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Design of Dual Band Antenna for WLAN Application

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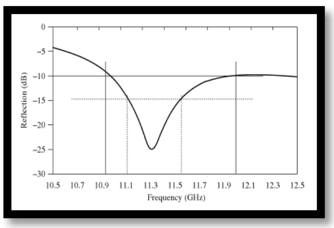
Graphical abstract



Abstract

This paper presents the antenna designed with radiating structure of *3.5* for dual band applications. This antenna is designed and simulated by using CST Studio Suite software at 2.4 GHz and 5.2 GHz based on standard IEEE 802.11a (5.15 GHz-5.35 GHz) and IEEE 802.11b (2.4 GHz-2.48 GHz) frequency bands. The radiating structure *5* and *3* are designed to radiated at frequency 2.4 GHz and 5.2 GHz respectively. Then, both structures are combined to achieve dual band resonant frequencies. The techniques that have been used to achieve dual band resonant are by designing the *3.5* shaped by using planar and coplanar waveguide (CPW) structures. There are three designs of dual band antenna which are Design *A*, Design *B* and Design *C*. The optimum return loss for 2.4 GHz and 5.2 GHz frequency response are -16.44 dB and -18.78 dB respectively achieved by Design *C*. The changes on the position of radiating structure *3* will effects the frequency response, return loss and gain of the antenna.

Keywords: Coplanar waveguide (CPW); dual band; gain; planar; radiating structure; return loss

Abstrak

Kertas kerja ini membentangkan antena dengan struktur radiasi *3.5* untuk aplikasi dual band. Antena ini direka dan disimulasi dengan menggunakan perisian CST Studio Suite pada 2.4 GHz dan 5.2 GHz berdasarkan piawaian yang telah ditetapkan oleh IEEE 802.11a (5.15 GHz-5.35 GHz) dan IEEE 802.11b (2.4 GHz-2.48 GHz) jalur frekuensi. Struktur yang direka pada frekuensi 2.4 GHz berdasarkan struktur *5* dan struktur *3*. Kemudian kedua-dua struktur ini digabungkan untuk mencapai dua salunan band frekuensi. Teknik-teknik yang telah digunakan untuk mencapai band dual gema adalah dengan mereka bentuk 3.5 menggunakan pandu gelombang satah dan sesatah struktur .Terdapat tiga reka bentuk antena yang Design *A*, *B* dan Design *C*. Kehilangan pulangan tertinggi bagi 2.4 GHz dan 5.2 GHz frekuensi adalah -16.44 dB dan -18.78 dB masing-masing dicapai oleh Design *C*. Perubahan kepada kedudukan struktur *3* memberi kesan kepada frekuensi , kembali kerugian dan keuntungan antena.

Kata kunci: Pandu gelombang sesatah (CPW); band dual; keuntungan; satah, struktur terpancar, kehilangan pulangan

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1.0 INTRODUCTION

Nowadays wireless communications is rapid in increasingly the technology development. The rapid progress promises to make interactive voice, data and video services available anytime and anyplace. Wireless communication systems come in variety of different sizes ranging from small hand-held devices to wireless local area networks.[1] The increasing in the use of the wireless portable devices and many others commercial applications in the wireless communications have increasing the demand of the services such as data or video transfer.[2]

In the wireless systems there are lot types of antennas that have been developed for its commercial. As mention before, the increase the bandwidth.[14-17] The popularity of wireless communications has made the system need to be more specific regarding the capacities it can carry and also the speed of the transmission.

higher demands of wireless portable devices have drag to the developing of dual band antennas which have multi applications and also can provide large bandwidth so that it can cover all operating frequencies needed in the system.[2-5]

The antennas also need to satisfy the IEEE802.11 WLAN standards. The IEEE802.11 is the most famous protocol that has been used widely nowadays. [6-10] This has led to the development of the antenna that can cover multiband applications and provide enough bandwidth to cover the operating frequencies within it. People found that wireless portable devices are very attractive because the user can use the devices without any cables and they also can move anywhere as long as they in the coverage area.[11-13] There is also a reason of developing a dual band antenna to

2.0 ANTENNA DESIGN

Previous work has been done on the novel compact printed antenna with radiating structure of 2.5 for dual band applications at 2.4 GHz and 5.2/5.8 GHz.[2] The authors had proposed different radiating structure for same applications. The radiating structure that has been proposed in this paper is 3.5.

