# Two Element Phased Array Dipole Antenna on Finite EBG Ground Plane

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**Abstract:** Two element phased array dipole antenna backed by finite EBG ground plane is proposed for the directional antenna. Two dipole element is fed with 90 degree phase difference. In the numerical analysis, the electromagnetic simulator WIPL-D based on the Method of Moment is used. The size of EBG ground plane is fixed to one wavelength by one wavelength at the design frequency of 2.45 GHz. The relation between the front-to-back ratio and the parameters of EBG ground plane is discussed. The maximum front-to-back ratio of 24 dB is obtained.

**Keywords:** phased array antenna, EBG, directional antenna, front-to-back ratio, WIPL-D

## 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. In the Yagi-Uda antenna, the induced currents on the parasitic elements are controlled by adjusting the length of parasitic elements and the distance of elements [1]. In the ESPAR antenna, the current of parasitic elements are controlled by adjusting the loaded reactance at the feed point of them [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]. 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 [4], [5].

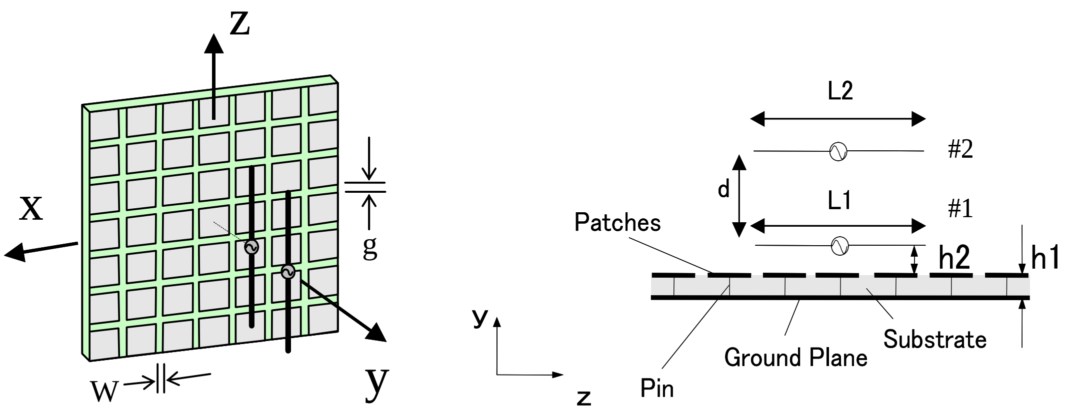
## 2. Analytical Model

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 = 20.6 mm. The length of two elements are L1 = 54.6 mm and L2 = 50.2 mm. The radius of each element is 1 mm. When this array antenna is located in free space, the front-to-back ratio 15.3 dB is obtained at the design frequency 2.45

GHz. This antenna is located h2= 3mm above the EBG ground plane with length $1\lambda_c$ by $1\lambda_c$. $\lambda_c$ is the wavelength at the design frequency 2.45 GHz. The relative permittivity of EBG material is 2.6 and its thickness is 4 mm. In the numerical analysis by WIPL-D, antenna elements are excited by the delta-gap generators and the thickness of EBG patches are assumed infinitely thin.

### 3. Results and Discussion

Fig. 2 shows the calculated front-to-back ratio for different number of EBG patches. The gap width is fixed to be g = 3 mm. Figs. 3 and 4 show the front-to-back ratio for 10 by 10 and 9 by 9 EBG patches, respectively. In Fig. 3, the front-to-back ratio of the two dipole array backed by the perfect electric conductor (PEC) is also shown for comparison. In the case of 10 by 10 EBG patches, the maximum front-to-back ratio of 24 dB is obtained at the frequency of 2 GHz.




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

Fig. 1. Structure of two element phased array dipole antenna on EBG substrate.
d = 20.6 mm, L1 = 54.6 mm, L2 = 50.2 mm, radius of dipole elements = 1 mm,
h2 = 3 mm, relative permittivity of substrate = 2.6, h1= 4 mm.

