|^2)(1-|\Gamma_t|^2)G_r(\theta_r,\varphi_r)G_t(\theta_t,\theta_t)\frac{\lambda^2}{16\pi^2 r^2} \quad (1)$$

where Γ_r and Γ_t are the reflection coefficient for the receiving antenna and the transmission antenna, $G_r(\theta_r, \theta_r)$ and $G_t(\theta_t, \theta_t)$ are the gain of the receiving antenna in the direction of the transmitting antenna and the gain of the transmitting antenna in the direction of the receiving antenna, and λ is wave length, respectively. The ratio of S_{21} and the value given by (1) shows how much S_{21} agrees with the ideal value in the far field. Fig. 5 (a) and Fig. 5 (b) show this ratio at 50 MHz and 300 MHz, respectively. In Fig. 5 (a), each S_{21} converge on the corresponding values given by (1).

At 50 MHz, the length of the antennas and the short pin is regarded as small compared with the wavelength. The span of the antennas and the short pin are about 0.22 λ and 0.045 λ, respectively. The effect of the short pins is considered to be small. In Fig.5-2, each convergence rate is different. The convergence rate of the dipole antenna is the fastest of all. The convergence rate of the biconical antennas is slow compared with that of the dipole antenna.

At 300 MHz, the span of the antennas and the short pin are about 1.30 λ and 0.26 λ, respectively. The transmission characteristics are different depending on the directions of the short pins and the number of the short pins. When the short pins are parallel to the direction of transmission, the convergence rate is the fastest of other biconical antennas having one pair of the short pins. When the angle between the direction of the short pin and the transmission becomes large, the convergence rate becomes slow. This result shows that the short pins of the biconical antennas affect the transmission characteristics and the distance that is considered to be far field is farther than the dipole antenna.

3. Conclusion

In this paper, using the simulation soft FEKO, we have calculated the influence on the characteristics of the biconical antennas caused by the short pins. The radiation patterns of the biconical antennas, which have the short pins in various directions, are not symmetrical. This comes from the current on the short pins.

The transmission characteristic of the biconical antenna varies by the directions of the short pins. Depending on the structure of the biconical antenna, each convergence rate is different.

In the future, we will demonstrate the validity of the simulation by an experiment.

References

[1] N. Suzuki, T. Nagai, A. Sugiura, Y. Yamanaka and T. Iwasaki, “EMI measurements using a biconical antenna”, TECHNICAL REPORT OF IEICE EMCJ98-2 Japanese, pp.9-16, 1998.

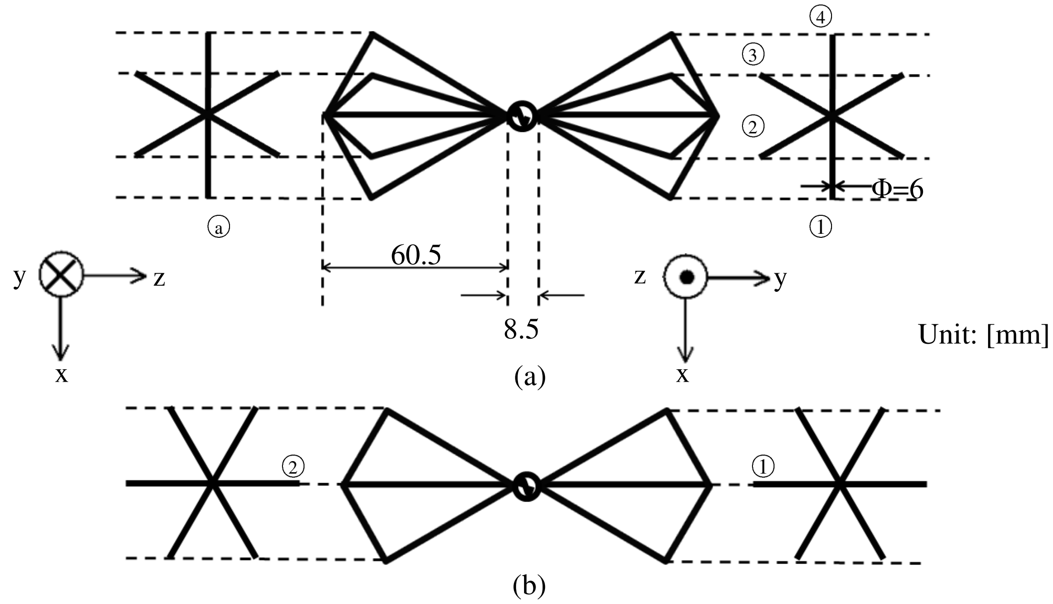


Fig. 1 The configurations of a biconical antenna and the position of the short pins

