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A Frequency Reconfigurable Antenna loaded with H-shaped Radiators for WLAN/WiMAX Applications

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Abstract

In this research we present a novel reconfigurable monopole antenna for WLAN/WiMAX (Wireless Local Area Network/Wireless Interoperability for Microwave Access) application. The monopole antenna consists of H–shaped radiators and a partial ground plane. The design simulations are carried on a FR4 substrate with height =1.6 mm, $\varepsilon_r = 4.4$ and $\delta = 0.002$ using HFSS v.13.0 simulation software. The proposed reconfigurable antenna can energize at 2.4GHz and 5.45GHz resonances with sensible antenna directivity at different PIN diode switching conditions. When the switch is OFF antenna operate at 2.4 GHz (WLAN) with S_{11}<-10 dB bandwidth of 430 MHz (2.57-2.14 GHz). When the PIN diode is ON antenna operate at 5.45 GHz (WiMAX) with S_{11}<-10 dB bandwidth of 150 MHz. Reflection coefficients and radiation properties appear that the proposed H–shaped patches in the reconfigurable antenna are a decent contender for WLAN/WiMAX applications.

Keywords: H-shape radiator, WLAN, PIN diode, reconfigurable

INTRODUCTION

Remote portable specialized gadgets assume a noteworthy part in the advanced world where one barely has a place without these specialized gadgets. The only solution to this is the use of antennas. Antenna with compact size and capability to resonate at multiband from a single system is the current demand for all wireless handheld devices. Moreover, the ability to reconfigure the bands between each other adds to the ability of switching between the wireless devices without changing the antenna. Reconfigurable antennas are those whose pattern or frequency or polarization or a combination of these can be changed from time to time by using different switching devices. Off late frequency reconfigurable antennas have attracted significant attention because of its simple design, compact nature, ease of achieving reconfiguration, avoidance of fading etc. Generally speaking, the framework used to reconfigure the bands of frequency of the reconfigurable antennas can be mechanical or electrical. Electrically reconfigurable antennas, which are significantly more prevalent, can be characterized into band exchanging and consistent tuning [1]. Band exchanging can be accomplished utilizing PIN-diode switches and the working recurrence band is exchanged among various bands, contingent upon the switching states [2-5]. So as to make our antenna tunable or to influence it to work in different band, we require a switching component. Along these lines, the trading part we can use here is a tuning diode. The kind of diode we can use here is a PIN diode. This PIN diode gives us the property of reconfigurability. As the effective opening length of the PIN diode is changed, the shift can be viewed. The distinction in band can be seen by interfacing and withdrawing the antenna parts [6-8]. The PIN diode likewise has some inductive, capacitive and resistive esteem [9].

In this paper we propose a frequency reconfigurable antenna for WLAN/WiMAX applications. Initially an H-shaped radiating patch with partial ground plane is designed to operate at 2.4 GHz (WLAN). In order to switch this antenna to 5.45 GHz (WiMAX) band two ideal PIN diodes are inserted between the H-shaped radiating stubs. The antenna exhibits good impedance matching and stable radiation patterns at the targeted frequencies.

The rest of the paper is arranged as follows. In Section 2, antenna design configuration is discussed. Design analysis is explained in Section 3. Results are highlighted in section 4.

ANTENNA CONFIGURATION

The proposed structure is depicted in Fig. 1. The antenna is outlined on FR4 substrate (*height =1.6 mm,* $\varepsilon_r = 4.4$ *and* $\delta = 0.002$) with compact dimension of 20 × 20 mm^2. The proposed research mainly consists of two configurations which are together used as a single antenna as shown in Fig. 1. Firstly a branched H-shaped stubs are designed on the front part of the antenna to resonate at 2.4 GHz, as shown Fig. 1(a). The H-shaped structure is the simplest structure. The design process of the proposed H-shaped structure is quite easy for implementation in various handheld devices [10]. The detailed H-shaped stub dimension is illustrated in Fig. 1(b), wherein we can observe that each H-shaped stubs is of the same dimension. In order to switch the antenna from 2.4 GHz to 5.45 GHz, two ideal PIN diode switches are used between the lower branches of H-shaped stubs as illustrated in Fig. 1(b). The introduction of these switches modifies the electrical current length path as a result of which antenna switches from

