

A NOVEL RADIATION PATTERN AND FREQUENCY RECONFIGURABLE MICROSTRIP ANTENNA ON A THIN SUBSTRATE FOR WIDE-BAND AND WIDE-ANGLE SCANNING APPLICATION

J. Ouyang, F. Yang, S. W. Yang, Z. P. Nie, and Z. Q. Zhao

School of Electronic Engineering
University of Electronic Science and Technology of China (UESTC)
Chengdu 610054, China

Abstract—A novel radiation pattern and frequency reconfigurable microstrip antenna is introduced in this paper. This antenna is designed on a thin substrate for the application of conformal phased antenna future. The proposed antenna make the operating frequency range 6 times larger than that of a simple rectangular microstrip antenna, and make the beam covering from $-70^\circ \sim 70^\circ$ compared with the traditional rectangular microstrip antenna beam which only covers $-50^\circ \sim 50^\circ$. It is potential on the application of wide-band and wide-angle scanning.

1. INTRODUCTION

Microstrip antennas have been widely used in conformal phased array owing to their distinct advantages such as light weight and small size. But conformal phased array antennas need a lower section for keeping flying capability of aircraft. At the same time, the thin substrate makes a narrowband characteristic affect the available application in conformal phased array. Many efforts have been devoted to the bandwidth enhancement of microstrip antennas, and many techniques have been proposed [1–4, 8, 9]. But with a limit of thin substrate, the antenna has 3 times bandwidth improvement compared with the traditional rectangular microstrip antenna at best. However, the proposed reconfigurable microstrip antenna makes the operating frequency range 6 times larger than that of a simple rectangular microstrip antenna.

Another significant problem embarrassing conformal phased array applications is how to achieve wide-angle scanning. A simple

rectangular microstrip can not be used for a wide-angle scanning exceeding 50° , because it only has a beam width 100° in E -plane and 110° in H -plane. In [5–7, 10], switching mechanisms are utilized to alter the current paths and provide pattern reconfigurable behavior. In this paper, the proposed microstrip antenna also has an ability to reconfigure radiation pattern that take a 3 dB space covering from $-70^\circ \sim 70^\circ$. So the useful antenna, proposed in this paper, can be used in board-band and wide-angle application in conformal phased array future.

2. ANTENNA STRUCTURE

The proposed frequency and radiation pattern reconfigurable antenna can be separated into two components. One is the frequency reconfigurable component. Another is the radiation pattern reconfigurable component. The frequency reconfigurable component at the right top corner of Fig. 1(a), is composed by a square microstrip antenna and a coupling strip. The radiation pattern reconfigurable component at the right underside corner of Fig. 1(a), is composed by a small square microstrip antenna which size is nearly $\lambda_g/2$ and a big square microstrip antenna which size is nearly λ_g . The blank rectangles in the Fig. 1 indicate the switches, which can be described as the FRs (frequency reconfigurable switches) and PRs (pattern reconfigurable switches). The FRs are the blank rectangles which are shown at the right top corner of Fig. 1. The PRs are the blank rectangles which are shown at the right underside corner of Fig. 1.

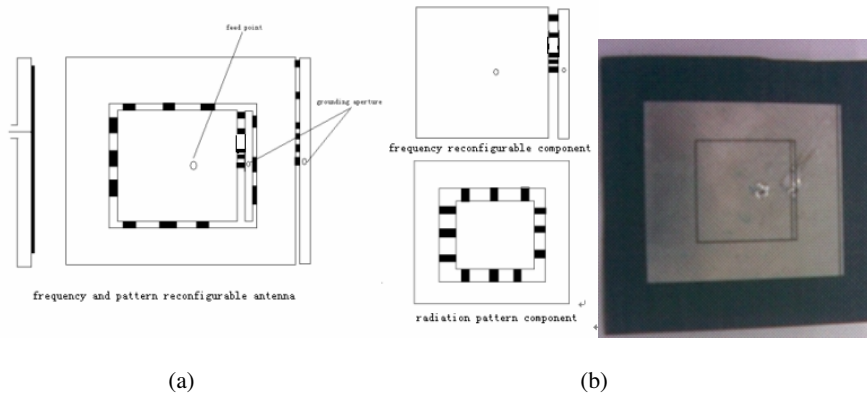


Figure 1. The proposed frequency and radiation pattern reconfigurable antenna structure, (a) frequency and radiation pattern reconfigurable antenna structure, (b) photograph of this antenna.

It is a frequency reconfigurable antenna with a board side radiation pattern, when turning the inside FRSs on, outside FRSs and the PRSs off. When turning the PRSs and outside FRSs on, inside FRSs off, the antenna becomes another frequency reconfigurable antenna with a divisive pattern. And, it also can achieve radiation pattern reconfiguration by turning the PRSs on/off. The interior FRSs control the frequencies of the small square microstrip antenna which works on the basal mode. The exterior FRSs control the frequencies of the large square microstrip antenna which works on the high-order mode.

Figure 1(b) is the photograph of the proposed antenna. The switches are replaced by a conterminous wire in the experimentation. The parameters of the width and length of the small square patch are 31 mm * 31 mm. The size of the big rectangle patch is 61 mm * 61 mm. The width of the gap between the patch and the coupling strip is 0.5 mm. The feed point is built at the place which has a space 5 mm from the square center. The feed probe radius is 0.5 mm. The height of the substrate is 1 mm ($0.01\lambda_0$), and its dielectric constant is 2.55.

