Reconfigurable Microstrip Antenna Array for Frequency Selectivity Application

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***Abstract*—A novel reconfigurable antenna array with frequency selectivity is presented. By switching the radiation structures between Whip-type and E-type structures, the working bandwidth range is adjustable from 3.7~4.0 GHz to 13.4~15.0 GHz, which is translated to a tuning ratio of 4:1. The spacing of elements is 11.0 mm for both bandwidths. To verify the feasibility, a prototype is fabricated and measured, and the reasonable agreement between the simulated and measured results is obtained. This antenna can be used in antenna systems of wide tuning ratios.**

Keywords—Frequency reconfigurable antenna; antenna array; wide tuning ratio; microstrip antenna.

I. INTRODUCTION

With the development of wireless applications, recent studies are focusing on reconfigurable microstrip antennas due to their numerous features, for instance, low cost, compact size, ease of excitation and low profile [1]-[3]. Common reconfigurable parameter of a microstrip antenna includes frequency, radiation pattern, polarization as well as a combination of the above [4]-[7]. Generally speaking, the tuning range of the frequency reconfigurable microstrip antenna array is generally within 2:1 [8]-[10], and thus whether half wavelength of high frequency or low frequency is chosen as the array spacing, a directional radiation pattern without the grating lobe can be realized.

However, for an ultra-wide tuning ratio, there is no reasonable array spacing to satisfy pattern characteristics in the full frequency band. Because in order to meet the high-frequency array spacing, the element must be arranged at high-frequency half-wavelength, whereas when the array works at low frequency band, it becomes a tightly-coupled array for the distance is much less than low-frequency half-wavelength. In this case, the element coupling is strong, and the isolation is less than 15dB. Therefore, a frequency reconfigurable microstrip antenna array with tightly coupled feature is investigated in this paper.

Other antennas with high isolation characteristics, such as Vivaldi antenna, can obtain a tightly-coupled array by loading isolation structure or owing to its favorable directing property. Nevertheless, this approach is not suitable for low-profile microstrip antennas. In addition, the overall space of the array is limited with the tightly-coupled constitution so that isolation structure cannot be employed. In this paper, the antenna array is loaded with electronic components to achieve a wide tuning frequency reconfigurable array. Its tuning rate can reach 4:1.

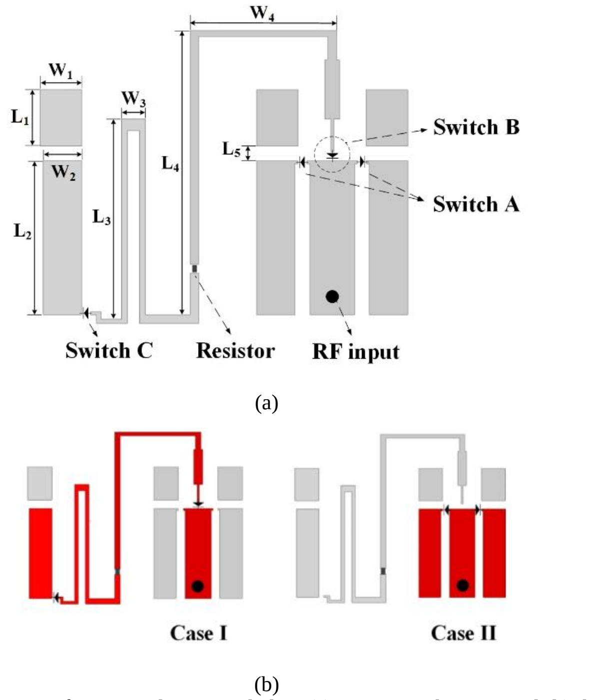


Fig.1. Design of antenna element including (a) structure schematic and (b) the diagram of the working mode for case I and case II

II. ANTENNA DESIGN

The element of the antenna array is designed in Fig.1. Specifically, the element structure is shown in Fig.1 (a). The element includes an E-type structure, a Whip-type structure and two coupling structures. The Whip-type structure is loaded with a 50-ohm resistor in the middle to achieve antenna matching at low frequencies and to reduce coupling between low-frequency array elements. What's more, the schematic diagram of the working mode is given in Fig.1 (b). The light-

TABLE I. CONFIGURATIONS OF THE THREE GROUPS SWITCHES TO ACHIEVE RECONFIGURABLE ANTENNA

	Fre. (GHz)	Switch A	Switch B	Switch C
Case I	3.7~4.0	OFF	ON	ON
Case II	13.4~15.0`	ON	OFF	OFF

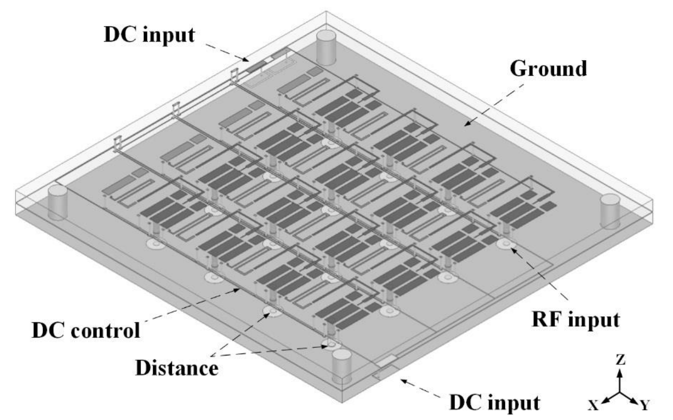


Fig.2. Design of reconfigurable antenna array.

gray structure is the part that is not directly excited. The red structure is the structure of direct excitation. We can see that switching the E-type and the Whip-type structure to achieve the selecting between case I and case II is achieved by controlling radio frequency (RF) switches on and off. The specific value of the DC offset voltage and the state of RF switches are given in Table I.