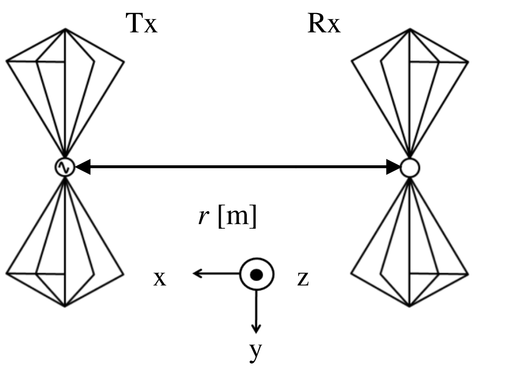


Fig. 2 The arrangement of a Tx antenna and a Rx antenna (Using two model 4)

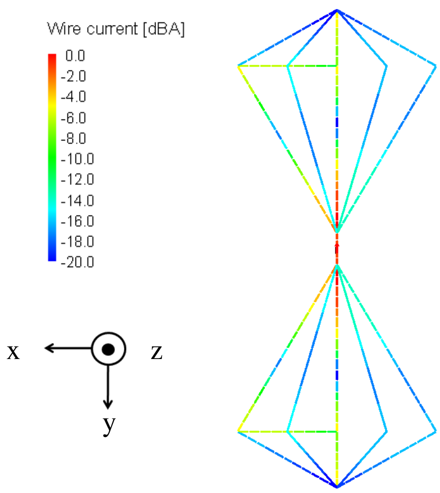
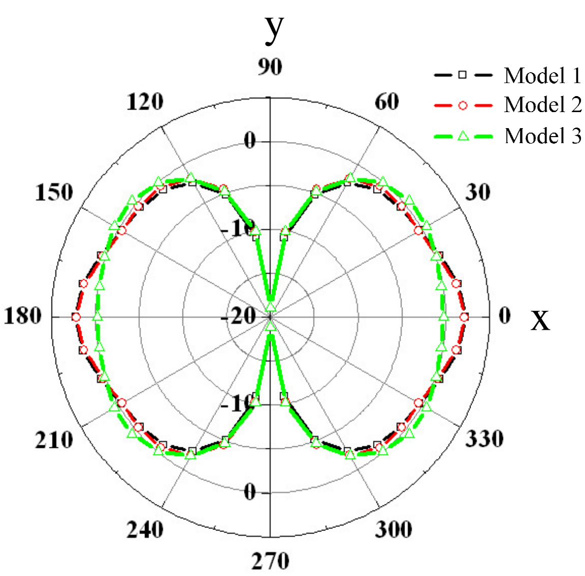


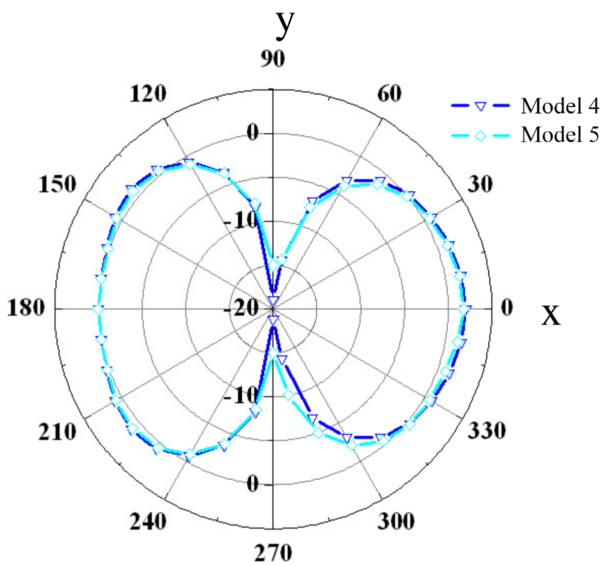
Fig. 4 The current distribution (Using the model 4)