3. RESULT AND DISCUSSION

Figure 2 shows the experiment frequency reconfigurable situation by turning the PRSs, outside FRSs off and inside FRSs on. The different frequencies are acquired by inside FRSs on in turn. And the antenna has a board-side pattern in this time. It is obvious that the proposed

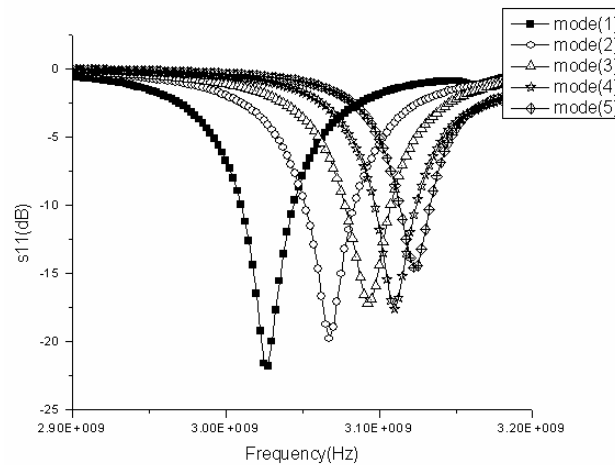


Figure 2. The frequency reconfiguration with interior FRSs.

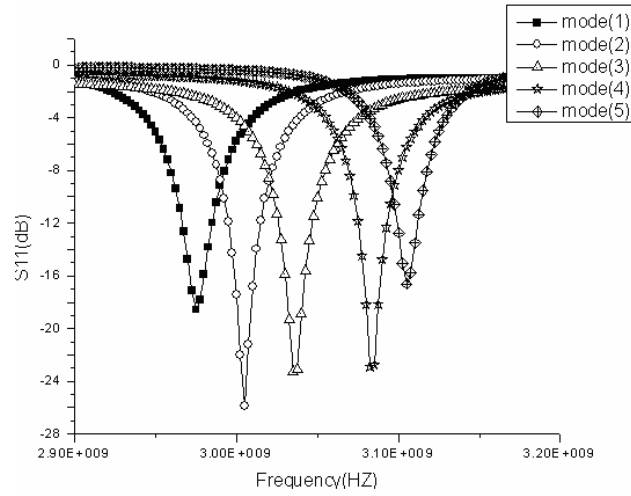


Figure 3. The frequency reconfiguration with exterior FRSs.

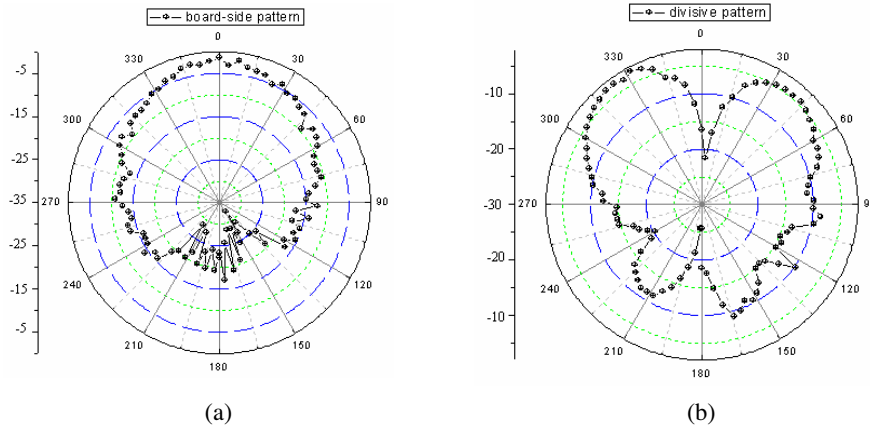


Figure 4. The pattern reconfiguration by turning PRSs on/off, (a) experimental pattern by turning PRSs off, (b) experimental pattern by turning PRSs on.

antenna makes the operating frequency range 6 times larger than that of a simple rectangular microstrip antenna. Fig. 3 shows the experiment another frequency reconfigurable situation by the PRSs, outside FRSs on and inside FRSs off. At this time, the antenna has a divisive pattern. It is obvious that the frequencies have a common area in the Figs. 2 and 3. Fig. 4 shows the pattern reconfiguration situation

by turning PRSs on/off. Fig. 4(a) shows a board-side pattern in E -plane when turning PRSs off. Fig. 4(b) shows a board-side pattern in E -plane when turning the PRSs on. It is obvious that the PRSs can control the antenna pattern and make beam covering from $-70^\circ \sim 70^\circ$.

4. CONCLUSION

A novel radiation pattern and frequency reconfigurable microstrip antenna is introduced in this paper. This antenna is designed on a thin substrate. The proposed antenna makes the operating frequency range 6 times larger than that of a simple rectangular microstrip antenna, and Compared with the traditional rectangular microstrip antenna beam which only covers $-50^\circ \sim 50^\circ$, the proposed antenna also make the beam covering from $-70^\circ \sim 70^\circ$. With a lower section, this structure would be greatly suitable for conformal phased array applications in future.

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