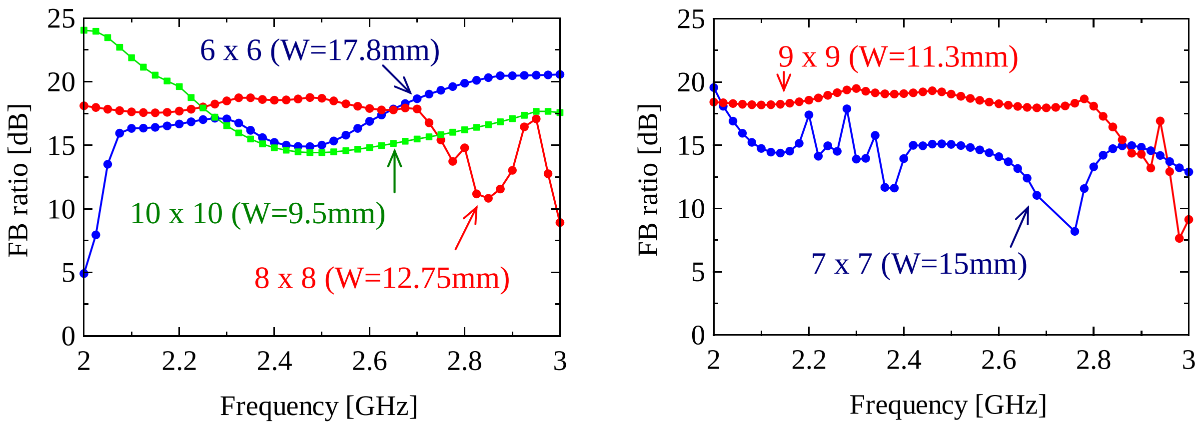



Fig. 2. Front-to-back ratio for different number of EBG patches, g = 3 mm.

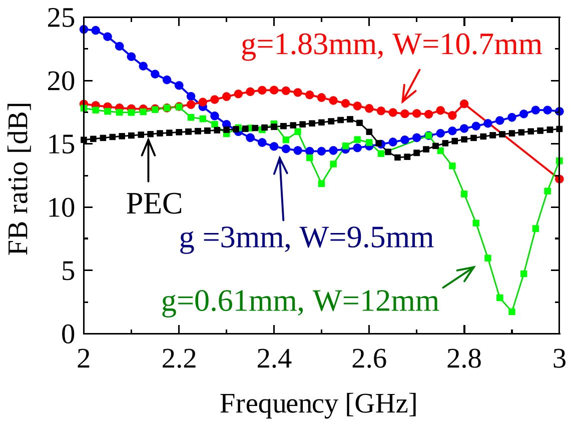



Fig. 3. Front-to-back ratio for 10 by 10 EBG patches.

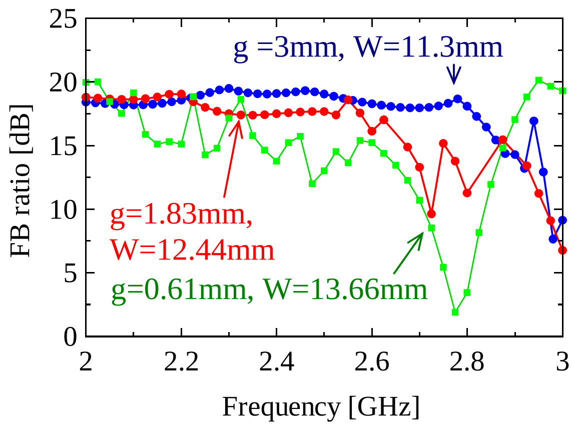



Fig. 4. Front-to-back ratio for 9 by 9 EBG patches.

Fig. 5 shows the electric field distribution in the vicinity of EBG ground plane of 10 by 10 patches at the frequency of 2 GHz. Fig. 6 shows the electric field distribution in the vicinity of PEC ground plane for comparison. In the case of the EBG ground plane, the electric field concentrates in the vicinity of gap between EBG patches. The electric field becomes weak near edge of EBG ground plane compared with the case of PEC plane. Therefore the backward radiation becomes small in the case of EBG ground plane.

## 4. Conclusion

Two element array dipole antenna with 90° phase difference feed on the finite EBG ground plane has been analyzed numerically. Although the parameters of two elements and EBG ground plane have not been optimized, the front-to-back ratio of 24 dB is obtained. Since the maximum front-to-back ratio of two element phased array dipole antenna located in free space is 15.3 dB, the front-to-back ratio is improved. By adjusting these parameters, higher front-to-back ratio will be obtained. This antenna will be promising as an element antenna for the base station antenna of short-range wireless communication system.

