

Frequency and Pattern Reconfigurable Antenna for WLAN and WiMAX Application



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Abstract An innovative bow tie frequency and pattern reconfigurable antenna is proposed in this paper which can be used for WLAN and WiMAX applications. The proposed antenna is a modified bow tie antenna with an additional branch on patch side. Two p-i-n junction (PIN) diodes are used for obtaining the required frequency and radiation pattern. One diode is placed on the patch side and another diode is placed on the ground side. The antenna operates at three different frequency values 3.35, 3.6 and 5.2 GHz with changing radiation patterns for each operating frequency. During simulation maximum efficiency of 80% along with a maximum gain of 1.2 dBi is obtained for on switch condition and an efficiency of 91% and gain of 2.1 dBi is obtained for off switch condition.

Keywords Frequency reconfigurable antenna · Pattern reconfigurable antenna · PIN diode · WLAN · WiMAX

1 Introduction

Today's smart handheld communication devices support operation over various bands such as Bluetooth, LTE, WLAN, WiMAX, GSM etc. and reconfigurable antennas are replacing multiband antennas due to their inherent advantages in all such applications. In literature, we observe discussion and design of various reconfigurable antennas. A rectangular patch with two longitudinal slits is presented in [1]. This antenna is equipped with a pair of PIN diodes along the slits to achieve frequency and pattern agility. Simulation of frequency and radiation pattern reconfigurable ring-type patch antenna is given in [2] that shows operation over 2.7, 2.8 and 3.6 GHz. An antenna with two quarter-wavelength radiators with a truncated quarter-wavelength ground

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plane and two quarter-wavelength parallel strips at the substrates edges capable to steer the radiation pattern in four directions using four PIN diodes is designed in [3]. A frequency reconfigurable antenna designed using a bowtie antenna and slots is explored in [4, 5], where band switching is achieved using switches between the slots and bowtie antenna. V-shaped slot antenna with T and C-shaped resonators is designed in [6]. This antenna controls its operation using four switches, at various bands over the frequency range from 970 MHz to 3.76 GHz with a stable pattern.

A microstrip patch antenna with two slots is designed to obtain three frequency reconfigurable bands over the range 2.4–5.8 GHz. Two PIN diodes are added along each slot to alter the electrical length of the antenna [7]. Rectangular patch antenna equipped with T-shaped slotted feed line, operating at 1.8, 2.3, and 2.4 GHz is designed in [8]. A bow tie antenna operating over Bluetooth, WiMAX and WLAN is presented in [9]. PIN diodes are used over bow tie arms for tuning operating bands.

The design of antenna presented here is a simple frequency and pattern reconfigurable antenna for WLAN and WiMAX applications.

2 Antenna Design and Geometry

The antenna proposed in this work is a bow tie antenna, derived from the design given in [10]. The structure of antenna is shown in Fig. 1.

Basic design of proposed antenna is a bow tie antenna printed on both side of substrate with an operating frequency of 5.5 GHz, the design equations are followed from [9, 10]. Optimized dimensions of antenna are $W_s = 30$ mm, $L_s = 26$ mm, $L_f = 3$ mm, $a = 13.5$ mm, $b = 10$ mm, $e = 7.5$ mm, $d = 16$ mm, $g = 10$ mm and $h = 10.8$ mm. Antenna makes use of two switching diodes each one placed on patch and ground structure. First diode is placed on the patch side in between the two branches

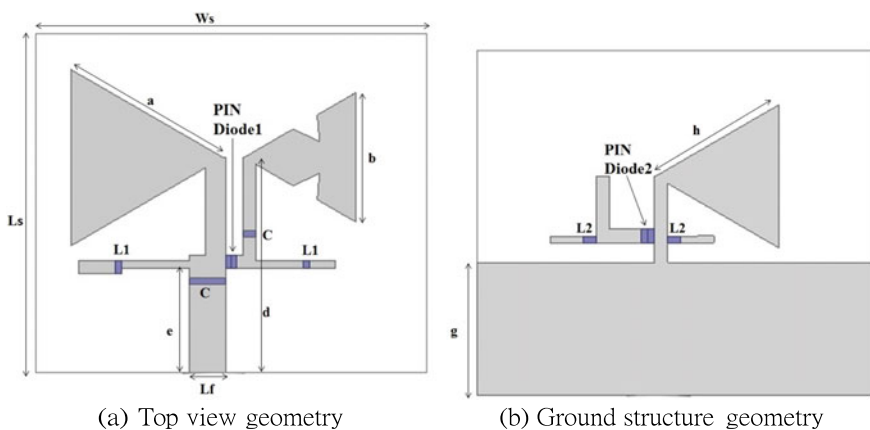


Fig. 1 Geometry of proposed antenna

of patch, second diode is placed on the ground side between the bow-shaped element and a stub. Biasing and DC blocking elements are added on antenna, which consists of two inductors (L1) of 33 nH and two capacitors (C) of 10 pF each. Two inductors (L2) of 1.8 nH are used for biasing purpose on ground side also. PIN diodes are basically used to alter the electrical length of the antenna so as to achieve frequency agility.

