

Research of Planar Inverted-F Antenna Based on Electromagnetic Band Gap

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Abstract – This paper proposes a capacitive miniature PIFA works at UHF band. Double-layer mushroom structure EBG is used as a reflector of the PIFA instead of PEC. The size of the new PIFA is 1/8 of the operation wavelength and 1/2 of the traditional one. The EBG structure enhances the radiation efficiency of the antenna about 33.3%.

Index Terms — EBG, PIFA, UHF, radiation efficiency.

1. Introduction

Planar inverted-F antenna (PIFA) is widely used in wireless communication systems. However, the main drawback is low radiation efficiency with a low profile. One way to enhance efficiency is to employ electromagnetic band gap (EBG) structure. EBG is a class of artificial periodic materials which suppresses the propagation of surface waves on the plane of the structure [1]. We can use this special feature of EBG structure to design low-profile and high-performance antenna [1], [2]. The size of PIFA based on EBG instead of PEC is 1/8 of the operation wavelength and 1/2 of the traditional one. The proposed antenna with EBG and PEC are studied with CST and measured in an anechoic chamber separately.

2. Design of the proposed antenna

EBG structure is so large in UHF band that it is inconvenient to produce and apply according to [2]. However, adding capacitance can reduce EBG size [3]. EBG size is effectively reduced when we add a metallic plane that forms a three-layer EBG structure. Fig. 1 is the configurations of double-layer EBG structure.

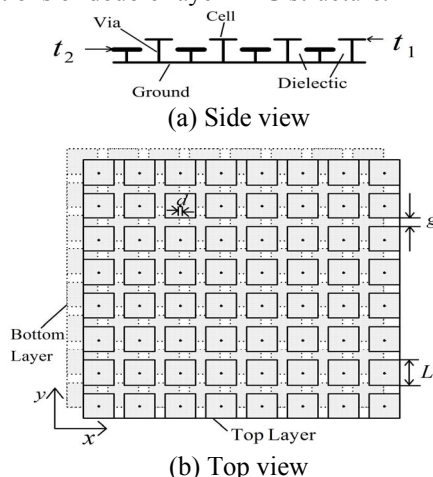


Fig. 1. Configurations of double-layer EBG.

The EBG structure composes of two same layers, an upper layer and a lower one. Cell length $L=17\text{mm}$, cell gap $g=2\text{mm}$, via diameter $d=1\text{mm}$. Cells' metal layers thickness are $t_1=0.2\text{mm}$, $t_2=1.3\text{mm}$.

Traditional PIFA size is 1/4 of the operation wavelength. Adding capacitive impedance can reduce the antenna size [4]. Fig. 2 shows the structure of PIFA. Upper and lower metal board parallelize and are connected to the ground. The lower-layer height is half of the upper one. The antenna length $l=41\text{mm}$, width $w=40\text{mm}$, and the height between upper-layer and ground is $h=8\text{mm}$.

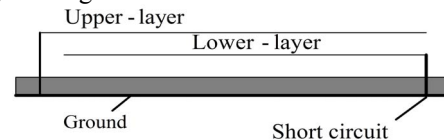


Fig. 2. Structure of PIFA.

3. Results of simulation and measurement

(1) Results of simulation

Double-layer EBG structure is the reflective board of the PIFA [5]-[7]. EBG is placed around the PIFA and they are connected to the same ground. Fig. 3 is PIFA model with EBG structure in CST.

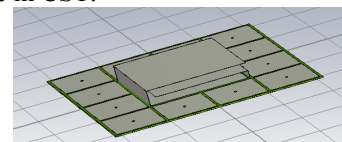
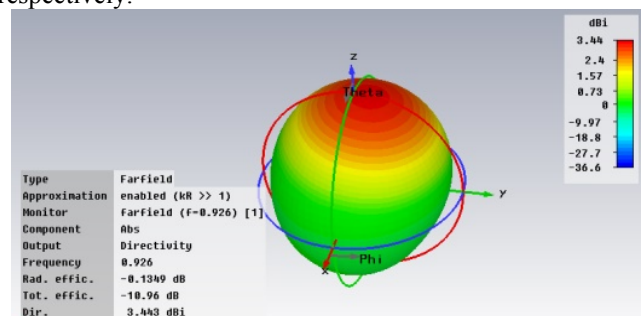
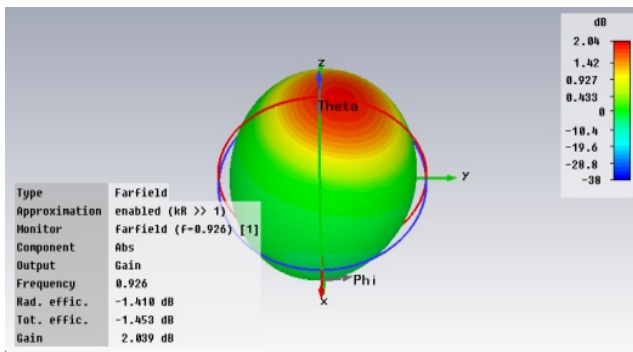


Fig. 3. PIFA based on EBG in CST.