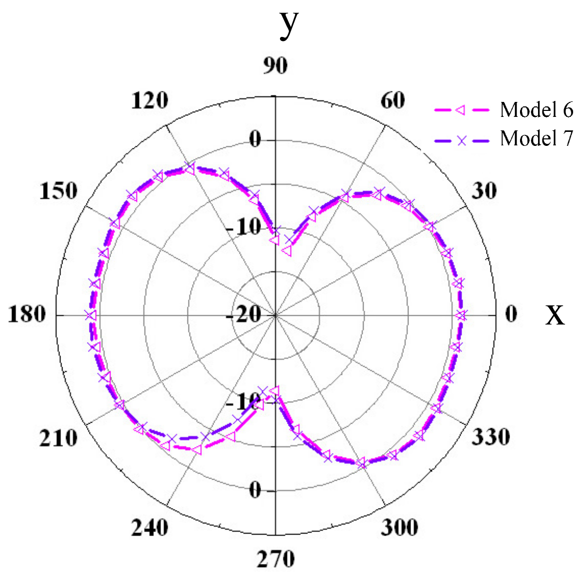
(a)

Table1 The positions of the short pins

Antenna model	Positions of the short pins
Model 1	No short pin
Model 2	All elements
Model 3	Fig.1-2 ① ②
Model 4	Fig.1-1 ⓐ ①
Model 5	Fig.1-1 ⓐ ②
Model 6	Fig.1-1 ⓐ ③
Model 7	Fig.1-1 ⓐ ④

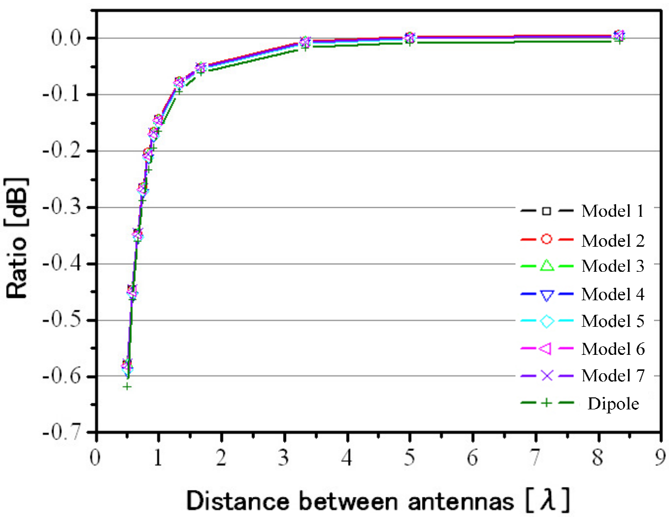


(b)

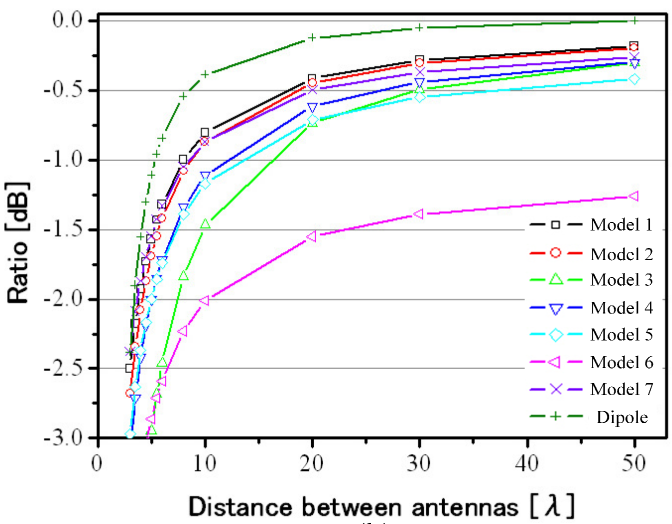


(c)

Fig. 3 Radiation patterns: (a) the model 1 to 3, (b) the model 4 and 5, and (c) the model 6 and 7.



(a)



(b)

Fig. 5-1 The transmission characteristics of all biconical antennas and the dipole antenna (a) at 50 MHz (b) at 300 MHz