

# Design and Study the Effect of Switching in Microstrip Patch Antenna for Cognitive Radio Applications

Gurpreet Kumar and Gursharanjeet Singh Kalra

School of Electronics and Communication Engineering, Lovely Professional University Phagwara – 144411, Punjab, India;  
gurpreet.14632@lpu.co.in, gursharanjeet.singh@lpu.co.in

## Abstract

Design of microstrip antenna having switches for accomplishing frequency reconfigurability is proposed. The proposed design is having six resonating frequency bands between 3.34GHz to 3.67GHz which were achieved by using different switching configurations. Switches were assumed as ideal so as to study the simulated results of the antenna. The antenna design was made on the FR4 substrate having height of 1.6mm. The overall size of the antenna is 39×40mm<sup>2</sup>. Simulated results are utilized to validate performance of antenna. The radiation pattern, return loss and measured bandwidth are presented in the paper. Simulated results presented in this paper make the antenna are appropriate for applications such as cognitive radio which requires sensing of spectrum to use the bandwidth in an optimal manner.

**Keywords:** Cognitive, PIN Diodes, Reconfigurable, Switching

## 1. Introduction

Recently the use of RF switches in microstrip patch antenna for achieving reconfigurability has been a great area of research. The parameters, for example, radiation pattern, frequency and polarization are changed to satisfy the application requirements. These antennas can be used in application like cognitive radio which requires the process of spectrum sensing to use the spectrum wisely<sup>1,8,9</sup>. There are other techniques that have been applied as well to achieve a desired operation in an antenna such as, physical size changing, addition of multiple layers and gaps<sup>14</sup>, using stacked patches<sup>12</sup>, inserting slits and changing the substrate material<sup>13</sup>. However these techniques can increase the size of the antenna significantly which will make it difficult for these antennas to fit into small

devices<sup>2-4</sup>. Further design optimization techniques need to be employed on these antennas to decrease the effective length and width of antenna<sup>3-6</sup>.

There have been multiple innovative techniques that have been used to achieve the reconfigurable operation in an antenna such as use of PIN diodes, varactor diodes to act as switches<sup>10,11</sup>. To change the current distribution in the slot FET components have also been used which actually alters the effective length of the antenna. The use of micro-electro-mechanical system to improve the accuracy in switching has also been widely employed in the designs, but this increases the cost and circuit complexity in the design<sup>5-7</sup>.

This paper aims to design and analyze microstrip antenna and study the effect of switching on the parameters of the antenna for example, gain, return loss,

\*Author for correspondence

directivity and VSWR of the antenna. The different switching configurations are presented in this paper. The switches are acting as ideal so small conducting slits were used to show the ON position of the switch while doing the simulation on CST Microwave Studio.

## 2. Antenna Configuration and Design

We will be discussing about the design structure of the antenna in this section. Figure 1 and 2 is showing the overall geometry of designed antenna. Antenna was designed using FR4 substrate having thickness 1.6mm and tangent loss 0.025. The size of the patch is  $19.5 \times 20 \text{ mm}^2$ . Microstrip line feed technique was used in this design and width of the feed line is 4.5mm. Slot is cut at the bottom of the antenna having area of  $1 \times 20 \text{ mm}^2$ . There are four switches that have been inserted in the ground plane at different position to observe the behavior of the antenna under different logical conditions of the switches. By turning on the switches at different instances six resonating frequency bands have been simulated. Omni directional and bidirectional radiation patterns have been observed at different resonating frequencies of the antenna and are presented later in this paper. The antenna initially resonates at 3.63GHz with full ground plane and when the slot was used at the bottom it produced different resonating frequencies.