Simulation results of PIFA based on EBG and PEC are shown in Fig. 4 respectively. Gain of PIFA with EBG is 3.443dB, and radiation efficiency is -0.1349dB namely 73.3%. While gain of PIFA with PEC is 2.039dB, radiation efficiency is -1.410dB namely 40%. Gain and efficiency of the antenna with EBG get improved about 1.4dB and 33.3% respectively.



(a) Simulation result of PIFA with EBG

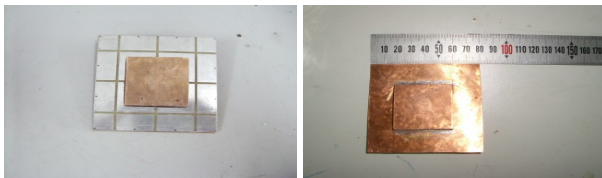


(b) Simulation result of PIFA with PEC

Fig. 4. Simulation results of PIFA with EBG and PEC.

(2) Results of measurement

Fig. 5 is the images of manufactured PIFA with PEC and EBG.



(a) PIFA with EBG (b) PIFA with PEC

Fig. 5. Manufactured PIFA with EBG and PEC.

S parameters of PIFA with PEC and EBG are shown in Fig. 6. Resonant frequency of PIFA with EBG drops to 867MHz while the PEC one is 926MHz. It drops totally about 6%. Bandwidth is 13MHz and the relative bandwidth is 1.5%.

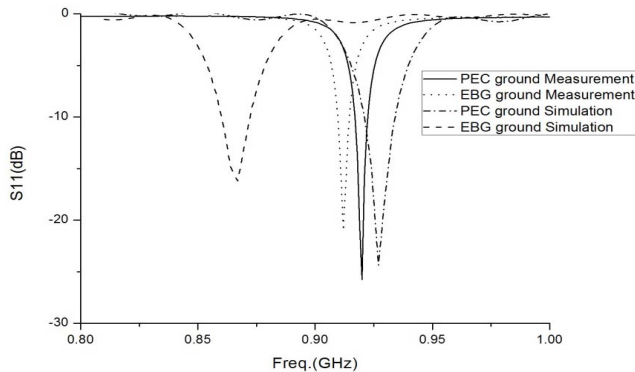


Fig. 6. S11 of PIFA with PEC and EBG.

Fig. 7 and Fig. 8 display the E and H plane pattern of measurement separately. Back lobe of PIFA with EBG is smaller than with PEC that gets a better directivity after comparing two pictures.

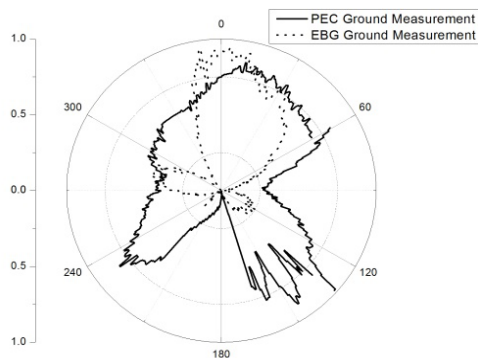


Fig. 7 E-plane pattern of measurement.

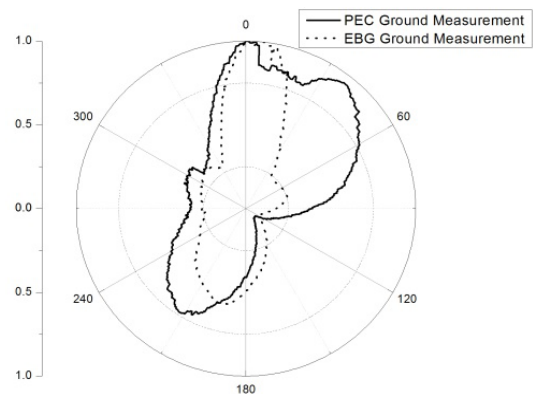


Fig. 8. H-plane pattern of measurement.

4. Conclusion

Radiation efficiency gets promoted 33.3% and gain promotes 1.4dB after using EBG instead of PEC in simulation. Gain promotes 4.74dB in measurement and the antenna size becomes smaller. Radiation patterns and working frequency don't changed apparently.

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