The structural parameters of antenna are as follows: L_1=1.90mm, L_2=5.20mm, L_3=6.75mm, L_4=9.60mm, L_5=0.50mm, W_1=1.40mm, W_2=1.30mm, W_3=0.81mm, W_4=4.95mm.

The antenna array structure is shown in Fig. 2. The array consists of two layers of dielectric substructures with thickness of 2mm and a dielectric constant of 2.65. The antenna array is printed on the front of the first layer of the dielectric substructure, the DC bias circuit is printed on the bottom of the first layer, and the ground and DC bias signal input ports of the array are printed on the bottom of the second layer.

III. ANALYSIS AND RESULTS

Simulations were performed using ANSYS HFSS. The reflection coefficients were measured using the Wiltron 37269A Network Analyzer and the radiation patterns, and gains were measured by the time-gating method. For the sake of brevity, the simulation and test results of VSWRs and Isolation are all given with the performance of the port-6 (see Fig.5) element in the array, and the performance of other ports is similar to that of port-6. Fig. 3 shows the VSWRs and Isolation simulation and test results. The antenna can achieve a impedance bandwidth for VSWR $\leq$ 2 from 3.7GHz to 4.0GHz in the case I and from 13.4GHz to 15.0GHz in case II. What's more, the worst isolation of port-6 with other nearby ports are given in difference case. The results show that the port-6 isolation is greater than 15dB in the operating band. Besides, Fig. 4 shows the directional patterns for the two

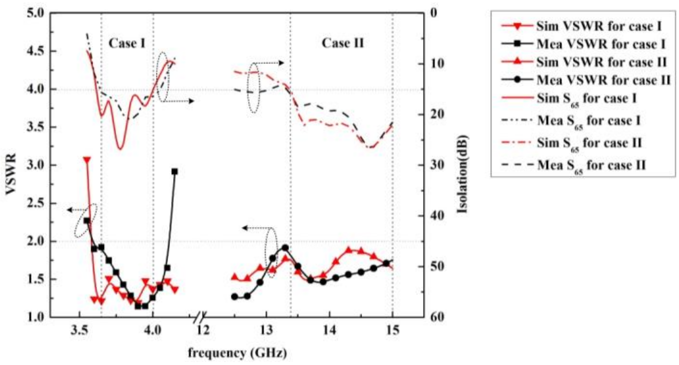
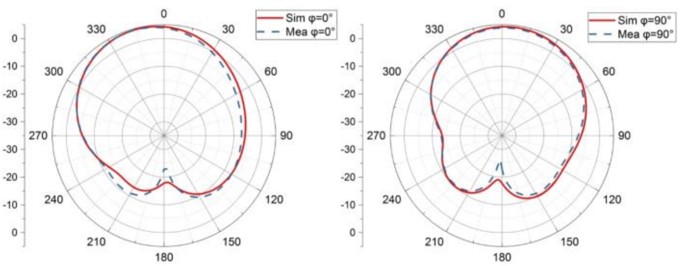
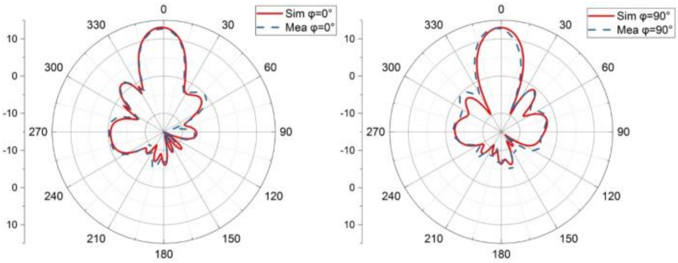


Fig. 3. Simulated and measured VSWRs and Isolation at Case I and Case II.



(a)



(b)

Fig.4. Simulated and measured radiation patterns (dBi) at (a) 3.7GHz and (b) 14.5GHz.

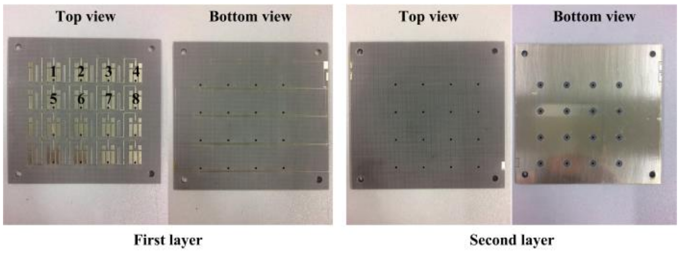


Fig.5. Fabricated frequency reconfigurable antenna array in different layer at top/bottom view.

operating modes, including the XOZ and YOZ plane patterns at 3.7GHz and 14.5GHz. The simulations are in good agreement with the test results. The validity of this antenna was confirmed. It can be noted that since the operating frequency of this antenna reaches the Ku band, it is difficult to use a suitable RF switch. Therefore, the ideal conduction and cut-off modes are used for measurement during the test, and no actual RF switch is added. Fig. 5 shows the top and bottom views of the various layers of the processing antenna.

IV. CONLUSION

The antenna array is designed and processed with bandwidths of 7.8% and 11.3% in the reconfigurable bands, and the tuning ratio is 4:1. This result is verified by experiments. And in both modes, the patterns maintain good radiation characteristics. This antenna is adapted to the wide-tuning-ratio reconfigurable antenna array system.

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