3 Simulation Results

ANSYS High-Frequency Structural Simulator (HFSS), an electromagnetic software for designing high-frequency electronic products is used for simulation of proposed antenna. The performance of antenna is observed in two modes. In the first mode when both the diodes are off the antenna supports WiMAX application with a frequency of operation 5.2 GHz. Gain of 2.1 dBi and efficiency of 91.05% is obtained for this mode during simulation. When both the diodes are on the antenna supports WLAN application with resonant frequency 3.35 GHz and 3.6 GHz. For 3.35 GHz gain of 1 dBi and efficiency of 74% and for 3.6 GHz a gain of 1.2 dBi with an efficiency of 80% is obtained during simulation. Return loss for the simulated antenna design is shown in Fig. 2. The performance of antenna is summarized in Table 1.

The antenna is simulated considering low loss FR4 substrate, whose dimensions are 30 mm * 26 mm * 1.6 mm. While obtaining the simulation results BAR 64 SC79 PIN diode is considered as switch. For on switch case, each PIN diode is replaced with

Fig. 2 Simulated return loss for proposed antenna

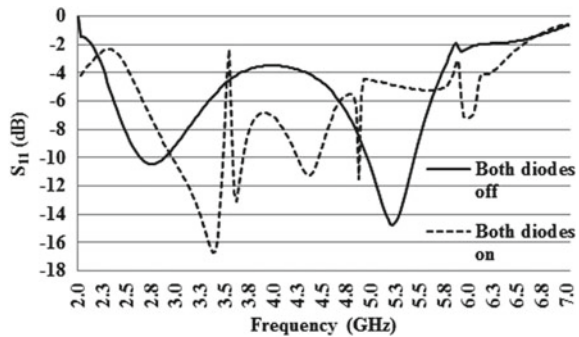


Table 1 Performance of proposed antenna

Mode	Switch position	Frequency (GHz)	Return loss (dB)	VSWR	Gain (dBi)	Efficiency (%)	% Bandwidth
I	Both on	3.35	-16.74	1.34	1	74	14
		3.36	-13.1	1.44	2.1	80	2
II	Both off	5.2	-14.76	1.44	2.1	91.05	9.6

a resistance of 2Ω and for off switch case, it is replaced with a parallel combination of a resistance of $3 \text{ k}\Omega$ and a capacitor of 0.17 pF . In both the modes, a series inductance of 1.8 nH is also considered in addition to the above stated equivalent circuit.

4 Reconfigurable Operation

Reconfigurable operation is obtained with two PIN diodes. As the state of diodes is changed the electric length of the antenna is changed and it results in changing frequency of operation. The electric field distribution for the first mode when both the switches are on is shown in Fig. 3. Figure 4 shows electric field distribution for both switches in off condition. As the switch configuration is changed the electric dimensions of the antenna are changed which leads to change in electric field distribution and surface current distribution on the antenna. From these figures, we note that for each case the electric field distribution is different, the result of which is

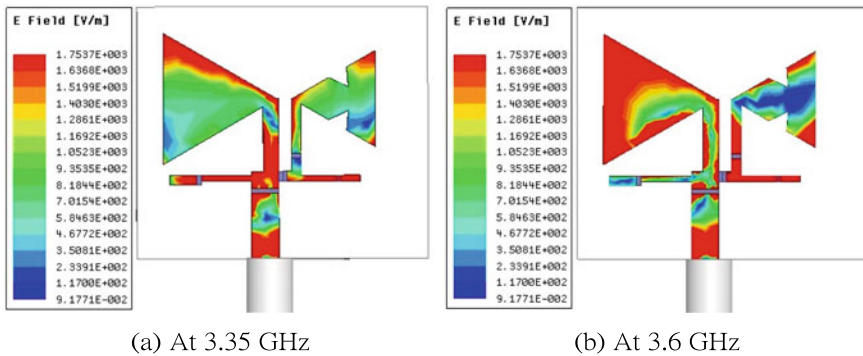
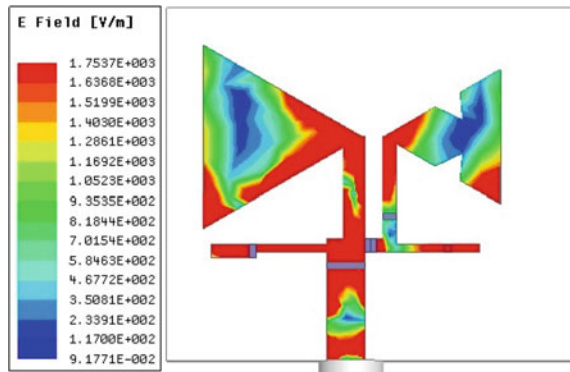
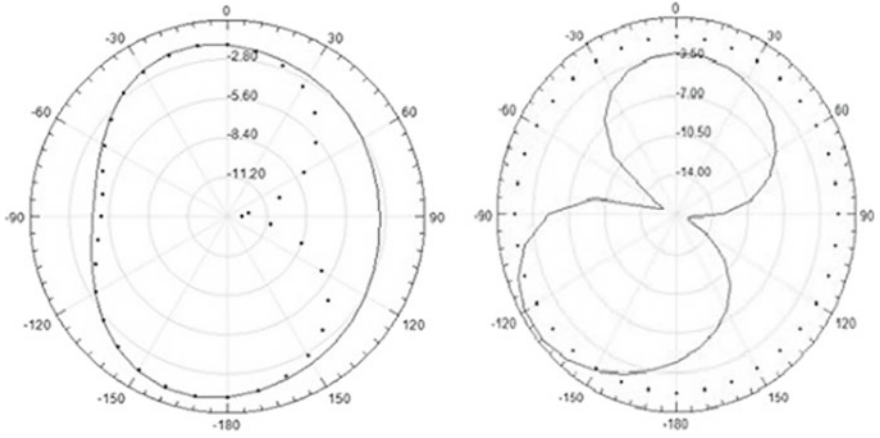


