A Novel Hybrid Reconfigurable Antenna for Portable Wireless Terminal Applications

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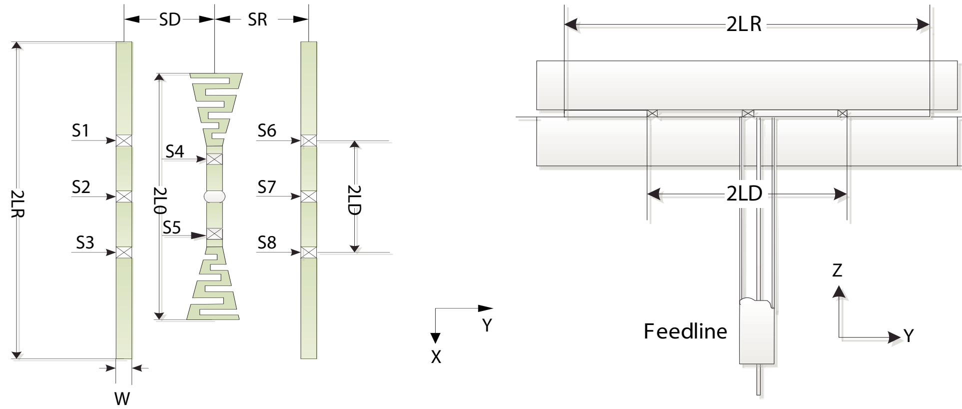
Abstract— In this paper, a dielectric embedded antenna with hybrid reconfigurable characteristics is proposed for portable wireless terminal applications, which is used as frequency or radiation reconfigurable antenna. The proposed hybrid reconfigurable antenna consists of a driven element, two parasitic elements and eight switches. By controlling the ON/OFF states of these switches set on the driven element, the proposed antenna can operate at two different frequencies, namely, 0.85 GHz and 1.9 GHz. The radiation reconfigurable characteristic is achieved by switching six switches installed on the parasitic elements. The proposed antenna has three modes of the radiation patterns at each frequency, has the potential to reduce noisy interference, and hence can improve the performance of the wireless systems. The simulation results demonstrated that the proposed antenna with flexible frequency and radiation pattern reconfigurable function is small in size and is promising for portable wireless devices.

1. INTRODUCTION

With the rapid development of communication technology, the reconfigurable antenna emerges as one of the most important research topics and has broad applications for various communication devices. A good reconfigurable antenna has the potential to improve the overall performance of a wireless communication system and can enable these systems to avoid noisy environments, to maneuver away from electronic jamming and to save energy via adjusting directing signals toward intended users [1]. Moreover, reconfigurable properties are usually realized by integrating electronic switches, capacitors or phase shifters into antenna structure. In [2, 3], a kind of wide slot antenna with frequency reconfigurable characteristics for ultra-wideband (UWB) communication systems has been proposed and investigated deeply. The designed antennas can be used as an UWB antenna, a multi-band antenna and a band-notched UWB antenna though controlling the states of the switches. In addition, a lot of Yagi antennas with pattern reconfigurable characteristics have been proposed [4–8] and widely studied. However, the radiation patterns of the proposed antennas can only scan in the upper-half space. In [9], a reconfigurable antenna with independently reconfigurable operating frequency, radiation pattern and polarization has been reported. Unfortunately, this antenna is large in size and has too many switches. In this paper, a novel hybrid reconfigurable antenna which has frequency and radiation reconfigurable functions was proposed for portable wireless devices. The proposed antenna integrated with eight switches, which controlled the current paths for providing frequency and pattern reconfigurable behaviors. The designed antenna can change the frequency band via adjusting its resonance length and meanwhile maintain the coincident radiation patterns, while the radiation pattern is also reconfigurable at each operating frequency band. In comparison with the previous reported antennas mentioned above, the proposed antenna with small size can not only provide the directional radiation, but also has the omni-directional radiation characteristic in the reconfigurable bands. In the simulation, ideal switches are employed to verify the proposed antenna [2, 3].

