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Two Element Phased Array Dipole Antenna on EBG Ground Plane

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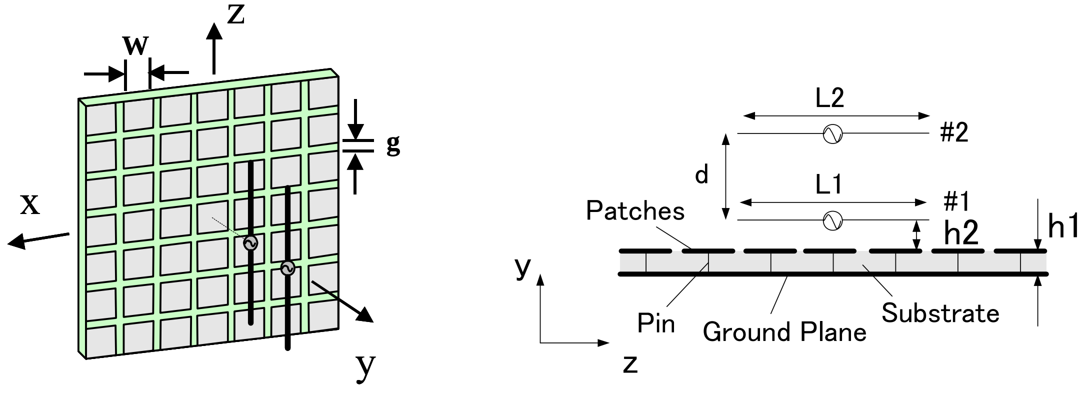
1. Introduction

For the short-range wireless communication, a small antenna with unidirectional radiation characteristics is desired. As the directional antenna composed of wire elements, the Yagi-Uda antenna and the electronically steerable passive array radiators (ESPAR) antenna are well known. These antennas consist of single driven element and some parasitic elements [1], [2]. These antennas are spatially phase controlled antennas. Authors have proposed the two element array dipole antenna with 90° phase difference feed for the directional antenna [3], [4]. By adjusting the length of each element and the distance between the two elements, the front-to-back ratio of 15.3 dB have been obtained at the design frequency of 2.45 GHz.

In this paper, this antenna is located on the electromagnetic bandgap (EBG) ground plane with finite size and numerically analyzed by using the electromagnetic simulator WIPL-D based on the Method of Moment [5], [6].

2. Analytical Model

Fig.1 shows the structure of the two-element phased array dipole antenna on the EBG ground plane. Each antenna element is fed with 90° phase difference. The distance between two elements is d = 20.6mm. The length of two elements are L1 = 54.6 mm and L2 = 50.2 mm. The radius of each element is 1 mm. The structure of phased array dipole antenna is optimized in order to obtain the maximum front-to-back ratio 15.3 dB at the design frequency 2.45 GHz when this antenna is located in free space. This antenna is located h2 = 3mm above the EBG ground plane with length $1\lambda_c$ by $1\lambda_c$. λ_c is the wavelength at the design frequency 2.45GHz. The relative permittivity and the loss tangent of EBG material are 2.6 and 0.0019, respectively. The



(a) Perspective view. (b) Cross sectional view.

Figure 1: Structure of two-element phased array dipole antenna on EBG substrate. h2=3mm, relative permittivity of substrate = 2.6-j0.00486, h1=4mm.

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thickness of dielectric layer h1 is 4 mm. The number of EBG patches is 9×9. In the numerical analysis by WIPL-D, two dipole elements are excited by the delta-gap generators and the thickness of EBG patches are assumed to be infinitely thin.

3. Results and Discussion

Figures 2, 3, 4 and 5 show the calculated front-to-back ratio for different length of EBG patches and gap width. The size of EBG ground plane is fixed to be $1\lambda_c$ by $1\lambda_c$. As the gap width between EBG patches g becomes larger from 0.005 λ_c, the front-to-back ratio becomes larger. When the gap width becomes $0.026\lambda_c$, the maximum front-to-back ratio of 19.63 dB is obtained at the frequency of 2.35 GHz. When the gap width becomes $0.024\lambda_c$, the maximum front-to-back ratio of 19.34 dB is obtained at the design frequency of 2.45 GHz.

