Reconfigurable Antenna Design

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Abstract— A compact of a reconfigurable rectangular microstrip slot patch antenna of operating frequencies in the range of (2–6) GHz is proposed for Wireless Local Area Network (WLAN) applications. It has one port excited with microstrip line feed mechanism. The proposed antenna consists of a single layer patch antenna with two parallel slots designed that can be controlled via two switches. Two parallel slots are incorporated to perturb the surface current path, introducing local inductive effect that is responsible for the excitation of the second resonant mode. By adjusting the status of the switches state either *on* or *off* mode in simultaneously, the resonance frequencies can be varied, thus achieving frequency reconfigurable.

I represent a fully information and design for reconfigurable antenna to use it in a new hybrid device known Cognitive Radio CR. A cognitive radio CR is a wireless transponder that can sense the environment in which it wishes to operate and can adapt itself to optimize its operation. Sensing the environment may involve the measurement of the communications traffic and interference across a large part of the electromagnetic spectrum. The radio will also have knowledge of the intentions of its user, to enable it to match its searches to the needs of the user. In simple words the operations consist of Sensing and Reconfigurability called a Cognitive Radio CR.

1. INTRODUCTION

There is a developmental trend in wireless communication system that demands the use of antennas capable of accessing services in various frequency bands [1], sometimes with the use of a single antenna [2]. The increasing demand for modern mobile, satellite and wireless communication systems in the world make many researchers worked hard in order to improve the performances and enhance the application of the Microstrip Patch Antenna (MSA). Reconfigurable antenna will be an attractive feature in the modern wireless communication system because it enables to provide a single antenna to be used for multiple systems [3]. Moreover, it also has great attention in wireless communication systems due to their capability to vary their operating frequency, radiation pattern and polarization [4]. In this case, we want a reconfigurable antenna that maintains its radiation pattern at different frequencies.

1.1. Antenna Design Procedure

The geometry of an antenna developed for Reconfigurable antenna is shown in Figure 1. In order to design this type of antenna, it is necessary to know the exact value of dielectric constant of the substrate material chosen. The permittivity of the fabric is easily extracted from the measured resonant frequency of a patch radiator designed using an assumed approximate value of the substrate

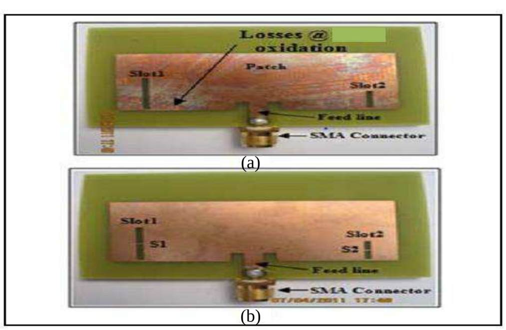

Figure 1: Antenna prototype: (a) Reconfigurable antenna with switches is in OFF mode. (b) Reconfigurable antenna with switches is in ON mode.

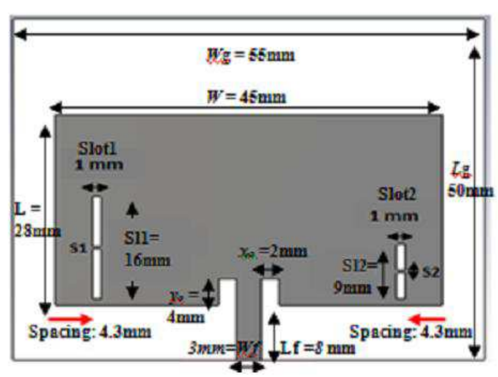

Figure 2: The structure of reconfigurable rectangular microstrip slots patch antenna with inset feed.

dielectric constant. The permittivity is determined as 4.7, from the knowledge of shift in measured frequency from design frequency.

Initially we designed a single Reconfigurable rectangular Microstrip patch antenna to understand the effect of its parameters.

- *In determining the operating dimensions and parameters, for the single patch antenna.*
- *Dielectric Constant of the Substrate* ε_r.

  The dielectric material that used here in my design of this Microstrip Patch Antenna is Polyester with $\varepsilon_r = 4.7$. The permittivity variation is ± 0.020.
- *The frequency of the operation* (f_0):

  The operating frequencies in the range of (2–6) GHz are proposed for Wireless Local Area Network (WLAN) applications.
- *Height of the dielectric substrate* (h):

  Microstrip Patch antenna has been designed in order to rule out the conventional antenna as the patch antennas are used in most of the compact devices [5]. Therefore, the height of the antenna has been decided as 1.6 mm.

  The parameters that decided by default in order to con-tinue to the design process are:

Table 1: The initial parameters.