Fig. 3 Electric field distribution: both diodes on

Fig. 4 Electric field distribution: both diodes off

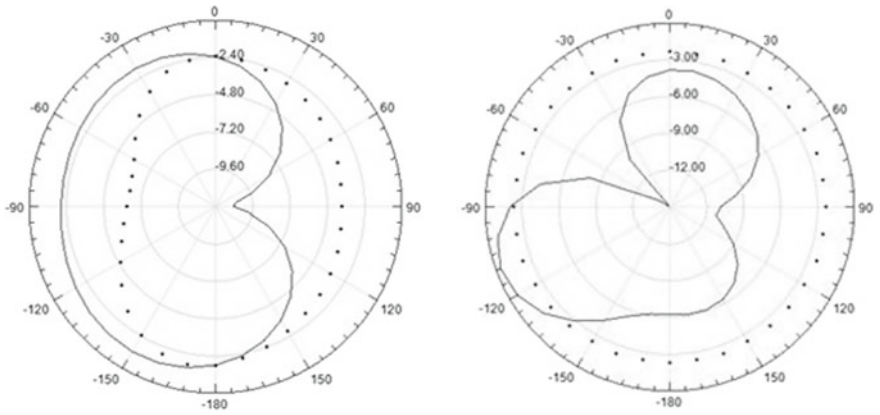


reflected in varying radiation patterns for each condition. Thus pattern reconfiguration is achieved along with frequency reconfigurability. The radiation pattern for the proposed antenna is shown in Figs. 5, 6, and 7.



(a) Theta variation ($-E_{\varphi} = 90; \dots E_{\varphi} = 0$) (b) Phi variation ($-E_{\theta} = 90; \dots E_{\theta} = 0$)

Fig. 5 Simulated radiation pattern at 3.35 GHz



(a) Theta variation ($-E_{\varphi} = 90; \dots E_{\varphi} = 0$) (b) Phi variation ($-E_{\theta} = 90; \dots E_{\theta} = 0$)

Fig. 6 Simulated radiation pattern at 3.6 GHz

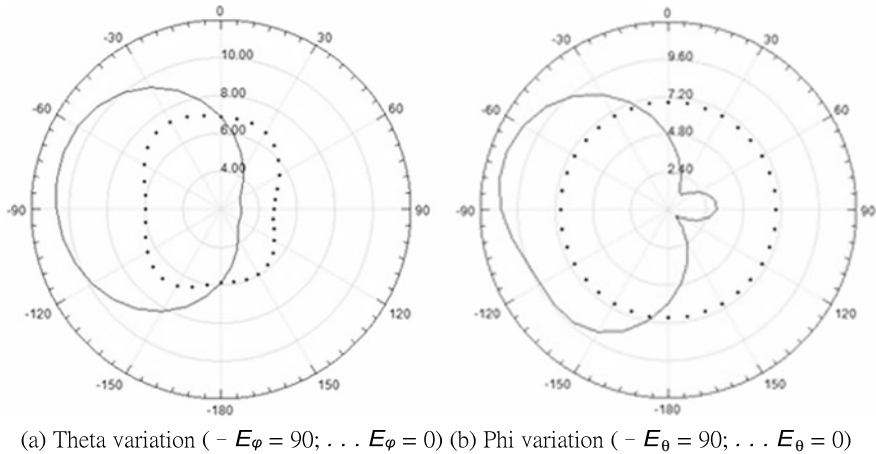


Fig. 7 Simulated radiation pattern at 5.2 GHz

5 Conclusion

A new design of a compound reconfigurable antenna using two switching diodes is proposed in this paper. The antenna works in two modes, in one mode operating frequency is 5.2 GHz and in another mode the frequency of operation is 3.35 GHz and 3.6 GHz, with a varying radiation pattern for each mode; hence the antenna exhibits frequency and radiation pattern agility. The proposed antenna supports WLAN and WiMAX applications with a small profile.

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