2. DESIGN OF THE PROPOSED HYBRID RECONFIGURABLE ANTENNA

Figure 1 shows the physical structure of the proposed hybrid reconfigurable antenna, where S1∼S8 are switches. It can be seen that the proposed antenna consists of a driven element, two parasitic elements and eight switches. Additionally, the antenna and these switches are embedded in the dielectric substrate, whose dielectric constant is 4.4 and the loss tangent is 0.002. The driven element, which is realized by using a meandered line dipole, is approximately a quarter wave length at the resonance frequency of 0.85 GHz in free space. Furthermore, two parasitic elements are set along the driven element at each side. The driven element is fed via a 50 Ω coaxial probe, which lies in the center of the proposed antenna. On the one hand, when the two switches, namely S4 and S5, on the driven element are OFF, the proposed antenna operates at 1.9 GHz, while when these two switches are ON, the antenna works at 0.85 GHz. On the other hand, when the switches on



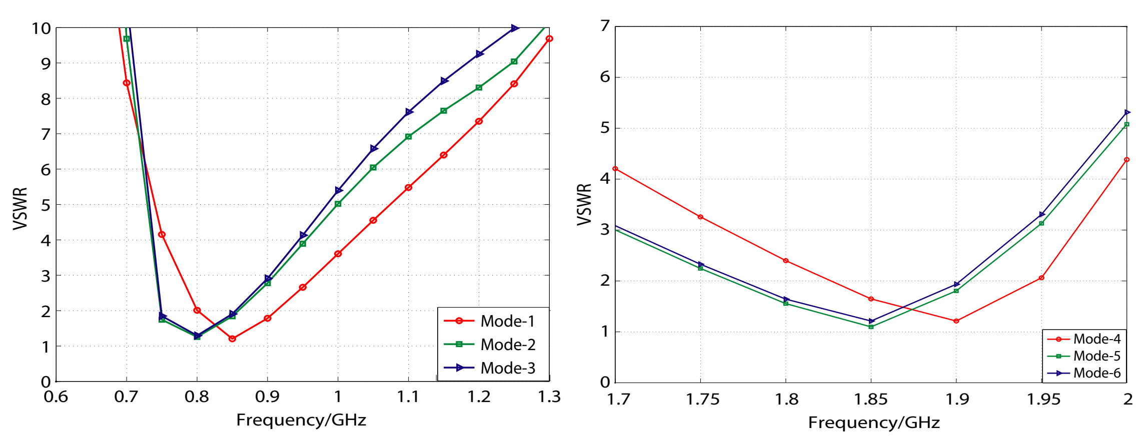
(a) (b)

Figure 1: Physical structure of the proposed hybrid reconfigurable antenna. (a) Top view of the antenna. (b) Side view of the antenna.

the parasitic elements are ON, the parasitic element can be regarded as reflectors, while they act as directors when the switches on the parasitic element are OFF. When the left parasitic element works as a director and the right parasitic element works as a reflector, the H-plane radiation pattern tilts to the negative y axis. Conversely, the H-plane radiation pattern tilts to the positive y axis with left parasitic element working as a reflector and the right parasitic element working as a director. When both of the parasitic elements are used as directors, the proposed antenna has omni-directional radiation characteristic.