ε_r	4.7
H	1.6 mm
f_0	2.4 GHz, 5.8 GHz

In this design, we use two feeding technique to simulate and compare between two method Inset feed, we start simulate with Inset feed.

1.1.1. Design Procedure

The inset feed models will be used to design the antenna [6]. Table 2 contains the specification structure of a Reconfigurable Rectangular Microstrip Slots Patch Antenna Using Inset Feed.

Table 2: The specification structure of a reconfigurable rectangular microstrip slots patch antenna using inset feed.

Parameters	Calculated Dimensions (mm)	Optimized Dimensions (mm)
Patch Width, W	37.02	45.0
Patch Length, L	28.4	28.0
Substrate Width, Wg	46.6	55.0
Substrate Length, Lg	38.0	50.0
Feeder length, Lf	4.8	8.0
Feeder width, Wf	2.88	3.0
x_o	0.5	2.0
y_o	4.0	4.0
slot1=slot2 (width)	1.0	1.0
Length of slot1 (sl1)	Optimization	16.0
Length of slot2 (sl2)	Optimization	9.0
Switch:S1=S2 (width)	1.0	1.0
Switch:S1=S2 (length)	0.5	0.5

2. RESULTS ON PERFORMANCE CHARACTERISTIC OF ANTENNA

2.1. Antenna Design with Two Slots (ON Mode)

When both switches are in ON mode (slots and switches), where S_1 and S_2 are located at the center of the slots, the antenna will produces multiband or single band frequency which is dropped at 2.4 GHz. The current position of the switch at the centre is chosen while its controlled the Reconfigurability frequency as shown in Figure 3.

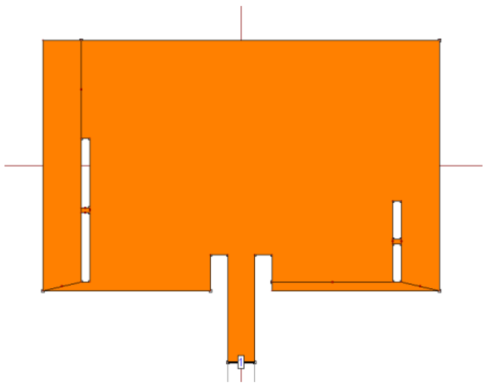

Figure 3: Antenna design with two slots (ON mode).

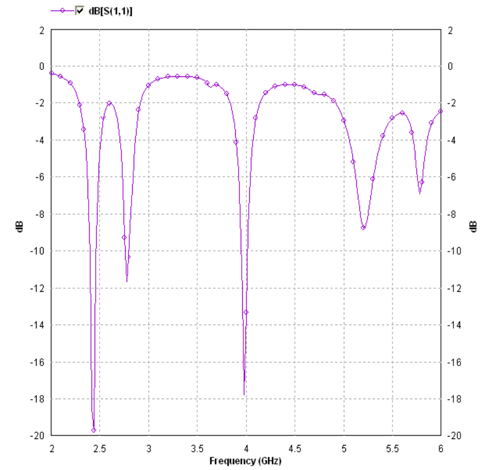

Figure 4: S_{11} parameter of single patch antenna with inset feed.

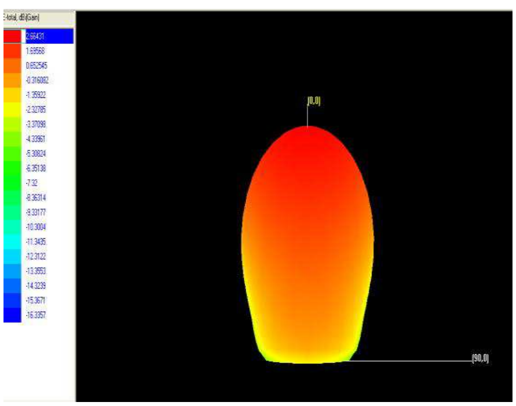

Figure 5: Antenna 3D radiation pattern for inset feed.

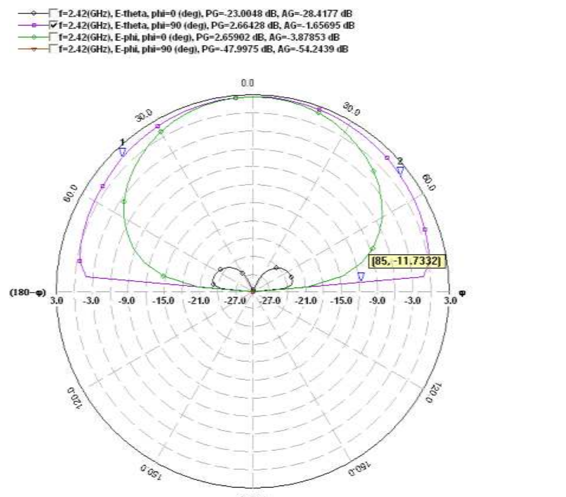

Figure 6: 2D radiation power with inset feed.

