The Microstrip Antenna with PBG Used for 3G System

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Abstract: Aiming at the request of the antenna used for 3G system, we first analyze the characteristics of microstrip antenna and design methods of size structure, and then design the microstrip antenna with PBG by using MWO. The detailed analysis inquiries into the influence on the reflection coefficient S_{11} by key parameters, such as the length of PBG sides, the structural periodicity of PBG, the feeding point of antenna, the dielectric constant and thickness of circuit board have been studied. Finally, the design principles and advantages of the microstrip antenna with PBG are summarized.

Key words: PBG, microstrip antenna, material structure parameter

1. INTRODUCTION

With technical development in integrated circuits, the physical volume of modern communication equipments has already been diminished consumedly, so a kind of new antenna with very small in physical volume and very light in weight is needed to match with it[1]. Microstrip antenna is one of these kinds of antenna with low section, panel structure of typical model, which develops with the request of modern communication development. The microstrip antenna has the outstanding advantages that a series of normal antenna can't compare to. The PBG structure constituted of one kind of dielectric material in another dielectric material by the cycle distribution, which develops quickly in recent years, can improve the characteristics of the microstrip antenna further. After the electromagnetic wave in the band gap is scattered by periodic dielectric medium, the electromagnetic wave intensity in some band will exponential decay because of the destructiveness interference and can't propagate in that structure, hence forming band gap on the frequency spectrum. If these characteristics can be applied of the reasonable, we can design a kind of microstrip antenna with excellent performance. The key fraction lies in the structure material parameter of PBG, such as PBG structure size, base material etc.

There are many methods to discuss the electromagnetism radiation characteristic of the PBG structure antenna. The typical model adopted is the Finite Difference Time Domain Method (FDTDM) combined with the grid put forward by K. S. Yee in 1966[2]. It disperses Maxwell equations at time domain, so that can solve the complicated structure system equations of various shapes and various materials [3]. This kind of method, according to the discrepancy of objects, can improve the computing velocity and precision in grid division of time-space steps, weighting optimization etc. Facing to the research of actual engineering, the more simple and direct method is just using the software that have already been commercialized, such as the HFSS, ADS or the MWO, to carry on design, analyze correlation and change regulation of structure parameters that we concern, finally design the device that satisfy an applied request.

2. STRUCTURE DESIGN OF THE MICROSTRIP ANTENNA

In common use, a rectangular microstrip antenna mainly includes a ground plate, a radiation unit and a power supply unit. The size of the substrate $L_0 \times W_0 \times h$, the size of radiation sticks slab $L \times W$, the length and width of feed line and the feeding point location are the parameters which we concern most in our design.

The antenna structure dimensions can be calculated by making use of microstrip theory [4]. For the new antenna structures with two-dimensional PBG, we can take these calculated results as the basic reference parameters with a little bit of modification in the simulation. Based on 3G standard, the up-converter work band of the microstrip antenna should be 1920—1980MHz. Simply taking the work frequency of the microstrip antenna as f_r = 1.9 GHz, we get the antenna length L = 7.12 cm, the antenna width W = 5.06 cm, the substrate length L_0 = 21.91 cm, the substrate width W_0 = 20.27 cm and the thickness of dielectric board h = 0.15 cm. For the first approaching step of the sample, simulation replace a feed line with a *'via port'*, the length and width of which are 0.55cm and 0.50cm respectively.

3. SIMULATION AND RESULTS ANALYSIS

3.1 Simulation Establish of PBG Structure Parts

Making use of the merchandise software directly, we first discuss the way of using PBG to improve the design of 3G antenna. As shown in Fig.3-1, there are three layers for the antenna basic structure, in which two layers (1, 3) are air layers with relative dielectric constant as1, and the intermediate layer is a duroid dielectric layer with relative dielectric constant as 2.32. According to the size of the microstrip antenna gotten in computing, the simulation layer dimension of our setup is 21.91 cm×20.27 cm. For the design project, we have done an electromagnetism simulation schematic by using the EM Simulator of MWO software. The rectangle microstrip radiation sticks slab of the antenna is shown in the Fig.3-2, and the ground plate of the microstrip antenna that does not use PBG structure is shown in Fig.3-3.