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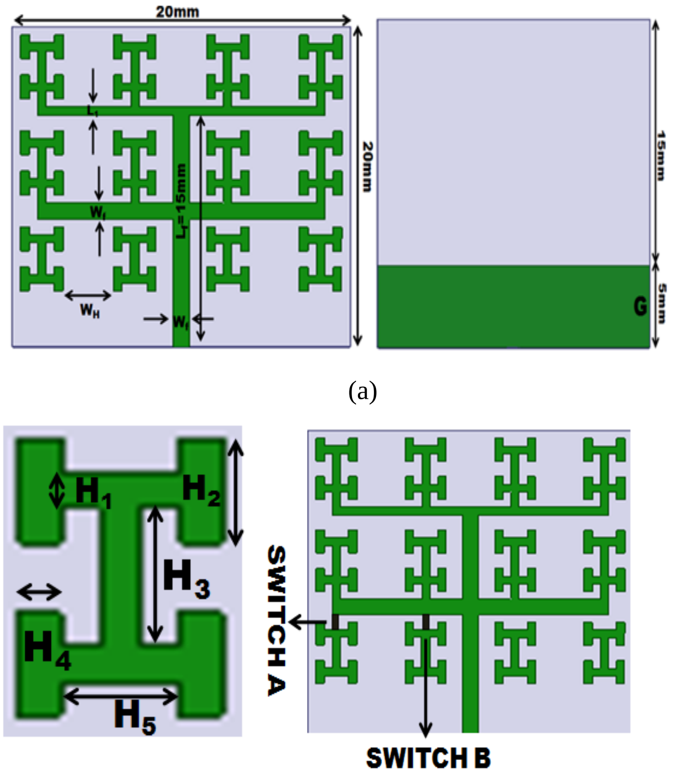
2.4 GHz to 5.45 GHz. The entire antenna is fed by microstrip feedline to achieve good impedance matching. The optimized dimensions of the H-shaped slots are given in Table 1.



(b) (c)

Figure 1. Structure of proposed reconfigurable antenna (a) Front patch & ground plane without switches, (b) H-shaped stub detailed geometry, (c) front patch with switches.

Table 1. Proposed Antenna's dimensions

Parameter	Dimensions (mm)
H_1	0.5
H_2	1.5
H_3	2
H_4	0.5
H_5	1.5
W_f	1
W_H	3
L_1	0.5
L_f	15

A. Antenna Design Equation

The antenna width and length can be designed by the following equations [11].

$$W = \frac{\lambda_o}{f_o\sqrt{(\varepsilon_r+1)/2}} \quad (1)$$

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \quad (2)$$

$$L = \frac{\lambda_o}{f_o\sqrt{\varepsilon_{reff}}} - 2\Delta L \quad (3)$$

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

DESIGN ANALYSIS

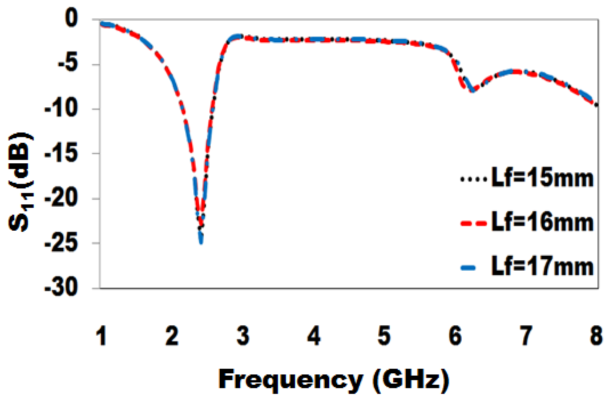
The proposed antenna outline and its point by point dimensional formats are presented in Fig. 1. The antenna comprises of H-shaped patch. The H-shaped patches are responsible for the resonance at 2.4 and 5.45GHz. A rectangular slot is scratched out in the ground plane to give impedance coordinating at these resonances. The general impedance coordinating of 50Ω is given by microstrip line utilizing lumped port excitation. To see the impact of change in optimized parameters, such as feed length (L_f) and width of ground patch (G) its parametric investigation are done.