Table 3: Designed values of dimensions of various antennas developed at resonant frequency.

Length (L) in mm	Width (W) in mm	ΔL in mm	ε_{reff}
28	45	0.7 87	4.6 5

2.2. Return Loss Characteristics

The inset feed used is designed to have an inset depth of 4 mm, feed line width of 3 mm, and feed path length of 12 mm. A frequency range of (2–6) GHz is selected and 201 frequency points are selected over this range to obtain accurate results.

By using inset depth of 4 mm, I get return loss of −20 dB which considered good result as shown in Figure 4.

2.3. Far-field Radiation Pattern Characteristics

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for $\varphi = 0$ and $\varphi = 90$ degrees would be important.

Figure 5 is shown the radiation pattern of inset feed.

The maximum gain is obtained in the broadside and this measured to be 2.66 dBi.

2.4. Antenna Design with Two Slots (OFF Mode)

When both switches are in OFF mode (slots and switches), where S_1 and S_2 are disappeared from the center of the slots, the antenna will produces multiband frequency which is dropped at 2.4 and 5.8 GHz, as shown in Figure 7.

2.5. Return Loss Characteristics

The inset feed used is designed to have an inset depth of 4 mm, feed line width of 3 mm, and feed path length of 12 mm. A frequency range of (2–6) GHz is selected and 201 frequency points are selected over this range to obtain accurate results.

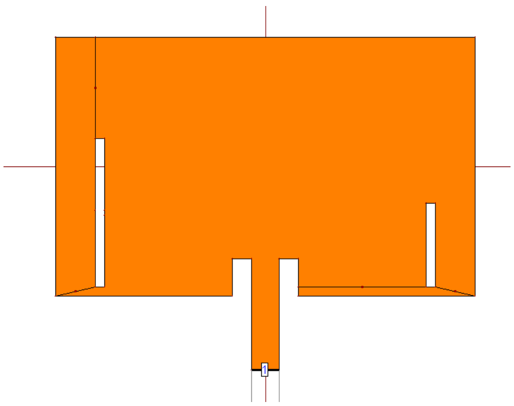

Figure 7: Antenna design with two slots (Off mode).

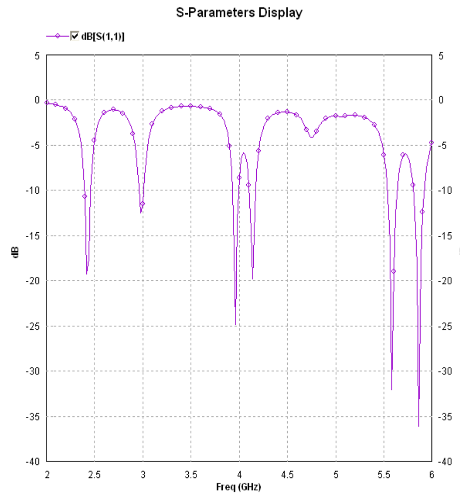

Figure 8: S_{11} parameter of single patch antenna with inset feed.

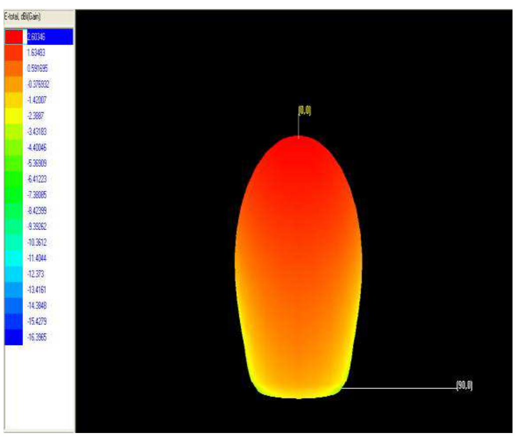

Figure 9: Antenna 3D radiation pattern for inset feed at 2.4 GHz.

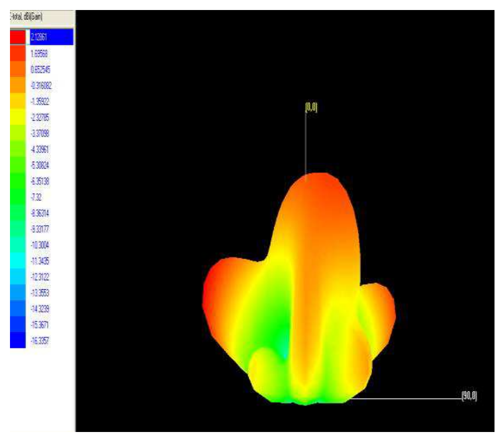

Figure 10: Antenna 3D radiation pattern for inset feed at 5.8 GHz.

