Frequency-Reconfigurable Microstrip Patch Antenna for Wireless Application

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***Abstract*—A frequency-reconfigurable microstrip patch antenna is proposed. The antenna is capable of frequency switching at six different frequencies between 1.452 and 1.89 GHz. RF p-i-n diode switches are positioned in the slot to achieve frequency reconfigurability. Simulated and measured results are used to demonstrate the performance of the antenna. The simulated return losses, together with the radiation patterns, are presented.**

***Index Terms*—Mircostrip patch antenna, microstrip slot antenna, reconfigurable frequency, RF p-i-n diode.**

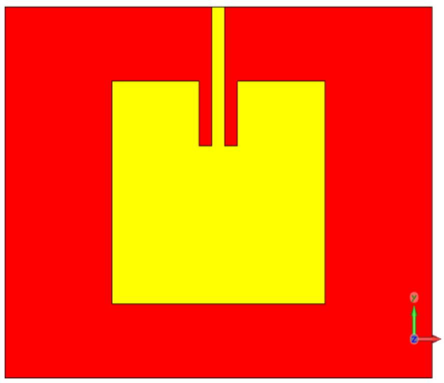
I. INTRODUCTION

In order to satisfy the requirements for the advanced systems used in modern wireless applications, different multiband and reconfigurable antennas have been proposed and investigated in the past years. In wireless communications, reconfigurable antennas are useful to support a large number of standards(e.g., UMTS, DCS, GPS and GSM) to mitigate strong interference signal and to cope with the changing environmental condition. It is widely explored since it gives more benefits than the conventional antennas whereby using a single antenna is competent to operate or support multiple operating frequencies, radiation patterns and polarization. Most reconfigurable antennas are frequency reconfigurable antennas due to their high reliability to be applied in multiple applications using single antenna. The basic working principal of this reconfigurable antenna is achieved by switching the status of an RF switch either to ON or OFF mode which affects the current distribution of the antenna. Switching components such as PIN diodes, varactor diodes, MEMs switches, optoelectronic switches are normally used to achieve frequency reconfigurable antenna.

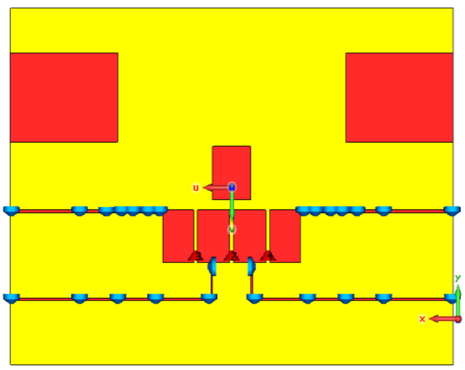
II. DESIGN AND CONFIGURATION

In this section, the structure of the proposed antenna is described. Fig. 1 shows the geometry of the proposed antenna. The antenna is designed on a Paper substrate with a thickness of 1.6 mm, permittivity of 2.31. The patch size is 48 58.3 mm . The length of inset feed is 14 mm with a width of 3.5 mm. The length of the transmission line is 30 mm with a width of 3.5 mm. Also, small slots introduced in the ground plane for biasing circuit. Due to the effect of the separation of the small slots, a surface-mount RF capacitor is used to provide RF wave connection throughout the ground plane. Three switches are placed in the slot. By changing the effective length of the slot, six different resonant frequency bands can be produced.

The corresponding diode configuration is shown in Table I. When all diodes are switched ON, the patch is properly grounded, and the antenna is resonating at 1.89 GHz. When all diodes are switched OFF, the patch acts as a feeding network to the slot, while the slot resonates at 1.452 GHz. RF p-i-n diode 1SV128 is used as the switch in the simulation.



(a) Front View of proposed antenna



(b) Back View of proposed antenna

Fig. 1. Geometry of the proposed antenna
(a) front view and
(b) back view.

TABLE
DETAILS OF SWITCH CONFIGURATION

Diodes Configuration			Frequencies (GHz)
D1	D2	D3	
OFF	OFF	OFF	F1=1.452
ON	OFF	OFF	F2=1.62
OFF	ON	OFF	F3=1.68
OFF	ON	ON	F4=1.782
ON	OFF	ON	F5=1.788
ON	ON	ON	F6=1.89

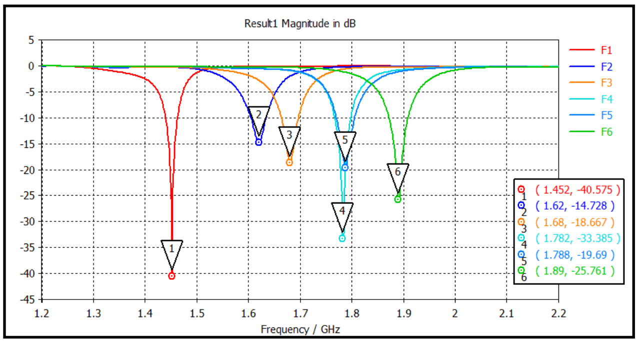
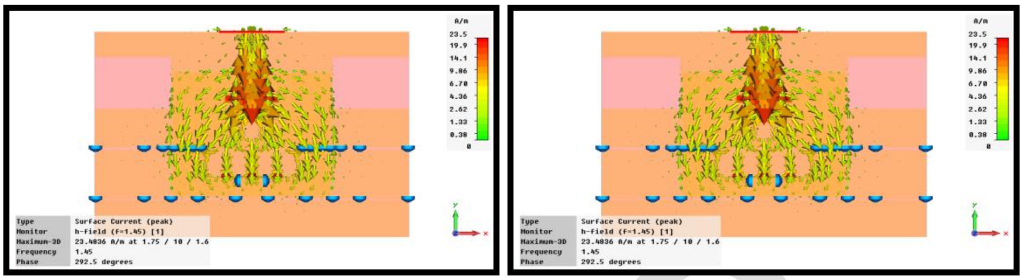


Fig 2. Simulated return loss, S_{11} results



a) All diodes are in OFF state (b) All diodes are in ON state

Fig 3. Surface current of Antenna

III. RESULTS AND DISCUSSION

Computer Simulation Technology (CST) Microwave Studio software is utilized to simulate the proposed antenna. The corresponding return loss results against frequency are presented. Fig. 2 shows the simulated return loss results. The simulated return loss are less than -10 dB at all frequency bands. Table II summarizes the simulation performance of the proposed antenna with different diode states. The proposed antenna is capable to reconfigure at six different frequency bands.

