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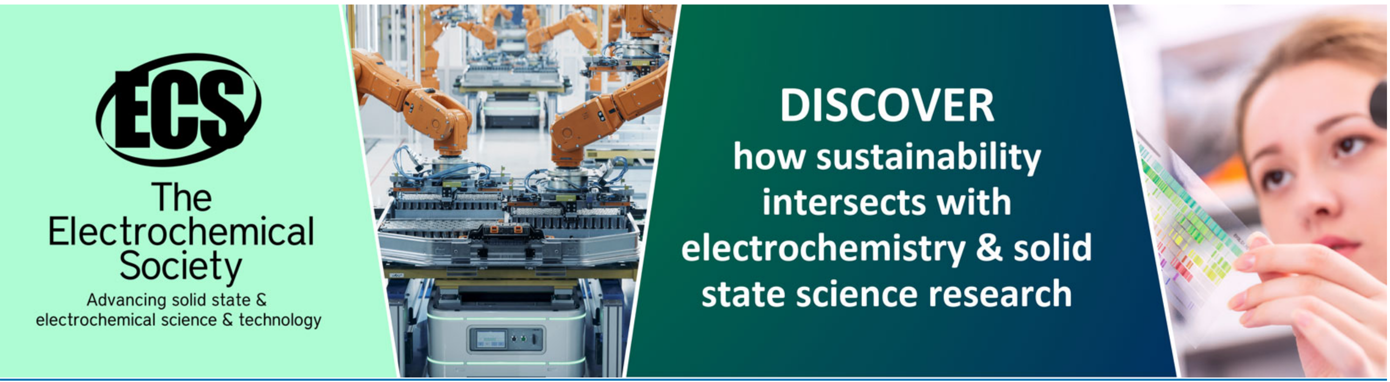

Design of Frequency Reconfigurable Antenna for WLAN/Bluetooth/WiMAX

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Abstract—A reconfigurable frequency antenna which can be switched in two frequency bands is designed. The antenna is composed of a rectangular patch, a diode switch and a rectangular ground plate, and the size is 30×30×1.6mm^3. The antenna changes the length of the branch through the diode switch to achieve the antenna model conversion. Simulation results show that the antenna S11<-10dB in the two frequency bands of 2.32~2.60GHz and 3.27~3.60GHz, covering WLAN (2.4~2.48GHz), Bluetooth (2.4~2.483GHz) and WiMAX (3.4~3.6 GHz) communication frequency bands.

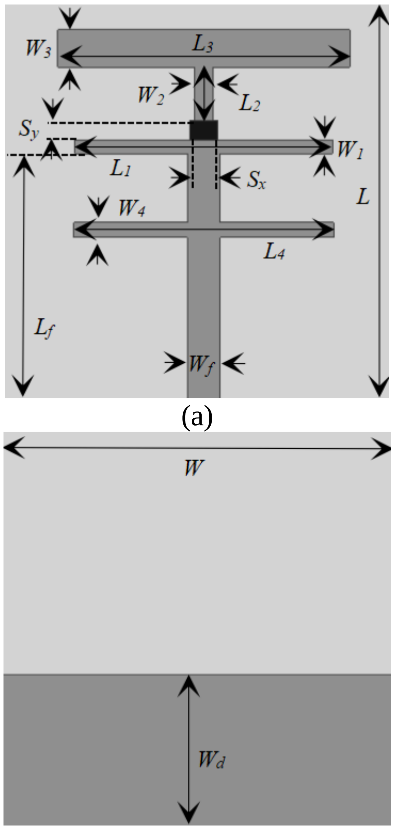
1. INTRODUCTION

There are two main ways to achieve frequency reconfiguration. One is to change the structure of the upper and lower surfaces of the antenna [1] (such as adding switches, slotting in the ground plate). The current flow direction and charged length of the antenna radiating element be changed; reference [2] uses 6 diodes to realize the reconfiguration of single frequency (1.79~1.94GHz) and single frequency (2.20~2.18GHz), and reference [3] uses 5 diodes realize the reconfiguration of single frequency (5.31~5.54GHz), triple frequency (2.26~2.32GHz/3.45~3.61GHz/5.56~5.77GHz) and dual frequency (1.89~1.92GHz/5.25~5.42GHz); Changing the antenna's external feed network [4] is also an effective way to achieve frequency reconfiguration. Reference [5] loads an external feed network on the antenna ground plane to prevent the RF signal from flowing from the feed end to the bias end.

This paper designs a frequency reconfigurable antenna that can be applied to wireless local area network (WLAN: 2.4 to 2.48GHz), Bluetooth (Bluetooth: 2.4 to 2.483GHz) and global wireless microwave Internet (WiMAX: 3.4 to 3.6GHz). The relevant parameters affecting the antenna are analyzed and compared. The antenna can be switched flexibly between the two frequency bands by loading a switch on the antenna branch and changing the state of the diode switch.