1. Effect of feed length (L_f):

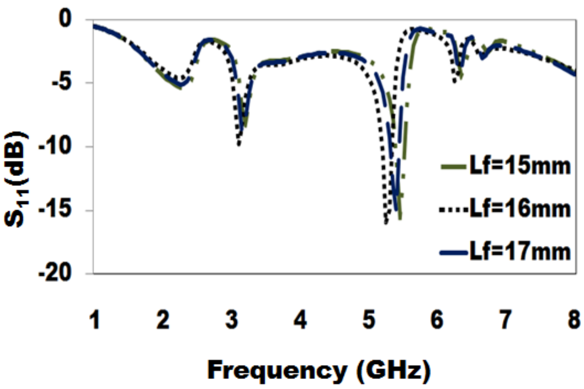
Keeping in mind the end goal to examine the impact of feed length on general impedance coordinating its parametric examination is completed for both the conditions (switches OFF and ON) and is shown in figure 2(a) and 2(b) separately. It can be studied that as the feed width changes the impedance matching for both the conditions are disturbed. The optimum impedance matching for switch ON and OFF conditions is obtained for Lf=15 mm.

2. Effect of ground patch (G):

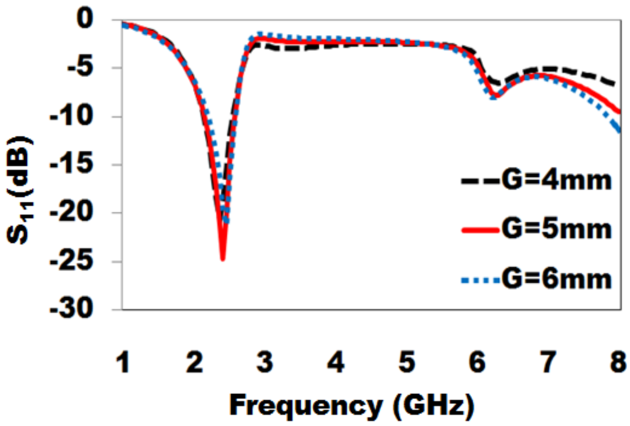
Like the above procedure the width of ground patch is additionally fluctuated and its impact is outlined in figure 2(c) and 2(d) for both the conditions (switches OFF and ON). It can be studied that the antenna achieves better performance with G=5mm.



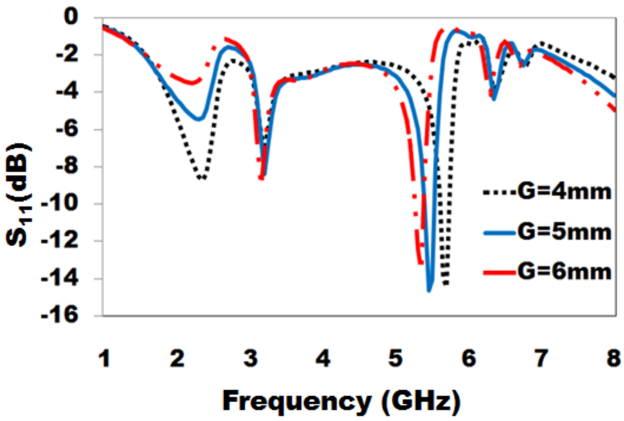
(a)



(b)



(c)