In the table, the ON state indicates the diode forward biased while the OFF state indicates it is reverse biased. Final design is also simulated for gain and directivity parameters in each state of diodes. Out of that all PIN diodes are in ON state and all are in OFF state are mentioned in figures 4-7. When all diodes in OFF state, the antenna resonates with 4.4 dB gain. In ON state of all diodes , the antenna resonates with 4.2 dB gain. Depending on the type of antennas, the switches such as RF MEMs, varactor diode and PIN diodes can be used. The choice is governed by electrical specifications, fabrication complexity, bias requirement, switching time and price. For instance, RF MEMs switches are very low loss and their other advantages are that they do not require bias lines. However, they are costly. PIN and varactor diodes are low cost and have a simple fabrication process. They require a proper bias network isolating the dc bias current from the RF signal, which usually leads to a complicated biasing network. Most of frequency reconfigurable slot antennas generate only single operating bands at a particular reconfigurable mode.

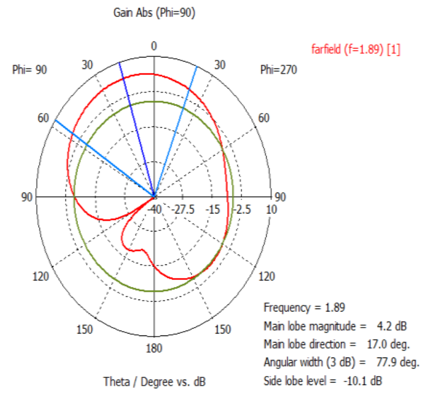


Fig. 4 Gain with ON state of all diodes

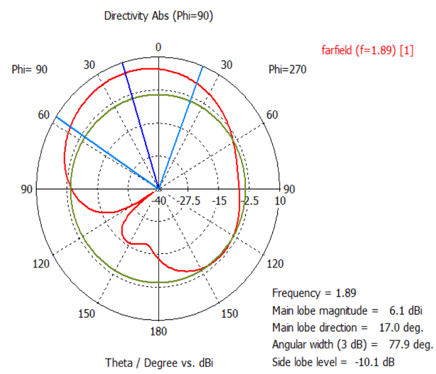


Fig. 5 Directivity with ON state of all diodes

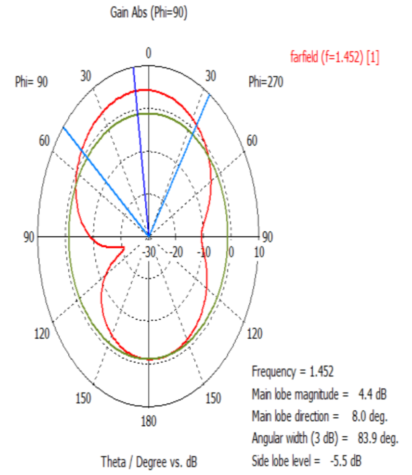


Fig. 6 Gain with OFF state of all diodes

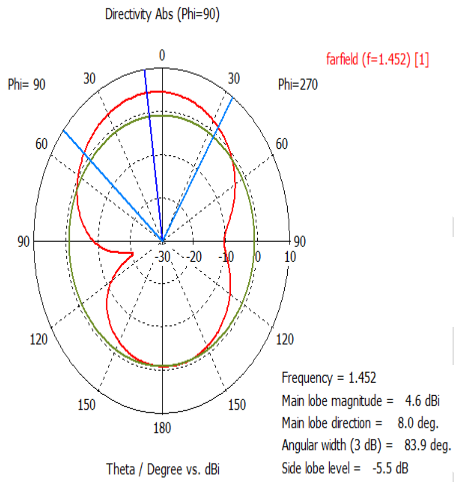


Fig.7 Directivity with OFF state of all diodes

TABLE II
SIMULATED PARAMETERS WITH DIFFERENT STATES OF PIN DIODES

Diodes Configuration			Frequencies (GHz)	Gain (dB)	Directivity (dBi)	BW (%)
D1	D2	D3				
OFF	OFF	OFF	F1=1.452	4.4	4.6	1.56
ON	OFF	OFF	F2=1.62	2.2	5.1	2.09
OFF	ON	OFF	F3=1.68	4.6	5.0	1.95
OFF	ON	ON	F4=1.782	5.1	5.3	1.74
ON	OFF	ON	F5=1.788	5.0	5.4	2.24
ON	ON	ON	F6=1.89	4.2	6.1	1.59

For visual intuitive explanation, the slot can be viewed as obstruction to the path of current, forcing a longer physical distance for to travel. The figure 3 shows the current distribution for two different states. Table II shows performance parameters like gain, directivity and fractional bandwidth for different resonance frequencies.

CONCLUSION

A frequency-reconfigurable microstrip patch switchable to slot antenna has been presented. The proposed antenna is capable to reconfigure up to six different frequency bands from 1.452 to 1.89 GHz. A frequency reconfigurability is obtained by switching the p-i-n diodes. This shows that the proposed antenna is potentially suitable for several wireless applications.

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