A Novel Reconfigurable Discrete Antenna

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Abstract: The integration and use of switches in microstrip patch reconfigurable antennas were investigated to get pattern forming in this paper, we also proposed a reflector shaping method by connecting switches between patch elements owe to its discrete structure, the experimental result demonstrated that it is effective, furthermore since the structure can be regarded as quasi-Yagi array, the maximum gain occurs at the end-fire.

1. Introduction

Reconfigurable antennas will be attractive field in the coming years along with the development of wireless mobile network, since high bit rate is required and the security of the users' information must be insured, while the conventional antennas that can vary pattern forming were too large in size or too expensive. Therefore, it becomes highly beneficial to develop reconfigurable antenna controlled through a combination of switches. A lot of antennas have been reported which employed reconfigurable structures, and utilized it to change phase distribution in the array in order to get steering pattern, or let it work at different operation modes [1], [2], herein, to address this issue, we consider of it in another way, we change the radiator patches by controlling the on or off status of the switches, as well as the reflector shaping. In our design, we formed several configurations such as dipole structure and cross dipole structure, as depicted in Fig.3 (a) antenna #1 and Fig. (b) antenna #2, in this way, pattern forming can be completed and directed to our desired direction. We will discuss the specification in section.2

2. Antenna Specifications and Operational Mechanism

Fig.1 and Fig.2 show the structure of the reconfigurable aperture proposed in this paper, it consists of 121 radiate patches (11*11) and 204 switches (200 connecting patches and 4 controlling via), the metal patch on the back of the substrate is a ground plane. The size of the radiate patch is 5.5mm*5.5mm, in order to work at 2.4GHz frequency, which is center frequency for bluetooth, the gap between every two patches is 1mm. The dielectric parameter of the material used for substrate is 4.4, the height of the substrate is 1mm.

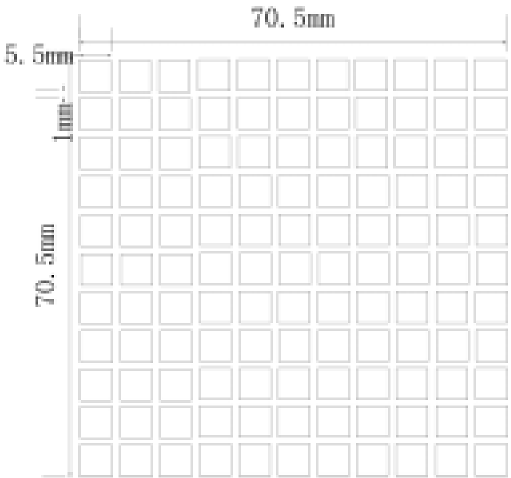

Fig.1 Sketch for Reconfigurable Patch

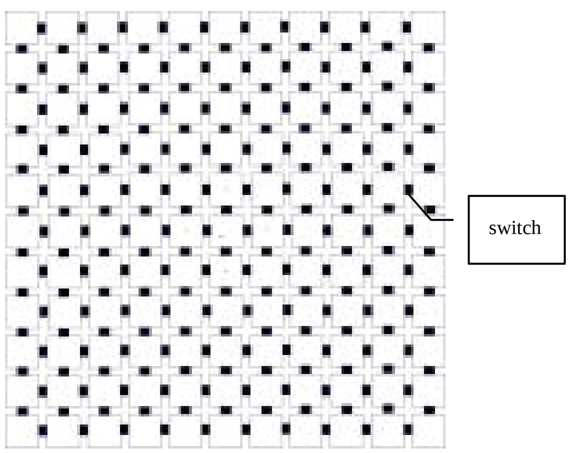

Fig.2 Sketch for Reconfigurable Patch with All Switches Off

For wireless access, we usually need end-fire pattern forming in most circumstance. Unfortunately, the directivity of patch is at broadside in generally. So we bethink of the microstrip dipole (or approximate dipole), because it's maximum directivity is located at the end-fire. Seen from Fig.3 (a) (b), the two branches of the dipole is formed by connecting the corresponding switches. For example, the angle of arrival of the user signal is located at $\phi = 45^0$, so the pattern forming need to be directed to this direction, we align the elements along the x-axis and y-axis, one branch is link to the inner conductor of coaxial feed line, the other is connected to the ground, consequently, that can be regard as a dipole, and it's length is between $\lambda_0 / 4$ (quarter wavelength in free space) and $\lambda_r / 4$ (quarter wavelength in substrate), which two branches is along x-axis and y-axis respectively, the details of the structure is showed in Fig.3 (b). It is convenient to synthesis any configuration which we want, since the size of each patch and the gap distance is identical, that we call it discrete structure.