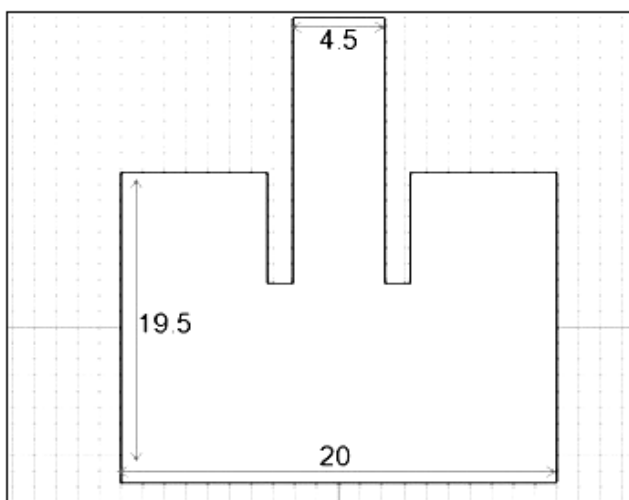


Figure 1. Top View.

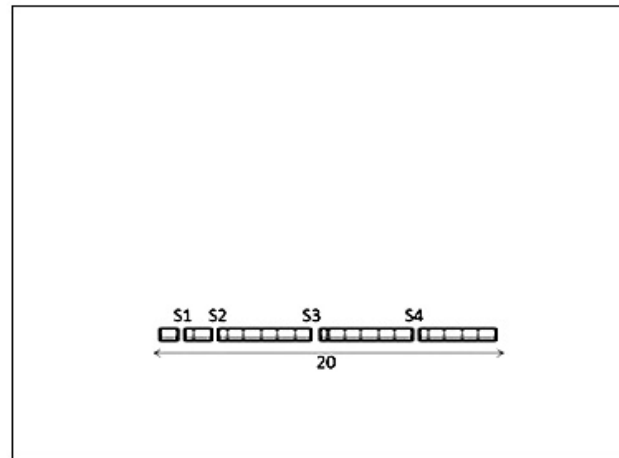


Figure 2. Bottom View.

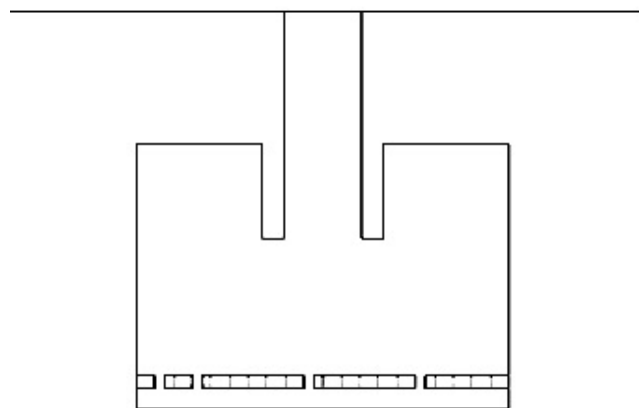
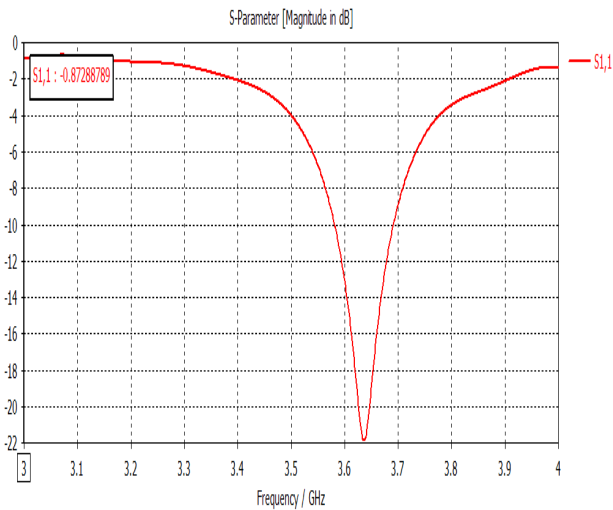


Figure 3. Antenna top view and switches at the bottom.