2. THE DESIGN OF THE ANTENNA

Figure 1 is a schematic diagram of the antenna structure. The top layer is a radiation patch composed of three rectangular branches connected by a microstrip line, and a diode is loaded at the middle branch. The middle layer is an FR4 dielectric substrate, and the lower layer is a rectangular ground plate. The selected MA4AGBLP912 diode is a 4Ω resistor when it is on, and when it is off, it is a 4kΩ resistor in parallel with a 0.25pF capacitor.



(a)

(b)

Figure 1. Antenna structure diagram: (a) Antenna front view; (b) Antenna back view

The resonance characteristic of the antenna is related to the size of the radiating element. Taking the rectangular radiating element as an example, the calculation method of the radiating element is as follows. Firstly, obtain the length of the live wire of the feeder and the radiating patch from the empirical formula, and then further optimize it by HFSS. The effective electrical length of the antenna is about 1/4 to 1/2 times the frequency at resonance. The empirical formula is as follows:

$$L = \frac{c}{2f\sqrt{\varepsilon_e}} \tag{1}$$

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10h}{w}\right)^{-\frac{1}{2}} \tag{2}$$

In formula (1), L is the effective electrical length of the antenna, f is the center frequency of the antenna, c is the speed of light in vacuum, ε_e is the effective dielectric constant of the dielectric substrate; in formula (2), ε_r is the relative dielectric constant, h and w is the height of the dielectric substrate and the width of the antenna microstrip line respectively.

The optimized parameters of the final antenna are shown in TABLE I.

TABLE I. OPTIMIZED PARAMETERS OF ANTENNA

Parameter	Size (mm)	Parameter	Size (mm)	Parameter	Size (mm)
W	30	L_2	4	W_3	1.1
L	30	L_3	22	W_4	2.8
S_x	2	L_4	19.6	W_f	2.5
S_y	1.5	W_1	1	L_f	18.6
L_1	19.4	W_2	1.4	W_d	11.5

3. SIMULATION OF THE ANTENNA

The simulation curve of antenna reflection coefficient (S_{11}) is shown in Figure 2.In order to simulate the actual situation; the RLC circuit is used to replace the actual diode on and off. It can be seen that the antenna works in model 1 (that is, when the switch is off), the S_{11} of the proposed antenna at 2.44GHz is -19dB, and the relative working bandwidth (3.27~3.60GHz) is 11%. The antenna works in model 2 (when the switch is turned on), the antenna S_{11} of the proposed antenna at 3.46GHz is -37.5dB, and the relative working bandwidth (2.32~2.60GHz) is 9.6%.

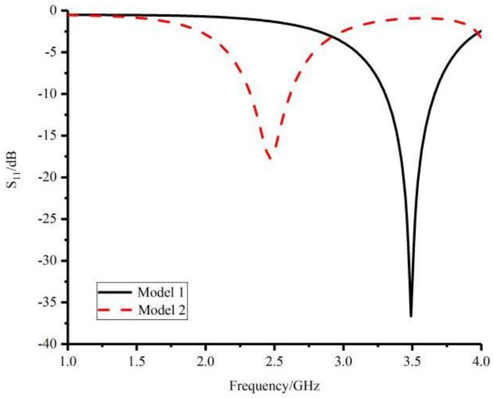
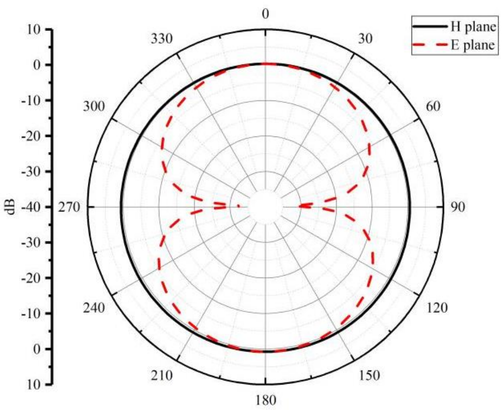
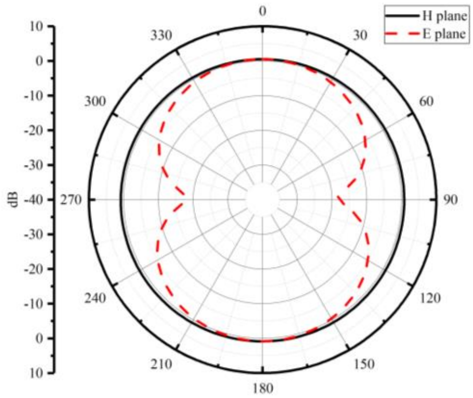


Figure 2. Simulation curve of antenna reflection coefficient

Figure 3 is the simulation radiation pattern of the antenna. The antenna has a dipole-like pattern at 2.46GHz on the E plane, and the H plane shows omnidirectional radiation. The maximum gain is 4.38dB, and the maximum gain at 3.44GHz is 3.21dB. The figure is similar to the first resonance point, and the maximum gain in the two reconstruction models is greater than 3dB, which meets the requirements of the wireless communication system.