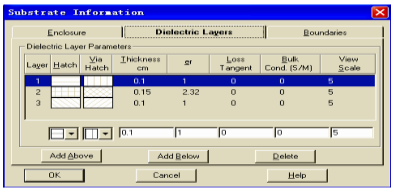


Fig.3-1 Electromagnetism simulation establish

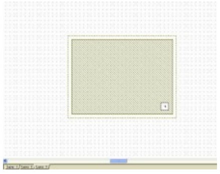


Fig.3-2 Microstrip radiation sticks slab

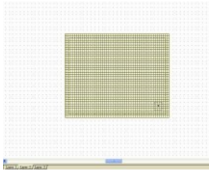


Fig.3-3 Ground plate of the microstrip antenna

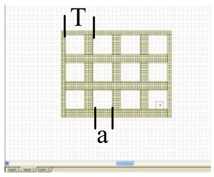


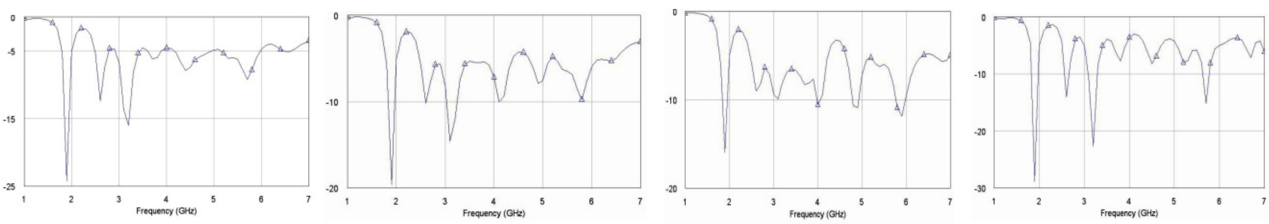
Fig.3-4 Ground plate of the antenna with PBG structure

In order to obtain widely working band and repressing high order subharmonic, we add PBG structure on the ground plate of the microstrip antenna. In 1998, Yongxi Qian put forward this kind of new PBG structure to micro strip[5], i.e. with cycle holes on the ground metal board. For the 3G antenna design, we also use this PBG structure in with square holes as shown in Fig.3-4. Here, '*T'* is set as the structural periodicity of PBG, '*a'* is set as the length of PBG sides. With this EM simulation design structure, we can carry on the simulation after setting up the frequency range.

3.2 Simulation Results and Analysis

3.2.1 Influence on the reflection coefficient S_{11} by the length of PBG sides

The reflection coefficient S_{11} of microstrip antenna affected by the changing length of PBG sides is shown in Fig.3-6 (a)-(d). Contrasting these serial figures, it can be found that along with the length of PBG sides enlarging continuously, the value of the fundamental wave's reflection coefficient S_{11} also enlarges continuously. Thus, the attenuation of the antenna will decrease, the working band of the antenna is increase gradually and the value of the triple harmonic's reflection coefficient S_{11} enlarges continuously.

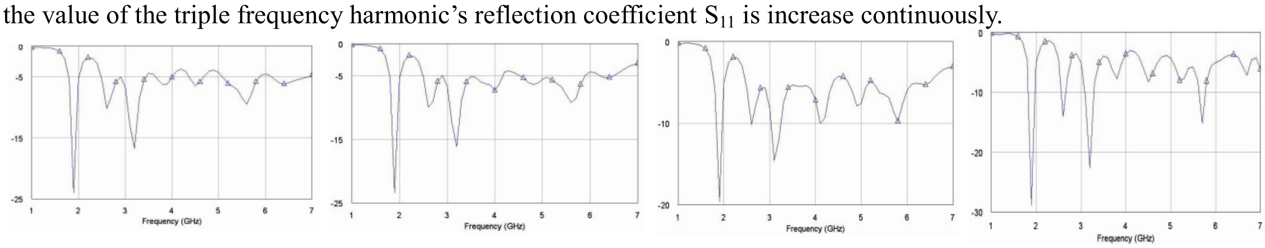


(a) *a* =0.82 cm, *T* =1.91 cm **(b) *a* =1.09cm,*T* =1.91 cm** **(c) *a* =1.37 cm,*T* = 1.91 cm** **(d) without PBG structure**