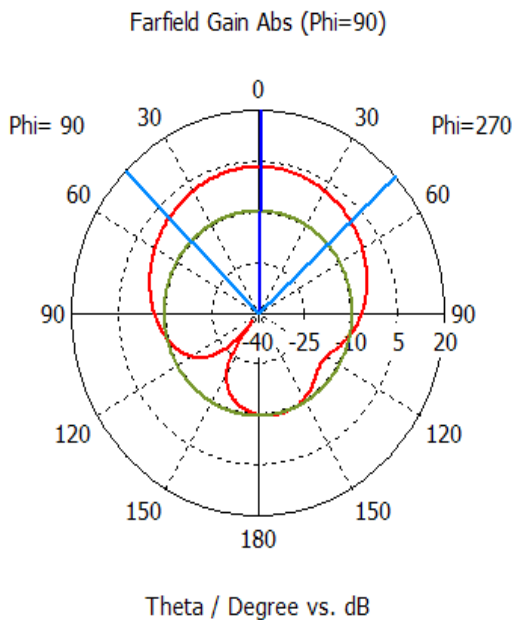
## 3. Results and Discussions

### 3.1 Simulated Results of Initial Design with No Slot

The Figure 4 is showing return loss plot of the initial design structure having no slot cut in the ground plane. The antenna was resonating at 3.63GHz and was having a return loss of -21.85dB. The VSWR of the design was also simulated its value was 1.17. The radiation pattern of the initial design was omni-directional having a gain of 3.31dB. The design was then modified and a slot was cut in the bottom ground plane of the antenna to introduce multiple resonating modes in the antenna by varying the overall effective size of the antenna.



**Figure 4.** Return loss plot of initial design.

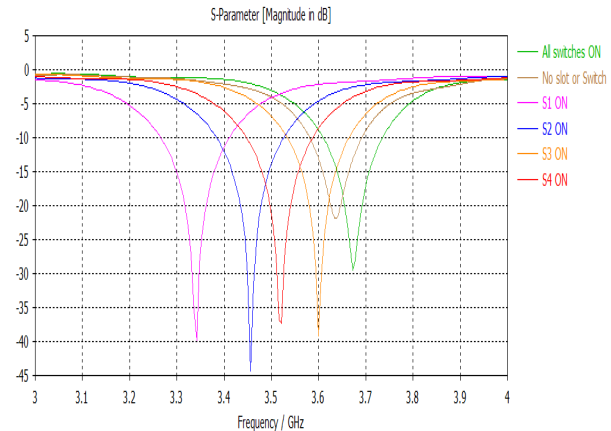


**Figure 5.** Radiation pattern of initial design.

### 3.2 Simulated Results by Cutting Slot in Bottom Ground Plane and by Introducing Switches

By inserting the slot and introducing four small switches in bottom ground plane of designed antenna, multiple resonant frequency bands were observed. Four switches were positioned optimally in the slot. The different switch configurations are shown on the Table 1. When S1 is on the antenna is resonating at 3.34GHz having a return loss of -39.72dB. Similarly by switching on switches S2, S3

and S4 antenna was resonating at 3.45GHz, 3.60GHz and 3.52GHz having return loss of -44.27dB, -39.19dB, -37.31 dB respectively. The radiation pattern at all frequencies as having same orientation with different gains. Similarly the VSWR of the design was having value below 1.5 at all resonating frequencies. The percentage bandwidth at all resonating frequencies was lying in the range of 3.11% to 4.31% and overall bandwidth ratio of 1.1:1 was measured from the simulated results.