(a)



(b)

Figure 3. Radiation pattern of the antenna: (a)2.46GHz; (b) 3.44GHz

4. ANTENNA PARAMETERS OPTIMIZATION

The simulation results show that the length and width of the ground plate affect the impedance matching of the antenna to a certain extent. The antenna surface current is mainly distributed in 4 rectangular stubs, so if the length of the stubs is changed, the resonance point of the antenna will shift. L_1 and L_4 mainly affect the resonant frequency in model 1, and L_2 and L_3 mainly affect the resonant frequency in model 2. Figure 4 and Figure 5 show the influence of the stub L_1 and the stub L_4 on the antenna resonance frequency near the first resonance point. It can be seen from Figure 4 that with the increase of L_1, the resonance point moves to the low frequency direction, and the impedance matching of the antenna gradually becomes better. Considering comprehensively, L_1 is selected as 19.4mm. It can be seen from Figure 5 that L_4 mainly affects the position of the antenna resonance point in model 1. As L_4 increases, the resonance point shifts to the high frequency direction. Considering comprehensively, L_4 is selected as 19.6mm. Figure 6 shows L_2 versus model 2. The resonance frequency influence curve of L_2 increases, the resonance point shifts to the right, and L_2 is 4mm to meet the requirements. In the case of model 2, L_3 also has an impact on the resonant frequency of the antenna. Analysis of Figure 7 shows that only L_3 is 22mm which meets the expected requirements.

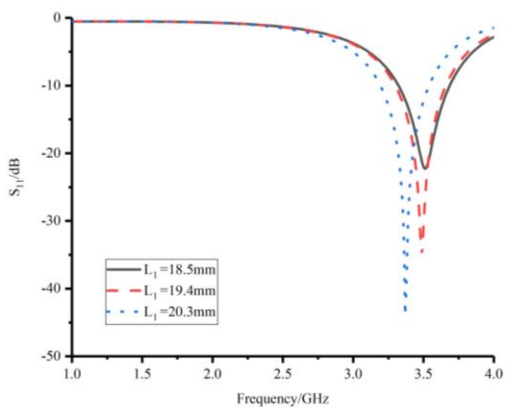


Figure 4. Under model 1, the impact of L_1 on S_{11}

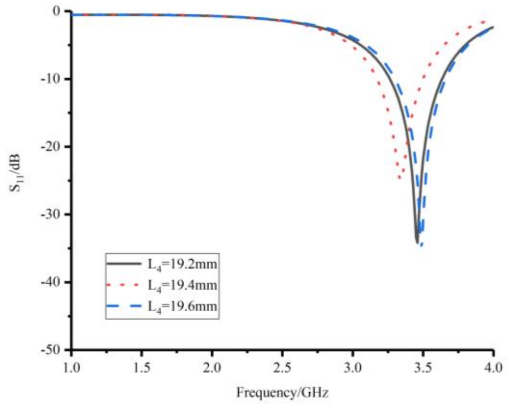


Figure 5. Under model 1, the impact of L_4 on S_{11}

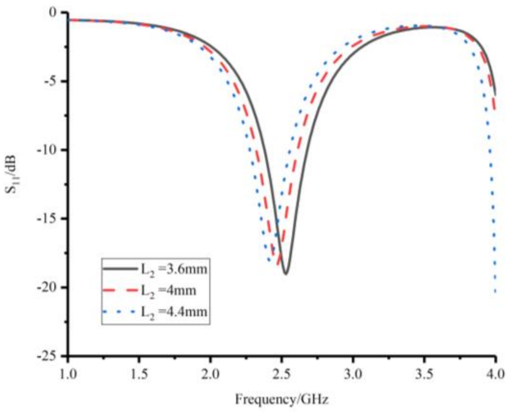


Figure 6. Under model 2, the impact of L_2 on S_{11}

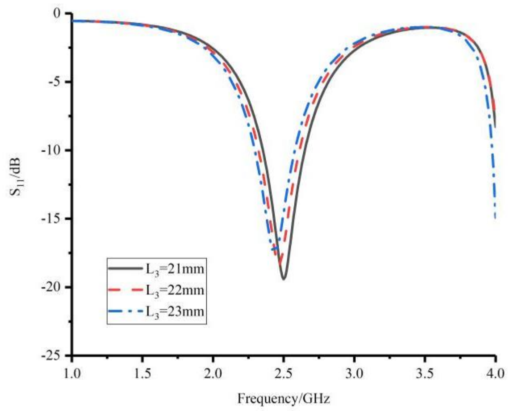


Figure 7. Under model 2, the impact of L_3 on S_{11}

5. CONCLUSION

This paper proposes a reconfigurable frequency antenna with a simple structure. The antenna can be switched in two working frequency bands of 2.32~2.60GHz and 3.27~3.60GHz, covering WLAN (2.4~2.48GHz), Bluetooth (2.4~2.483GHz) and WiMAX (3.4~3.6GHz) communication frequency bands. A diode switch is added at the feeder line and the branch, and the electrical length of the antenna radiating element is changed.

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