Figure 6 shows the electric field radiation patterns in xy plane in the case of $g = 0.024\lambda_c$ and $0.005\lambda_c$ at the frequency of 2.45 GHz. The front-to-back ratio for $g = 0.024\lambda_c$ and $0.005\lambda_c$ are 19.34 dB and 16.37 dB, respectively. In the case of $g = 0.024\lambda_c$, the directivity of 7.93 dB is obtained.

Figure 7 shows the electric field distribution in the vicinity of EBG ground plane in the case of $g = 0.024\lambda_c$ at the design frequency of 2.45GHz. Figure 8 shows that in the case of $g = 0.005\lambda_c$ at the frequency of 2.45GHz. In the case of $g = 0.024\lambda_c$, the y component of electric field is suppressed at the surface of EBG ground plane. This means that the EBG ground plane works well in this case.

4. Conclusion

Two-element array dipole antenna with 90° phase difference feed, located on the EBG ground plane, has been analyzed numerically. The structure of two-element array dipole antenna is fixed to obtain the maximum front-to-back ratio in free space. The size of EBG ground plane is fixed to be $1\lambda_c$ by $1\lambda_c$. The front-to-back ratio of 19.34 dB is obtained at the design frequency 2.45GHz when the gap width is $g = 0.024\lambda_c$. By adjusting the size of EBG patches and gap width between patches and the geometry of two-element array dipole antenna, higher front-to-back ratio may be obtained. This antenna is promising as the directional antenna for the base station of the wireless communication system.

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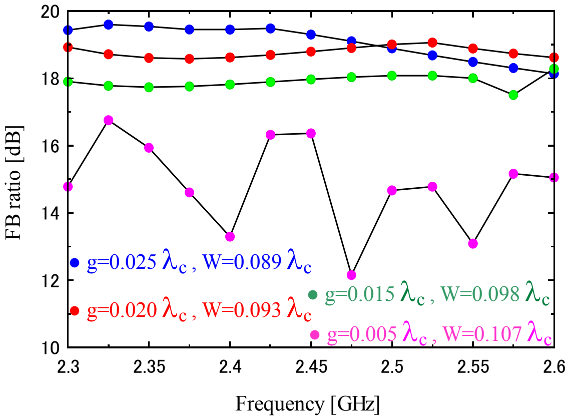


Figure 2: Front-to-back ratio.
($g=0.005\lambda_c - 0.025\lambda_c$)

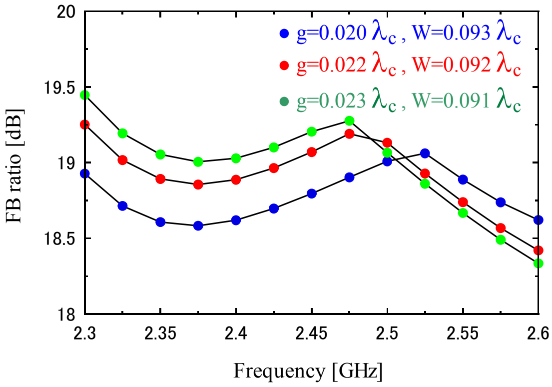


Figure 3: Front-to-back ratio.
($g=0.020\lambda_c - 0.023\lambda_c$)

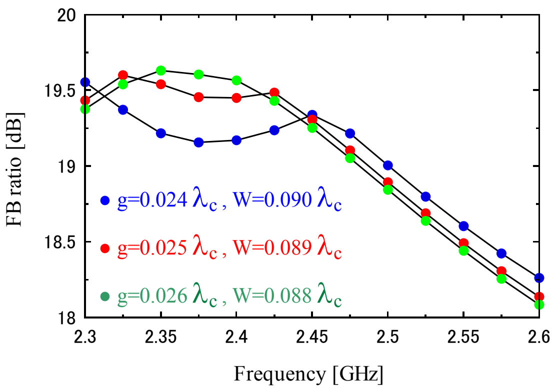


Figure 4: Front-to-back ratio.
($g=0.024\lambda_c - 0.026\lambda_c$)

