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NON SURFACE WAVE MUTUAL REDUCING IN MICROSTRIP ANTENNAS ARRAY

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Abstract—It is well known that the mutual coupling can be classed with surface wave mutual coupling and non-surface wave mutual coupling simply in microstrip antennas array. The surface wave mutual coupling has been researched far and wide and lots of interest researches have been present in recent years. But the investigating about the non-surface wave mutual coupling which contains space coupling, fringe field coupling. This paper introduces a simple method that can be used in design of closely spaced microstrip antennas array without surface wave coupling, and which can also be used to combine with the reduction surface wave strategy to improve the isolation in the antennas array. Two traditional microstrip antennas with the air substrate in this paper are used to analyze the affection of the different correlative parameters in the condition of non-surface wave mutual coupling. Using the proposed model, the mutual coupling, described by the network parameter S21, of about -15 dB from the initialization of about -6 dB, and the gain of the proposed structure can also improve 2.53 dB.

1. INTRODUCTION

$\lambda/2$ space between antenna elements is the usual used in the antennas array design because of the superiority such that the grating lobes vanish, keeping the balance between gain and minor-lobes. In the actual applications, the efficiency of microstrip antenna has opposition relationship with the medium permittivity, especially with a thick substrate. Getting maximum gain with minimum number of antenna elements, is regard as the most important things in antenna array. If there is no surface wave brings out power, a majority of power can be radiated from antenna array. The simply method getting non-surface wave microstrip antenna is proposed with a substrate which permittivity is closed to 1.0. The disadvantage of the situation is that the microstrip antenna have a biggish dimension closed to $\lambda/2$ which make the distance of the patches closed to 0.02λ. This is why research is expected to reduce coupling at a separation of nearly 0.02 of the free space wavelength.

Periodic structures such as photonic band gap (PBG) and defected ground structures (DGS) have drawn an increasing interest because of their extensive applicability in antennas and microwave circuits [1–5] for reducing the coupling. But the complex structures affect the application in the large-scale microstrip antennas array. Paper [6] gave a simple technique for realizing compact arrays of microstrip antennas, but the proposed structure need a small LC and high L/C which can not be used to some conventional wide band microstrip antenna such that the U slot microstrip antenna, E shape microstrip antenna, and lots of thick substrate microstrip antennas, because of the thick substrate with high L. Lots of paper were present in [7–19] for analyzing the couple in antenna or antenna array already.

This paper introduces a simple method that can be used in design of closely spaced microstrip antennas array without surface wave coupling in most situations, and which can also be used to combine with the reduction surface wave strategy to improve the isolation in the antennas array.

2. MODEL AND METHODS

The element of microstrip antenna without surface wave is shown in Figure 1. (A square microstrip antenna with $L = W = 47.75$ mm, $f_0 = 3$ GHz, feed position = 7.5 mm from the center of the patch, via radius = 0.5 mm, substrate $h = 1$ mm.)

The traditional dualistic microstrip antennas array and the S parameters with a $\lambda/2$ distance is shown in Figure 2. Because the non-surface wave microstrip antenna is proposed with a substrate which permittivity is closed to 1.0. So the microstrip antenna has a biggish dimension closed to $\lambda/2$ which make the distance of the patches is closed to 0.02λ edge to edge in the E-plane of the array.

From the figure we can see that (1). the resonance frequencies increase, and the S11 become badly. (2). the mutual coupling described by S21, is -5.63 dB between the two patch with a $\lambda/2$ distance.

The proposed method will be described afterward.

A) Increasing the width for reducing coupling

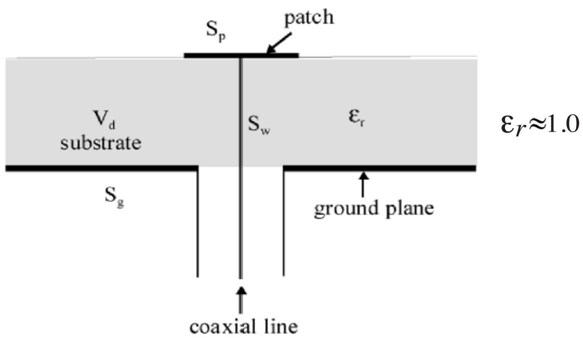

Figure 1. The element of microstrip antenna without surface wave.

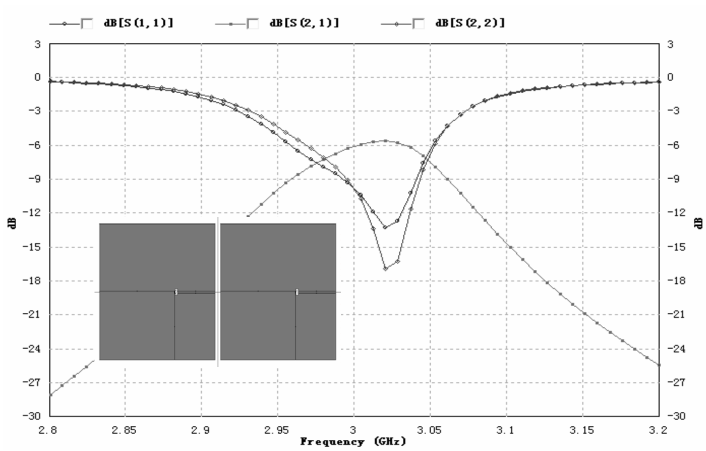

Figure 2. The traditional dualistic microstrip antennas array and the S parameters with a $\lambda/2$ distance.