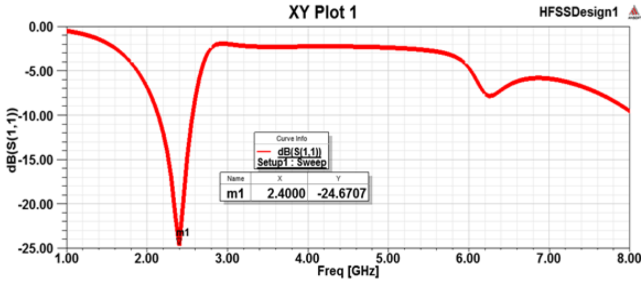


(d)

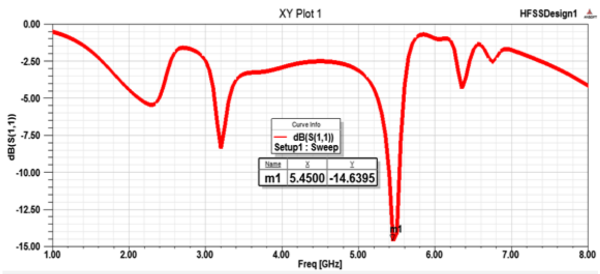
Figure 2. Parametric study of (a) Feed Length in OFF state, (b) Feed Length in ON state (c) Ground patch in OFF state and (d) Ground patch in ON state

RESULTS

The proposed structure is simulated using HFSS v.13.0 simulator on FR4 substrate having thickness of 1.6mm. The estimated S_{11} of the proposed structure in OFF and ON conditions are depicted in Fig 3(a) and 3(b). When the PIN diode is OFF antenna operate at 2.4 GHz (WLAN) with S_{11}<-10 dB bandwidth of 430 MHz (2.57-2.14 GHz). When the PIN diode is ON antenna operate at 5.45 GHz (WiMAX) with S_{11}<-10 dB bandwidth of 150 MHz (5.53-5.38 GHz). The simulated input impedance of the antenna under OFF state is presented in Fig. 4(a). It can be studied that the antenna resistance at 2.4 GHz is almost near to 50 ohms and reactance is almost near to zero. Similarly, the input impedance of the antenna under ON state is studied and is depicted in Fig. 4(b). It is evident from the figure that under ON condition also antenna achieves good impedance matching.

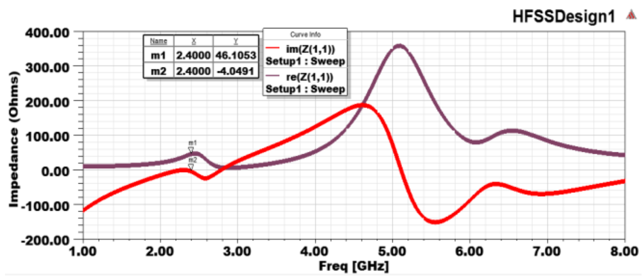


(a)

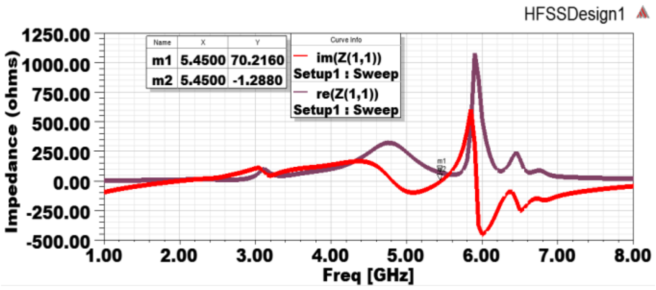


(b)

Figure 3. Simulated S_{11} for (a) OFF state (b) ON state



(a)

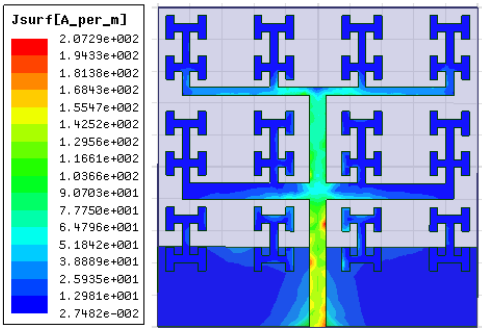


(b)