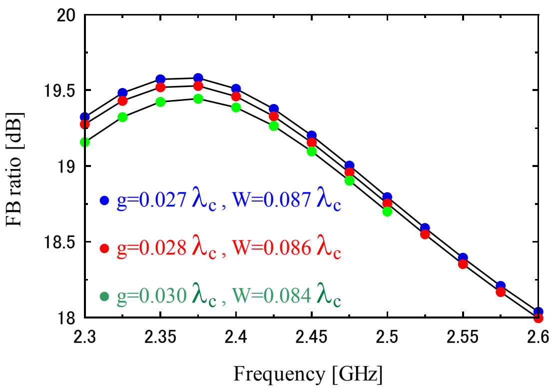
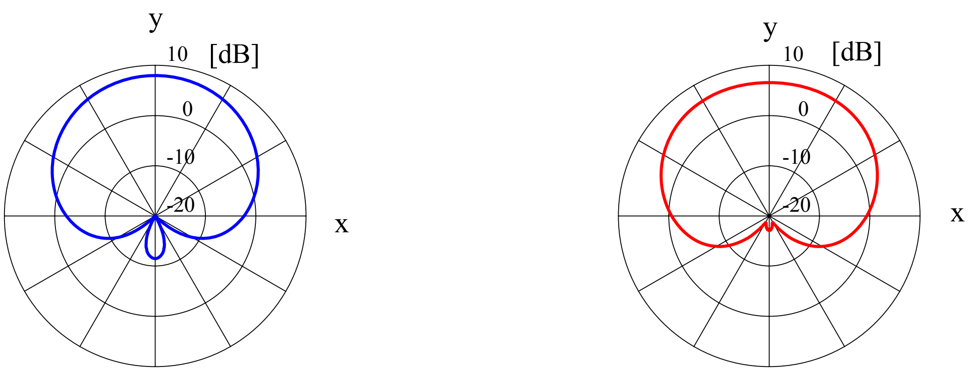


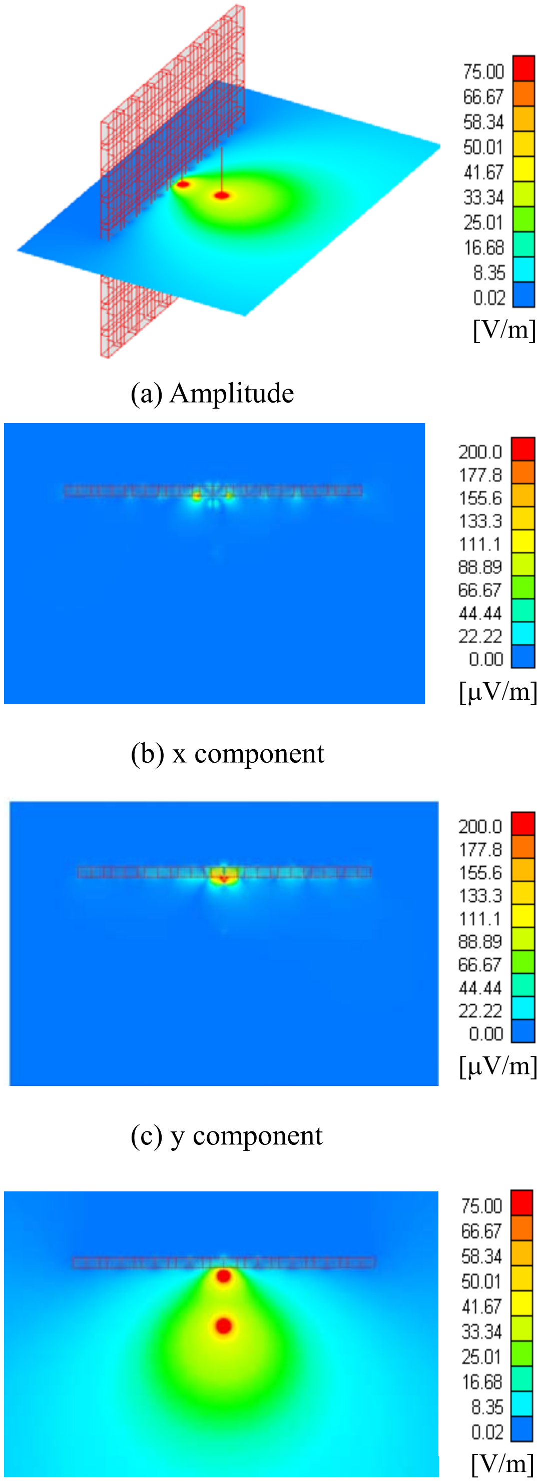
Figure 5: Front-to-back ratio.
($g=0.027\lambda_c - 0.030\lambda_c$)