If the radiating edges of two patches are brought close to each other, the mutual coupling can be used the field lines in the E-plane of the array for analysing. So increasing the width of edge, field lines will be rarefaction and the mutual coupling will be reducing too, which can be see in Figure 3.

Figure 4 shows a proposed structure with flexuose edge for increasing the width of the edge. The quadrate flexuose edge dimension is equal to 5 mm and the other parameters are same as Figure 2. From this figure we can see that (1). the resonance frequency increased. (2). The mutual coupling described by S21, is -9.11 dB between the two patch with a $\lambda/2$ distance, which reduce 3.4 dB than the general

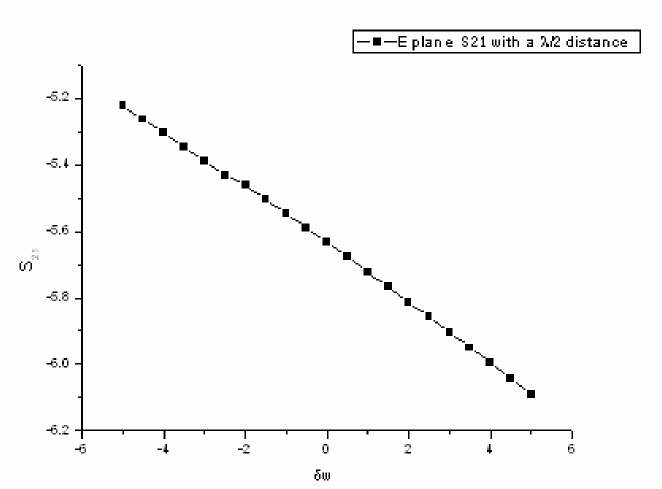

Figure 3. The S21 with the width variety.

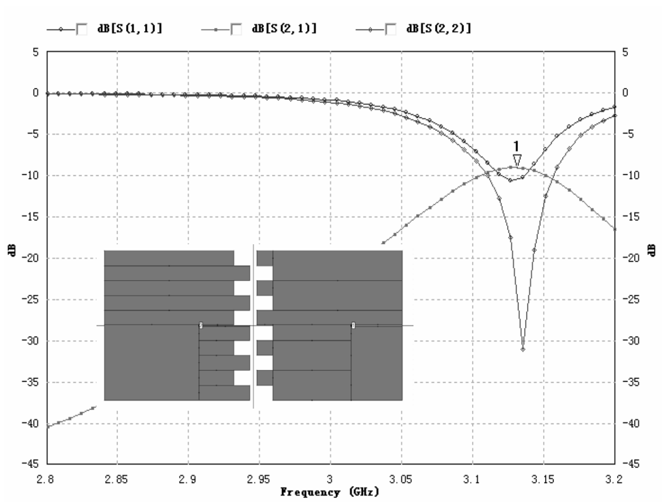

Figure 4. The proposed structure with flexuose edge.

situation.

B) Heightening metallic ground wall for reducing coupling

Using the simple microstrip patches which have the parameters with $L = W = 47.75\,\text{mm}$, $f_0 = 3\,\text{GHz}$, feed position $= 7.5\,\text{mm}$ from the center of the patch, via radius $= 0.5\,\text{mm}$, substrate $h = 1\,\text{mm}$. The space between the two patches is $\lambda/2$ which makes the distance of the patches closed to 0.02λ edge to edge in the E-plane of the array. A heightening metallic ground wall is builded between the two patches. It is noted in Figure 5 that the S21 will reduce when increases the height of the metallic ground wall.

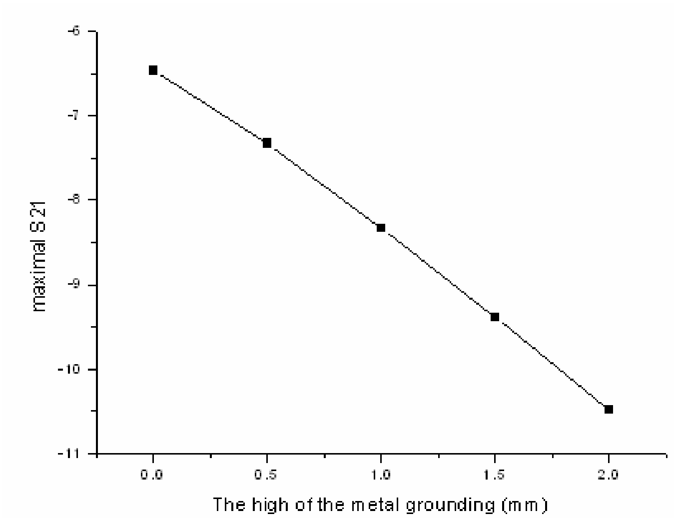

Figure 5. The S21 with the heightening metallic ground wall.