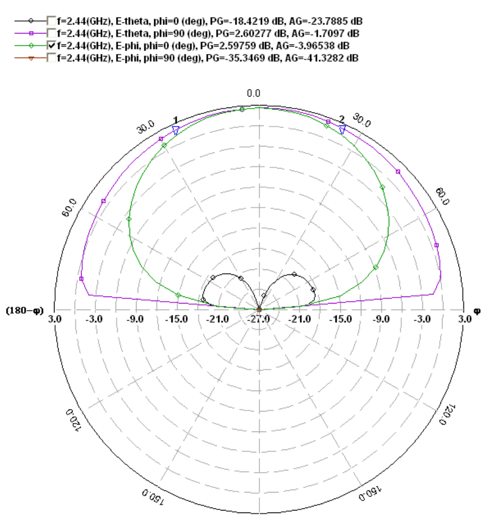

Figure 11: 2D radiation power with Inset feed at 2.4 GHz.

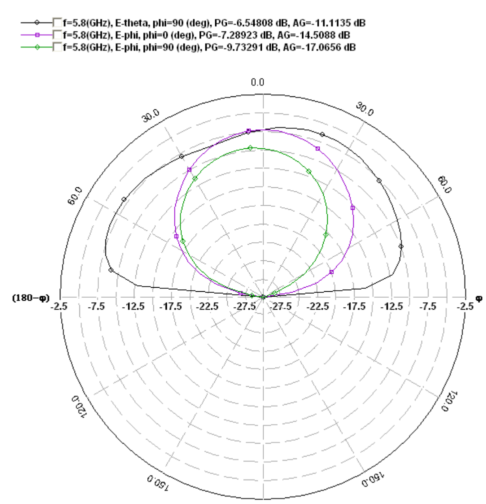

Figure 12: 2D radiation power with Inset feed at 5.8 GHz.

Table 4: Summary of simulation results.

Parameter	Reconfigurable antenna with OFF switches condition	Reconfigurable antenna with ON switches condition
	Simulation	Simulation
Resonant frequency (GHz)	f1= 5.8 f2= 2.4	f1= 2.4
Return Loss, S11 (dB)	S11,1= -18.02 S11,2= -35.12	S1,1= -20
Beamwidth	3 dB Beam-Width= 96.5 3 dB Beam-Width= 60.24	3 dB Beam-Width = 50.99
Gain	g1= 2.66 dB g2= 2.1 dB	g1= 2.6 dB

By using inset depth of 4 mm, I get return loss of −18 dB at 2.4 GHz and −35 dB at 5.8 GHz which considered accepted result as seen in Figure 8.

2.6. Far-field Radiation Pattern Characteristics

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for $\varphi = 0$ and $\varphi = 90$ degrees would be important.

Figures 9, 10 are shown the radiation pattern of inset feed for 2.4 and 5.8 GHz.

The maximum gain is obtained in the broadside and this measured to be 2.66 dBi at 2.44 GHz and 2.12 dBi at 5.8 GHz, see Figures 11 and 12.

3. CONCLUSION

A new reconfigurable of rectangular slots patch antenna with operating frequencies in range (2–6) GHz was designed, built and measured. It has been demonstrated with IE3D simulation and experimental results that the antenna is useful in Wireless Local Area Network (WLAN) [7]. The purpose antenna can handle and control the frequency band either to a single band or multi-band frequency in one time. A comprehensive parametric study has been carried out by optimizing the various dimensional parameters (slots and switches). Slots are added to a rectangular patch antenna (switches are in OFF mode) in order to obtain multiband resonance frequencies at 2.4 GHz and 5.8 GHz with return loss less than −10 dB. Two switches are added, which is the switch are in ON mode to control the Reconfigurability of the antenna designed only at 2.4 GHz frequency. By adjusting the status of switches that optimally fixed along the slots, we can vary the resonance frequencies, thus achieving the frequency reconfigurable. More work in the future will be focused since the result of 5.8 GHz is not really good in the antenna performance where the gain is very smaller compare to 2.4 GHz [8]. Besides that, in the advance of technology era, all electronic related devices are reducing in size. Therefore it is important for the sizes of these antennas to be reduced. The preferred substrate also needs to be wisely selected. The permittivity of the substrate affects the size and performances of the antenna.

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