Fig.3-6 Influence on the reflection coefficient S_{11} by the length of PBG sides

3.2.2 Influence on the reflection coefficient S_{11} by the structural periodicity of PBG

With the structural periodicity of PBG changing, the variation of the reflection coefficient S_{11} of the microstrip antenna is shown in Fig. 3-7 (a) to (d). Contrasting these serial figures, it can be found that along with the structural periodicity of PBG T enlarging continuously, the value of the fundamental wave's reflection coefficient S_{11} also enlarges continuously. Thus, the attenuation of antenna will increase, the working band of the antenna becomes broad gradually, the value of the triple frequency harmonic's reflection coefficient S_{11} is increase continuously.



(a) *a* =1.09 cm,T =1.37 cm **(b) *a* =1.09 cm,*T* =1.64 cm,** **(c) *a* =1.09 cm,*T* =1.91 cm** **(d) without PBG structure**

Fig.3-7 Influence on the reflection coefficient S_{11} by the structural periodicity of PBG

3.2.3 Influence on the reflection coefficient S_{11} by the feeding point of the antenna

For the microstrip antenna under discussion, we take T = 1.91 cm, a = 1.37 cm and work frequency as 1.9 GHz. Changing the position of the feeding point is equivalent to changing the driving phase of slit source, which can make a great influence on the reflection coefficient S_{11}.Along with the feeding point location changing, the variation of the reflection coefficient of the microstrip antenna S_{11} is given in Table 3-1.

Table 3-1 Influence on the reflection coefficient S_{11} by the feeding point of the antenna

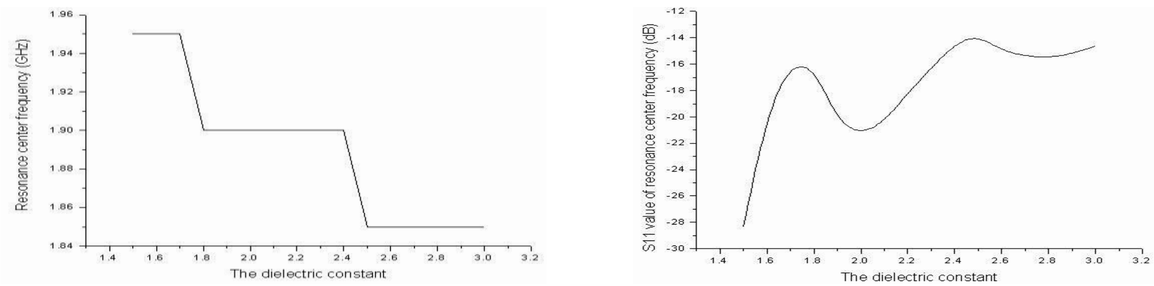
Location of Feeding point	Center frequency (GHz)	S_{11} value at the center frequency (dB)
The central of the antenna	2.05	-0.3308
The corner of the antenna	1.9	-15.97
1/4 of antenna's long side	1.9	-7.86
The central of antenna's long side	2.65	-8.918
1/4 of antenna's wide side	1.9	-16.72
The central of antenna's wide side	1.9	-15.57

From the table, it can be discovered that when the feeding point location changes along the antenna's long side, the antenna's resonance center frequency and its S_{11} value will change significantly; when the feeding point location changes along the antenna's wide side, the antenna's resonance center frequency is invariable, and the variety range of its S_{11} value is very small.