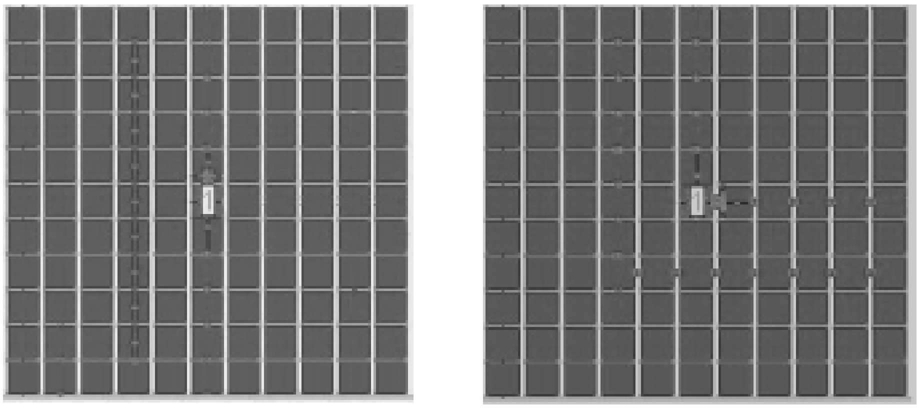

Fig.3 (a) Sketch for Antenna #1   Fig.3 (b) Sketch for Antenna #2

Another advantage of this reconfigurable antenna is that the reflector can be shaped flexibly. As we know, in conventional Yagi antenna mounting a parasitic reflector nearby the radiator at suitable location will increase the directivity and front-back ratio, so we can form a reflector for the radiator by utilizing switches. As depicted in Fig.3 (a) and Fig.3 (b), we shaped the reflector into the configuration that we needed, our experimental result demonstrated our ideals. However, because of the other parasitic elements existing, the distance between the reflector and the radiator must be optimized carefully, so it is named quasi-Yagi antenna.

3. Experimental Result

Simulation and measurement experiments have been carried out to demonstrate the functionality of this reconfigurable discrete antenna. Simulation is accomplished by IE3D, which is excellent simulation software in MOM for planar antennas.

Fig.4 and Fig.5 is simulated and measured S11 parameter curve corresponding to the structures of Fig.3 (a) and Fig.3 (b). Observed from the two figures, simulation and measurement result demonstrate that the resonant frequencies of the two styles approximate to 2.4 GHz, but the return loss is not low enough, which result to the gain of these antennas are limited.

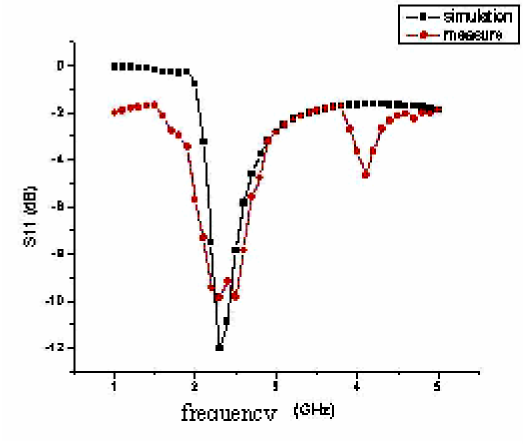

Fig.4 S11 for Antenna #1

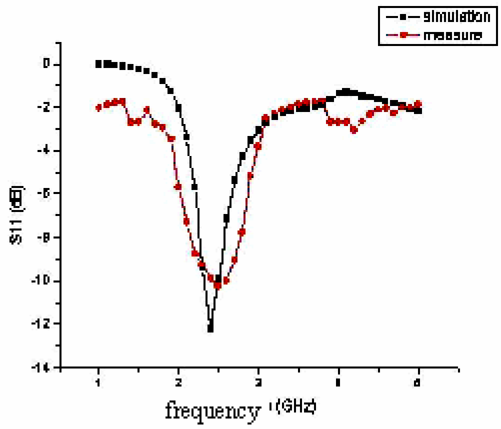

Fig.5 S11for Antenna #2

Then, we fabricated the antenna, and measured the pattern at 2.4GHz, Fig.6-Fig.7 show the details of it. Owe to symmetry of the structure, only the pattern maximum directivities located at $\phi = 0^0$ and $\phi = 45^0$ have been provided, other directions can be got by rotation.