The basic structure for the 3.5 antenna consists of 3 layers which are patch, dielectric substrate and ground plane as shown in Figure 1. The top layer is patch or antenna layer which is the radiator that made from the copper (annealed) with thickness of 0.035 mm. Then, the second layer is dielectric substrate (80 mm×80 mm). In this paper the material that has been used for dielectric substrate is FR4 board with thickness of 1.6 mm, dielectric constant of 4.4 and tangent loss of 0.019. While the bottom layer is the ground plane that used material from the copper annealed with thickness of 0.035 mm.

SMA connecter is used to connect the 50 Ω coaxial cable and the 50 Ω microstrip lines on FR4 board. The proposed antenna was designed and simulated by using CST Studio Suite software at 2.4 GHz and 5.2 GHz. The lengths of the radiating structure 3 and 5 are based on the 5/4.[10-13]The antenna geometry of radiating structure 3 and 5 are shown in Figure 2. The feeding methods that have been used in this paper are planar and coplanar waveguide feed line. The feed line is inserted at the radiating structure 5 to achieved dual band frequency response. The antenna dimensions[11] are shown in Table 1.

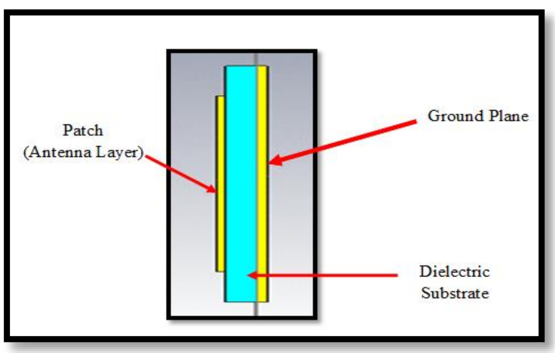
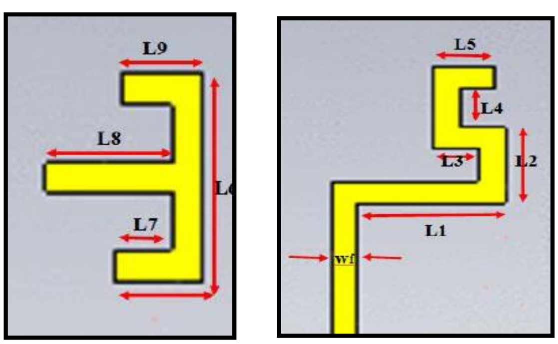


Figure 1 Basic antenna structure from side view



(a) (b)

Figure 2 Antenna geometry for (a) Structure 3 (b) Structure 5

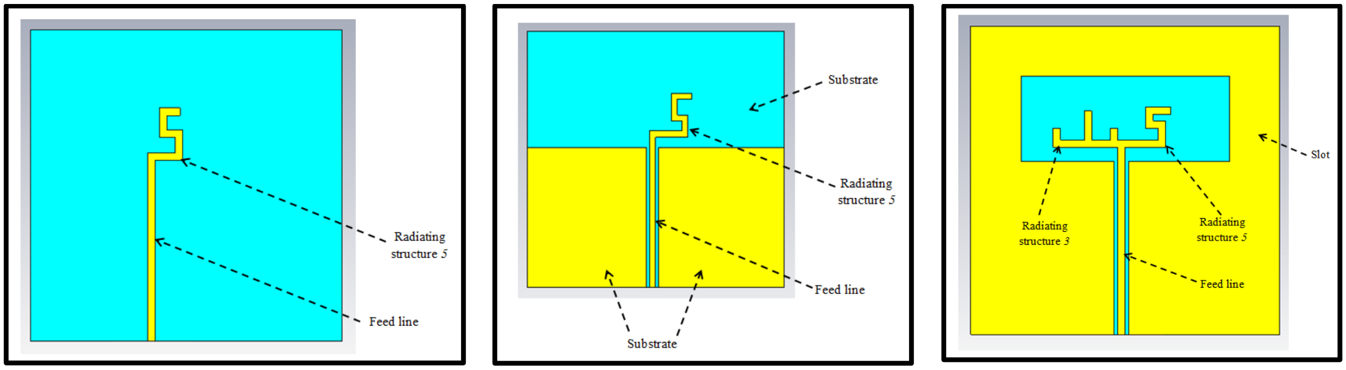
Table 1 The dimensions of the 3.5 antenna in mm