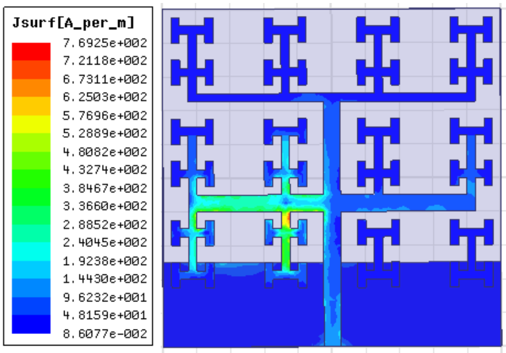
Figure 4. Simulated input impedance for (a) OFF state (b) ON stat

B. Current Distribution

The surface current distribution of the antenna at 2.4GHz when the switches are OFF and 5.45GHz when the switches are ON is illustrated in Fig. 5(a) & (b). It can be studied that during OFF state (i.e. 2.4 GHz), the current around the feedline is dense. For ON state (i.e. 5.45 GHz), the current along the lower branch (i.e. around the switch) of H-shaped stub are dense. Thus, it can be concluded that at both the resonances, antenna has corresponding current length path.



(a)

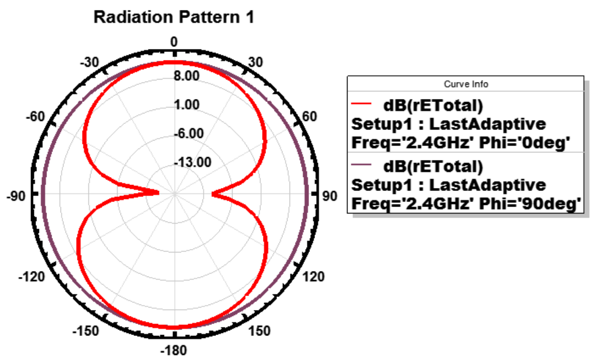


(b)

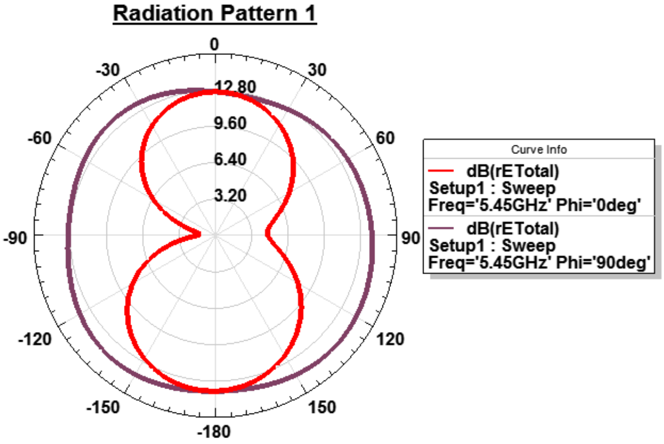
Figure 5. Current distribution at (a) 2.4, (b) 5.45 GHz

C. Radiation Pattern

The proposed configuration simulated radiation pattern for condition Ø $=0^0$ and 90^0 for both the resonant frequencies are illustrated in Fig. 6. It can be visually perceived that, at both the frequencies for Ø$=90^0$ antenna shows omnidirectional pattern and for Ø$=0^0$ it shows bidirectional pattern. Moreover the patterns are broadsided and stable in nature.



(a)



(b)

Figure 6. Simulated radiation pattern at (a) 2.4, (b) 5.45 GHz

CONCLUSION

A novel planar frequency reconfigurable monopole antenna which depends on an H-shaped structure has been proposed. Since the proposed H– shape has a straightforward structure, it can easily be integrated with wireless devices. Results demonstrate that the proposed antenna can resonate with a decent pattern. It is seen that with the usage of ideal PIN diode, antenna switches between 2. 4 GHz and 5.45 GHz operating bands; thus facilitating the proposed antenna for WLAN and WiMAX applications. The compact size, frequency reconfigurability phenomenon and stable radiation patterns makes the design quite attractive for the aforementioned applications

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