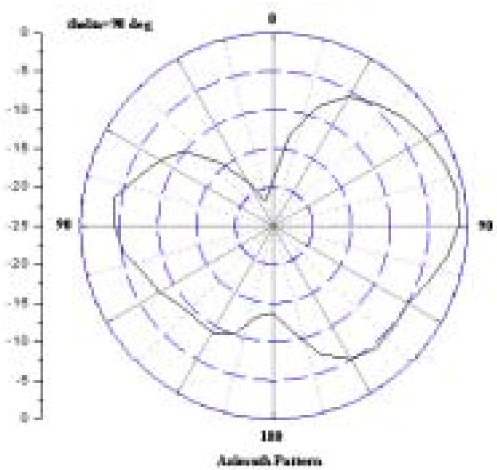

Fig.6 (a)

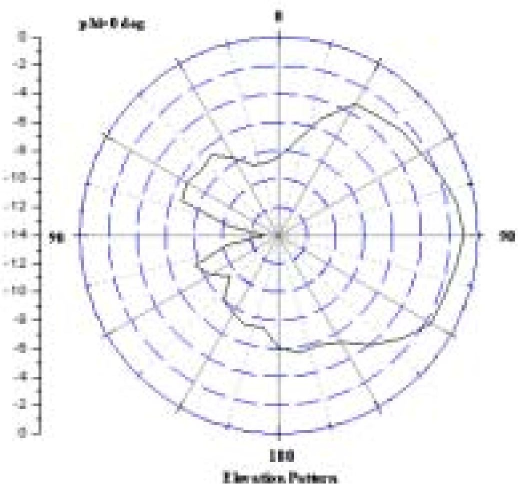

Fig.6 (b)

(The pattern for Antenna #1)

From the measure result we can see, that pattern forming has be tuned efficiently, since its structure is symmetrical by the center, we can get pattern forming directed to the other angle such as 90^0, 135^0 and so on, thus this antenna can almost scan every direction, moreover the end-fire radiation is achieved, judged from Fig.6 (b) and Fig.7 (b), that is very profitable for wireless access in the complex transmitting environment, although the relative gain is not very high.

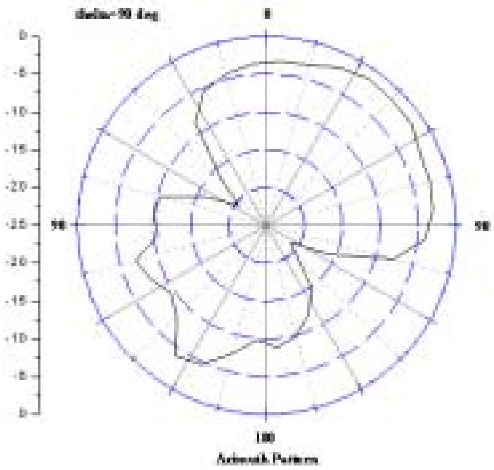

Fig.7 (a)

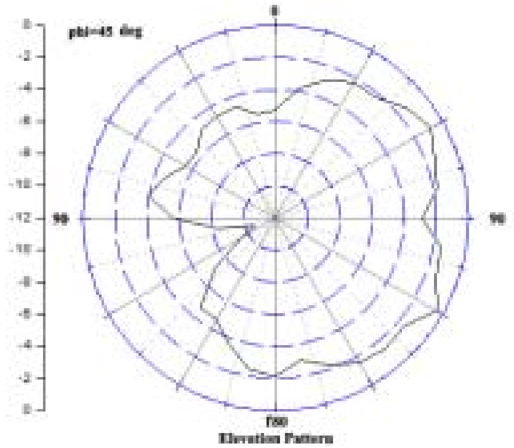

Fig.7 (b)

(The pattern for Antenna #2)

4. Conclusion

By utilizing switches and controlling their status, we obtained pattern forming conveniently and decrease the cost of manufacture. To improve the directivity and get unidirection radiation, the reflector shaping has been proposed. Also we can integrate other optical algorithm in this antenna design to optimize the configuration, thereby, to get the perfect structure and the best performance.

Reference:

[1] William H. Weedon and William J. Payne, “MEMS-Switched Reconfigurable Antennas”, IEEE Antennas and Propagation Society International Symposium, July 8-13 2001.

[2] James Sor, Y. Qian, M. F. Chang and T. Itoh, “Multi-Mode Microstrip Antennas for Reconfigurable Aperture”, IEEE Antennas and Propagation Society International Symposium, Volume1:1 Page (s): 318-320, 2000.