Symbol	Dimension
L1	12.5
L2	5
L3	3.3
L4	3.5
L5	4.5
L6	16.67
L7	3
L8	7.5
L9	3
L10	2.39
LF	46.5

The basic structure of 3 and 5 as in Figure 3 and Figure 4 are designed. Then, both structures 3 and 5 are combined to form 3.5-shaped antenna. A planar and coplanar waveguide technique has been used to achieve dual band frequencies. The position of the radiating structure 3 is turned or rotated to 90° position so that the antenna can achieved dual band frequencies at 2.4 GHz and 5.2 GHz. The prototype of the antenna is shown in Figure 4.

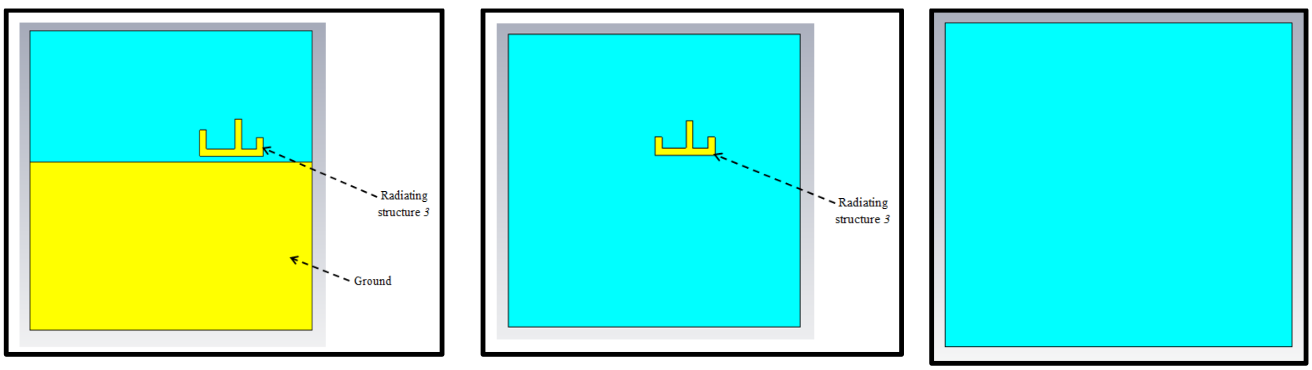
There are three types of antenna designs which are Design A, Design B and Design C. Design A is a planar antenna where the radiating structure 3 is placed at the same plane with the ground plane. The planar feed line is connected with the radiating structure 5 and the input port. Design B and Design C are based on coplanar waveguide structure. For Design B the radiating structure 3 is placed at the back side of the FR4 dielectric substrate. The radiating structure 5 is placed at the same plane with the ground. Then the coplanar waveguide (CPW) feed line is connected with the radiating structure 5. While for Design C the radiating structure 3 and 5 are combined to form 3.5 shaped.

Design C has slot surrounding the radiating structure, whereas Design B has slot on the right and left of the feed line only.



(a) (b) (c)

Figure 3 Antenna structure from front view (a) Design A(b) Design B (c) Design C



(a) (b) (c)

Figure 4 Antenna structure from back view (a) Design A(b) Design B (c) Design C

■3.0 RESULTS AND DISCUSSION

The antenna is designed and simulated by using the CST Microwave studio at 2.4 GHz and 5.2 GHz. Design *C* has the optimum return loss, bandwidth and gain at 2.4 GHz while Design *B* show the optimum performance at 5.2 GHz. Figure 5 and Figure 6 show the comparison of return loss for the simulation and measurement results. All antenna designs have broader bandwidth which can cover the applications desired. Design *C* has the highest directivity for both frequency which are 5.34 dBi and 6.53 dBi. At 2.4 GHz, Design *B* has the highest efficiency which is 98.6% while at 5.2 GHz; Design *C* has the highest efficiency which is 82%.