During the design, the selection of the feeding point is very important because it will influence on the antenna's resonance center frequency and the S_{11} value of resonance center frequency. Once the feeding point is determined in selection, it should avoid the misregistration of the feeding point along the antenna's long side to promise the resonance center frequency of the antenna being constant. The change of feeding point location along the antenna's wide side is equivalent to the change of phase difference of two slit source, which will influence the matching statue of the antenna of the transmit system. Reasonable application of this characteristic can promise the resonance center frequency of the antenna being constant and make the gain of the antenna increase.

3.2.4 Influence on the reflection coefficient S_{11} by the dielectric constant

With the dielectric constant changing, the changes of the resonance center frequency and the reflection coefficient $S_{11}$of the microstrip antenna are shown in Fig.3-8 (a) and (b), respectively.



(a) the resonance center frequency vs. ε_r (b) the reflection coefficient S_{11} vs. ε_r

Fig. 3-8 Influence on center frequency and S_{11} by the dielectric constant

From the figure, it can be seen that the resonance center frequency of the antenna lets up gradually along with the increment of the dielectric constant. Once the dielectric constant increases about 20%, the resonance center frequency of the antenna lets up a 0.05 GHz. The S_{11} value of resonance center frequency enlarges gradually along with the increment of the dielectric constant. Once the dielectric constant increases about 0.1, the S_{11} value of resonance center frequency equally enlarges 0.91 dB. While designing antenna, making the dielectric constant let up properly in the certain range can promise the resonance center frequency of the antenna as constant and raise the gain of the antenna.

3.2.5 Influence on the reflection coefficient S_{11} by the thickness of the circuit board

With the thickness of the circuit board changing, the change of the reflection coefficient S_{11} of the microstrip antenna is given in Table 3-2.

Table 3-2 Influence on the reflection coefficient S_{11} by the thickness of the circuit board

The thickness of the stripe (cm)	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20
Center frequency (GHz)	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
S_{11} at the center frequency (dB)	-13.69	-14.44	-15.20	-15.97	-16.77	-17.64	-18.49	-19.49	-20.40

From the table, it can found that due to the increment of the thickness of the circuit board, the antenna's resonance center frequency is invariable, but the S_{11} value of resonance center frequency will let up gradually. Once the thickness of the circuit board increases 0.01cm, the S_{11} value of resonance center frequency equally let up 0.839 dB. While designing antenna, making the thickness of the circuit board enlarge properly in the certain range can promise the resonance center frequency of the antenna as constant and raise the gain of the antenna.

4. CONCLUSION

Based on the theoretic analysis of the microstrip antenna, we have discussed the size structure design method. By giving the similar design formula, then we simulated the antenna which can run at 1.9 GHz frequency and calculated its reflection coefficient S_{11} by using MWO based on the MOM. The PBG structures are used on the earth plate for the purposes of expanding bandwidth, bating high order harmonic wave and optimizing gains.

Through the simulation analysis, we discovered that the feeding point location is the biggest influence factor of the antenna performance, because its variation will cause bigger variety of the resonance center frequency of the antenna and the S_{11} value of resonance center frequency. The variation of the dielectric constant will also cause the changes of the resonance center frequency of the antenna and the S_{11} value of resonance center frequency, but the changing ranges are smaller

The varieties of the length of PBG sides, the structural periodicity of PBG and the thickness of the circuit board all will not influence the resonance center frequency of the antenna basically. The varieties of the length of PBG sides and the structural periodicity of PBG mainly influence the gain, the work band of the antenna and the reflection of the high sub harmonic. The thickness changing of the circuit board mainly affects the gain of the antenna.

While designing antenna, reasonably selected parameter, such as the length of PBG sides, the structural periodicity of PBG, the feeding point of the antenna, the dielectric constant and the thickness of the circuit board, can promise the antenna working in suitable frequency and the gain of the antenna, open widely the work band of the antenna availably, repress each high sub harmonic availably, and raise the signal to noise ratio of the microstrip antenna.

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