## References

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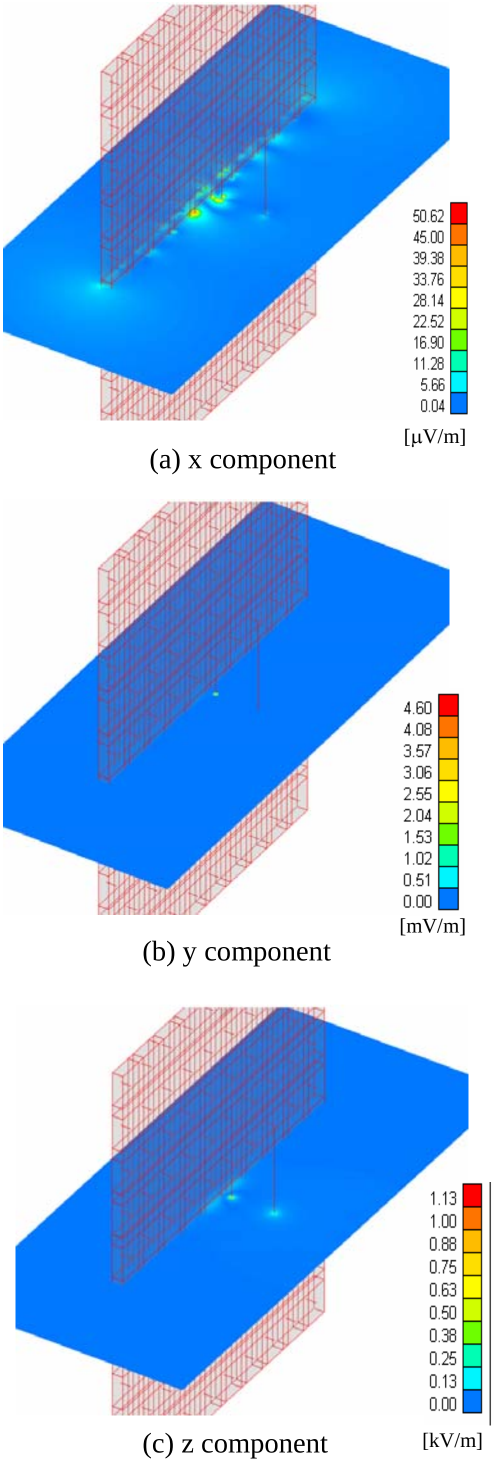
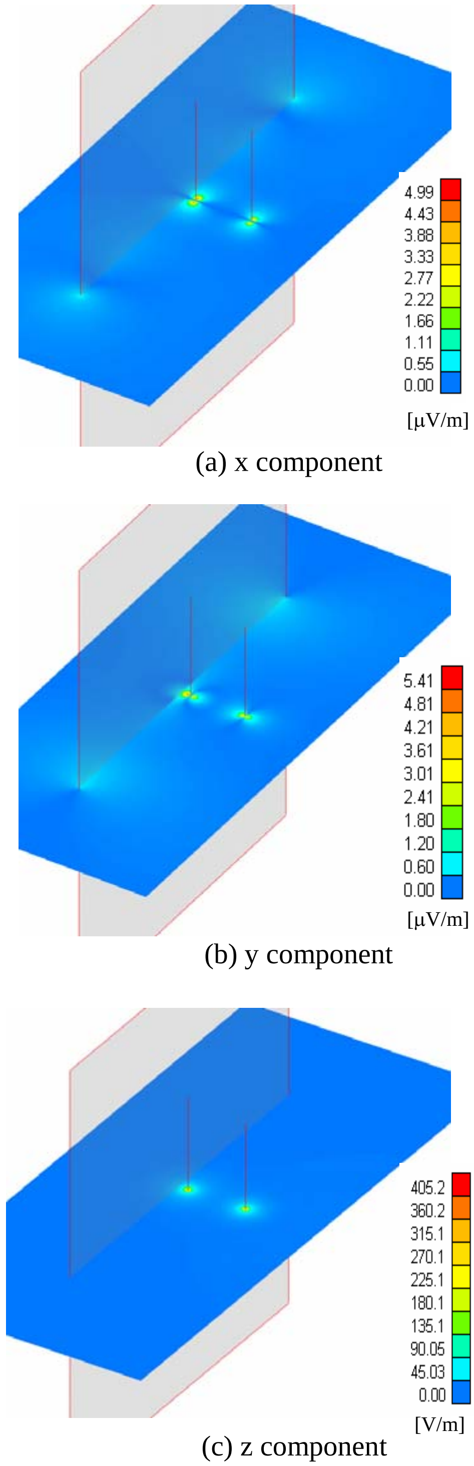



(a) x component

(b) y component

(c) z component

Fig. 5. Electric field distribution in vicinity of EBG ground plane. Number of patches 10 by 10, g = 3 mm, W = 9.5 mm, frequency = 2 GHz, FB ratio = 24 dB.




(a) x component

(b) y component

(c) z component

Fig. 6. Electric field distribution in vicinity of PEC ground plane. Frequency = 2 GHz, FB ratio = 15 dB.