Table 2 and 3 show the comparison of the return loss, bandwidth and gain between Design *A*, Design *B* and Design *C*. The measurement results are also shown in Table 2 and Table 3. The measurement results are show good agreement with the simulation results at most of the frequency range. However, there are a little bit different between simulation and measurement results can be found especially for Design *B*. This is due to the environmental effect such as air, temperature and humidity during fabrication process.

Figure 13 and Figure 14 are shown the antenna prototype for all antenna designs.

Table 2 Comparison of simulation and measurement results between Design *A*, Design *B*, Design *C* at 2.4 GHz

	Design					
	A		***B***		***C***	
	Sim	***Meas***	***Sim***	***Meas***	***Sim***	***Meas***
Return Loss (dB)	-11.04	-19.34	-10.17	-12.14	-16.44	-19.78
Bandwidth (MHz)	403.13	764.14	391.30	478.26	1259.30	1006.2
Gain (dBi)	2.86	1.44	3.23	2.56	4.70	2.75

Table 3 Comparison of simulation and measurement results between Design *A*, Design *B*, Design *C* at 5.2 GHz

	Design					
	A		***B***		***C***	
	Sim	***Meas***	***Sim***	***Meas***	***Sim***	***Meas***
Return Loss (dB)	-15.95	-11.22	-29.74	-9.09	-19.96	-18.78
Bandwidth (MHz)	806.3	878.5	2000	-	1191.4	1067.9
Gain (dBi)	4.58	3.25	2.36	3.90	5.68	3.30

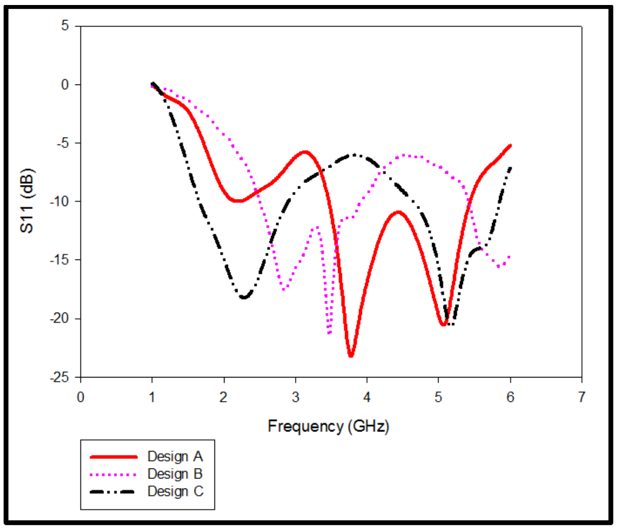


Figure 5 Comparison of simulation results between Design A, Design B and Design C

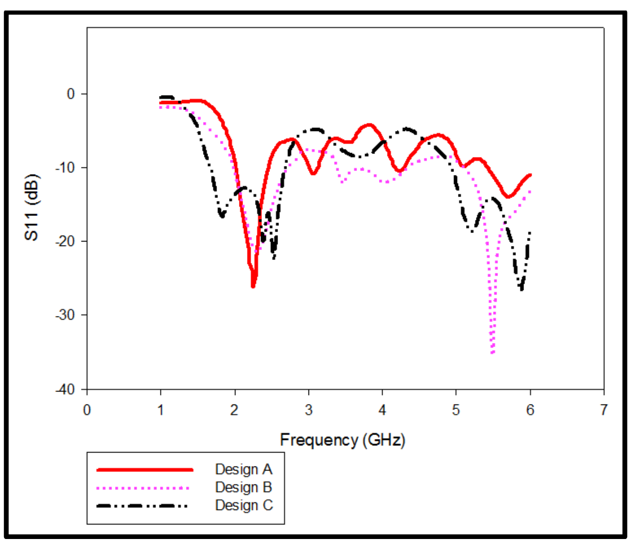
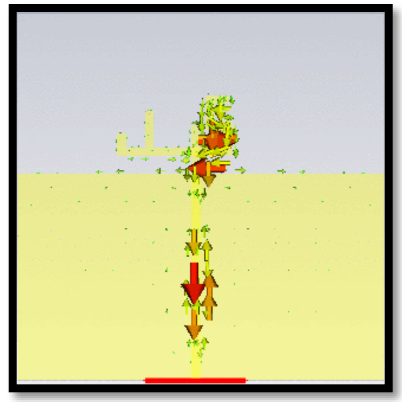