3. RESULTS AND DISCUSSIONS

To verify the performance of the proposed hybrid reconfigurable antenna, high-frequency structure simulator (HFSS) is employed to obtain the VSWR and the radiation patterns. The optimized dimensions of the proposed antenna are: $H = 3\,\text{mm}$, $W = 2\,\text{mm}$, $2L0 = 0.26\lambda_0$, $2LR = 0.34\lambda_0$, $2LD = 0.142\lambda_0$, $SD = SR = 0.06\lambda_0$, where λ_0 is the wavelength in the free space at the resonance frequency of 0.85 GHz. Since the impedance of the utilized switches is very low, metal strips of size $2 \times 2\,\text{mm}$ are adopted for the proof of the ideal switch concept [2, 3]. The states of the eight switches at each mode are listed in Table 1. The simulated VSWR is shown in Fig. 2. It can be seen that the proposed antenna can operate from 0.78 GHz to 0.87 GHz at mode-1, mode-2 and mode-3. When the proposed antenna works at modes 4–6, it can cover the bandwidth of 1.79 GHz–1.92 GHz with VSWR under 2.5. The radiation patterns are described in Fig. 3. It can be seen from Fig. 3 that the proposed antenna can be used as an omni-directional antenna at mode-1 and mode-4. In other modes, the antenna has Yagi-like radiation patterns. The simulated peak gain for the mode-2, mode-3, mode-5 and mode-6 are 3.95 dBi, 3.85 dBi, 6.6 dBi and 6.63 dBi.



(a) (b)

Figure 2: VSWR of the proposed hybrid reconfigurable antenna.

Table 1: Modes of the proposed hybrid reconfigurable antenna.

Modes	S1	S2	S3	S4	S5	S6	S7	S8
Mode-1	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
Mode-2	ON	ON	ON	ON	ON	OFF	OFF	OFF
Mode-3	OFF	OFF	OFF	ON	ON	ON	ON	ON
Mode-4	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Mode-5	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
Mode-6	OFF	OFF	OFF	OFF	OFF	ON	ON	ON

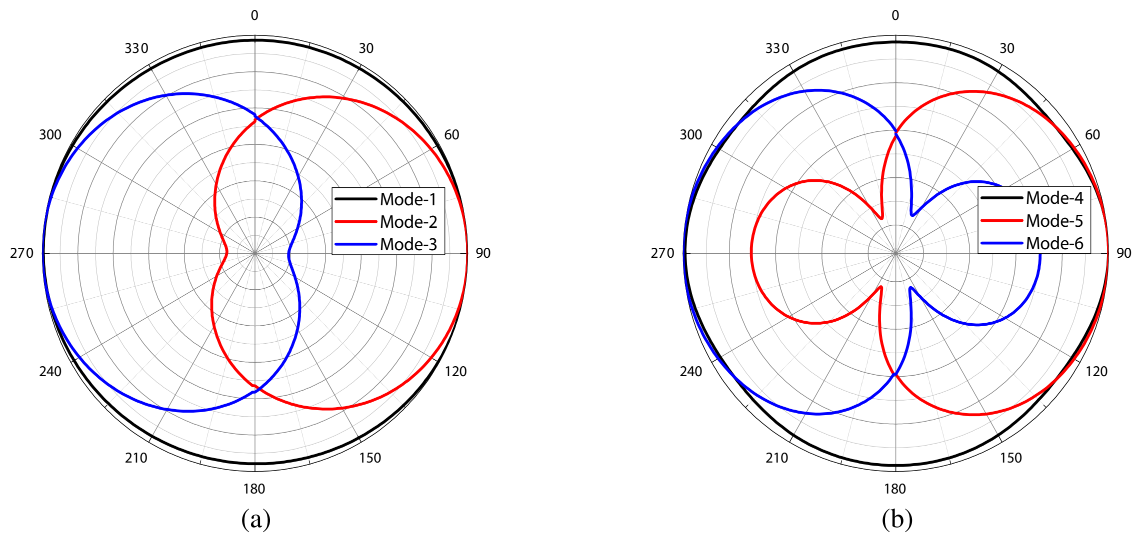


Figure 3: Radiation pattern of the hybrid reconfigurable antenna.

4. CONCLUSION

A dielectric embedded antenna with frequency and pattern reconfigurable characteristics for portable terminals has been investigated. The simulation results demonstrated that the proposed antenna can operate at 0.85 GHz and 1.9 GHz, while the radiation patterns are directional or omnidirectional. The antenna is small in size. In the future, we will fabricate and measure the proposed antenna by using the PIN diodes.

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