This is clarified in Figure 5, where a reduced coupling to -11 dB when the height of the ground wall is 2.0 mm. It is expected because the higher ground wall can truncate the field more effectively.

3. DESIGN

Combining the proposed structures, we get a simple and effective method to reduce the non-surface mutual coupling. The traditional parameters of the structure are the same as before. The E-plane separation between the edge is 2 mm, a cross coupling of -5.63 dB is observed. The proposed structure is shown in Figure 6, and the quadrate flexuose edge dimension is equal to 5 mm. The height of the ground wall is 2.0 mm with a 1.0 mm thick substrate.

From Figure 6, we can see that the mutual coupling described by S21, is -13.1 dB between the two patch with a $\lambda/2$ distance, which reduced 7.47 dB than the general situation.

The far fields are calculated on a infinite ground, described in Figure 7. The left one with a maximum gain 8.5 dBi, is the far field of the traditional structure. The right one with a maximum gain 11.03 dBi, is the far field of the proposed structure.

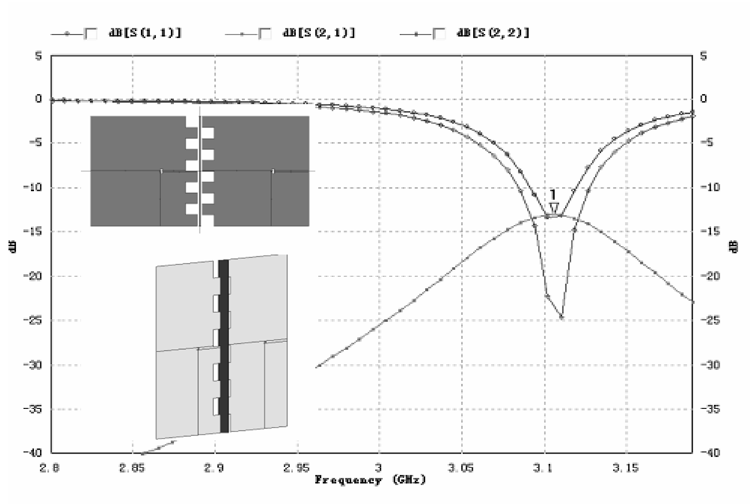

Figure 6. The proposed structure combining the two method.

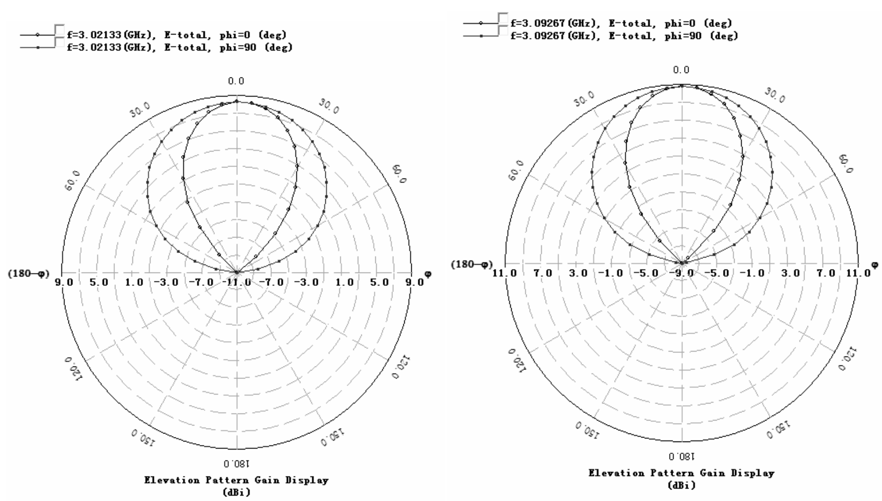

Figure 7. Comparing the far field of the traditional structure (left) and the proposed structure (right).

The comparing shows that the reduction mutual coupling patches have improved gain 2.53 dBi. The main reason is the reduction mutual coupling patches have a improved antenna efficiency which is 87.39% compared 52.83%.

4. CONCLUSION

This paper introduces a simple method which can reduce the non-surface mutual coupling. The mutual coupling, described by the network parameter S21, is reduced to −15 dB from the initialization of about −6 dB, and the gain of the proposed structure can also improve 2.53 dB. The proposed structure can be used in design of closely spaced microstrip antennas array without surface wave coupling, and which can also be used to combine with the reduction surface wave strategy to improve the isolation in the antennas array.

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