(a) $g = 0.024\lambda_c$
FB ratio = 19.34dB

(b) $g = 0.005\lambda_c$
FB ratio = 16.37dB

Figure 6: Electric field radiation patterns in xy plane at 2.45 GHz.



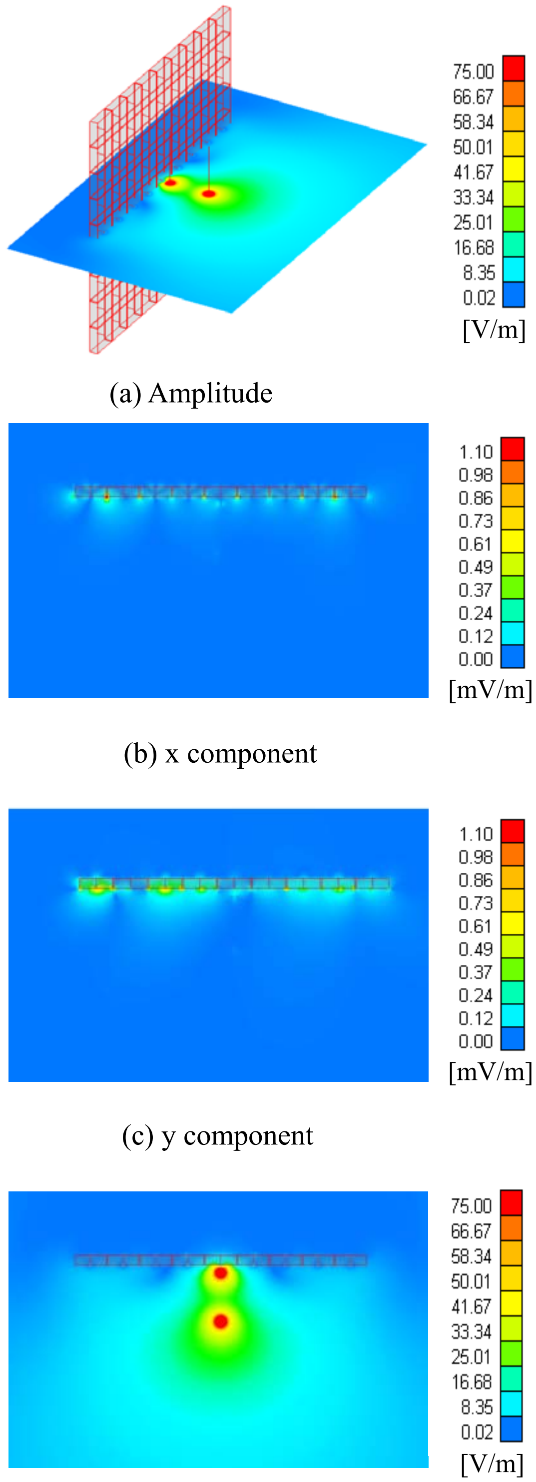
(a) Amplitude

(b) x component

(c) y component

(d) z component

Figure 7: Electric field distribution in vicinity of EBG ground plane in xy plane.
Number of patches 9×9, $g = 0.024\lambda_c$, $W = 0.090\lambda_c$, frequency = 2.45GHz, FB ratio = 19.34dB.



(a) Amplitude

(b) x component

(c) y component

(d) z component

Figure 8: Electric field distribution in vicinity of EBG ground plane in xy plane.
Number of patches 9×9, $g = 0.005\lambda_c$, $W = 0.107\lambda_c$, frequency = 2.45GHz, FB ratio = 16.37dB.