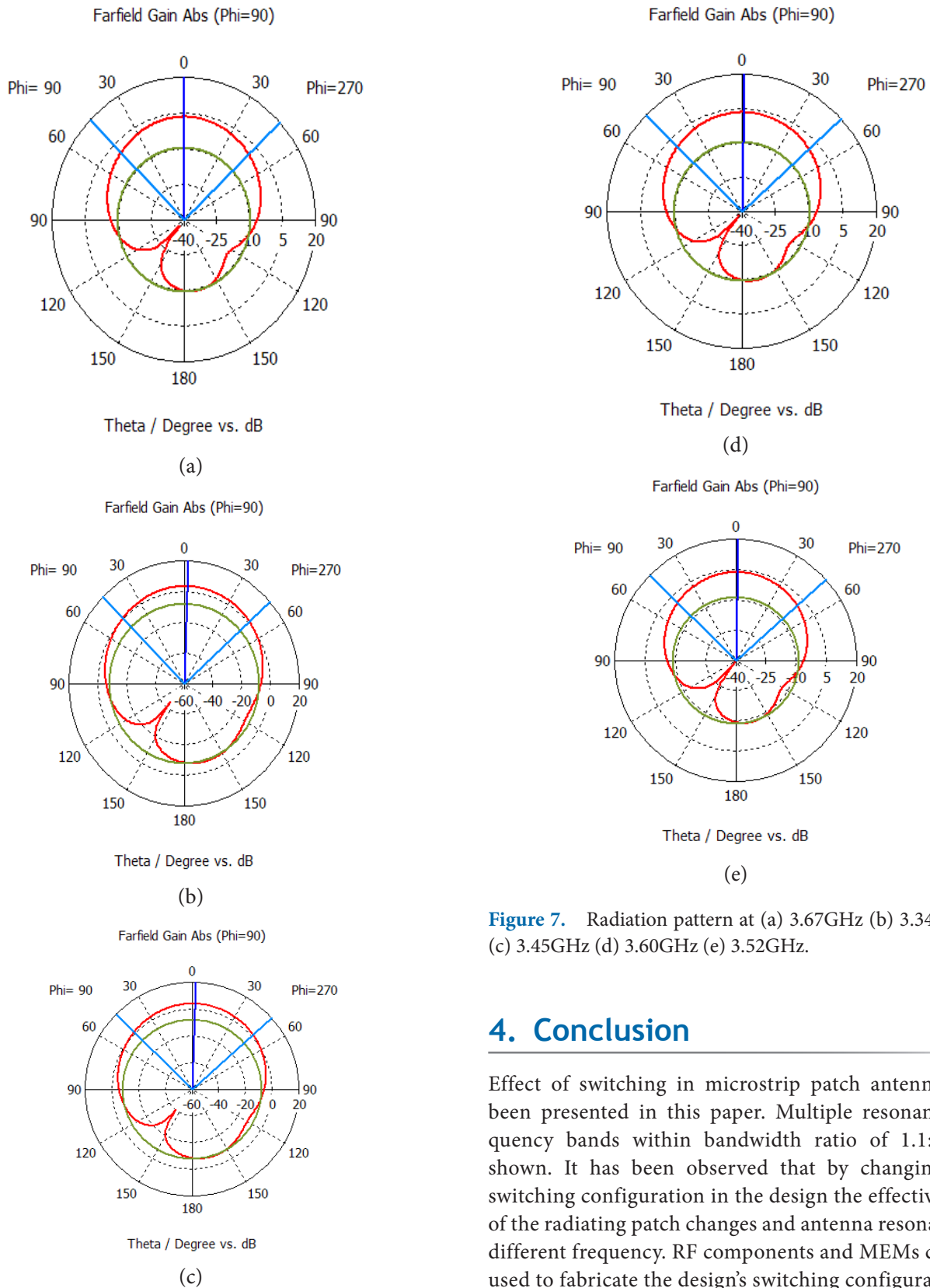


**Figure 6.** Different switching configurations showing return loss of the design.

Radiation patterns at various resonating frequencies can be seen in fig.7. All the radiation patterns are having similar radiation pattern orientation except the gain at each resonating frequency is different. The maximum gain of 4.04dB was measured at resonating frequency of 3.45GHz and minimum gain of 3.31dB was measured at resonating frequency of 3.63GHz. At all other frequencies the gain of the antenna lies in this range.

**Table 1.** Switch configurations showing simulated return loss and measured bandwidth

Switch Configurations	Frequency(GHz)	Return Loss(dB)	Measured bandwidth
No slot or Switch	3.63	-21.85	3.11%
All switches ON	3.67	-29.39	3.39%
S1 ON	3.34	-39.72	4.31%
S2 ON	3.45	-44.27	4.10%
S3 ON	3.60	-39.19	3.65%
S4 ON	3.52	-37.31	3.97%



**Figure 7.** Radiation pattern at (a) 3.67GHz (b) 3.342GHz (c) 3.45GHz (d) 3.60GHz (e) 3.52GHz.

## 4. Conclusion

Effect of switching in microstrip patch antenna has been presented in this paper. Multiple resonant frequency bands within bandwidth ratio of 1.1:1 are shown. It has been observed that by changing the switching configuration in the design the effective size of the radiating patch changes and antenna resonates at different frequency. RF components and MEMs can be used to fabricate the design's switching configuration.

## 5. References

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