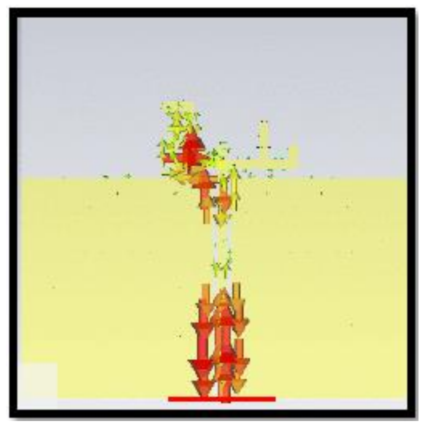
Figure 6 Comparison of measurement results between DesignA, Design B and Design C

3.1 Surface Current

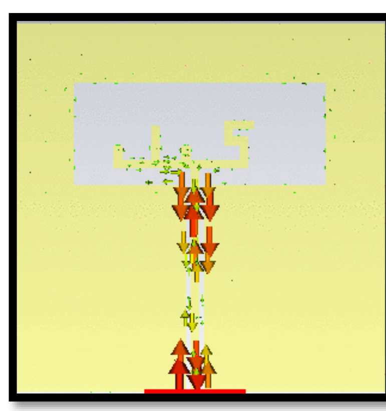
Figure 7 and Figure 8 show the surface current at frequency of 2.4 GHz and 5.2 GHz for all designs. Design A and Design B has more current radiated at radiating structure 5 compared to the Design C at frequency 2.4 GHz. While at 5.2 GHz, the current is radiated at both radiating structure for Design A and Design C compared to the Design B which the current radiated more at radiating structure 5.



(a)

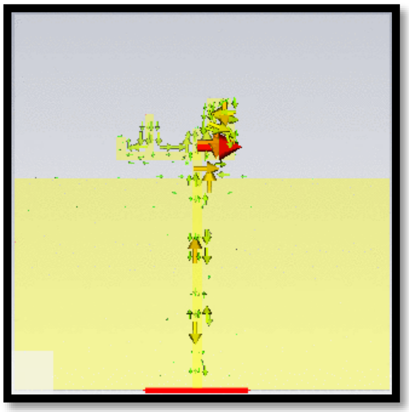


(b)

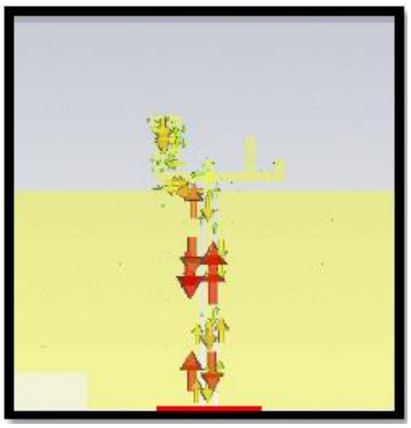


(c)

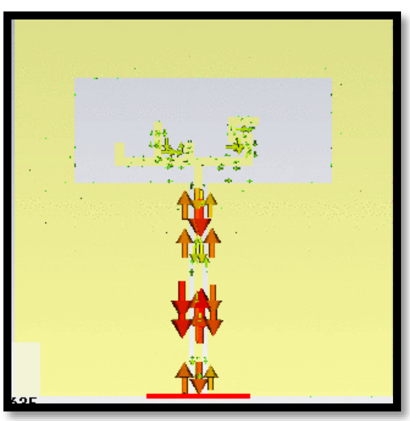
Figure 7 Surface Current for at 2.4 GHz (a) Design A (b) Design B (c) Design C



(a)



(b)



(c)

Figure 8 Surface Current for at 5.2 GHz (a) Design *A* (b) Design *B* (c) Design *C*

3.2 Radiation Pattern

The radiation pattern for all designs at 2.4 GHz and 5.2 GHz at azimuth angle (□) of 90° and 0° are shown in Figure 8 and Figure 9 and Figure 10. The red line and green line represent the radiation pattern at 2.4 GHz and 5.2 GHz respectively. The radiation patterns for all designs are look likes directive antenna type.

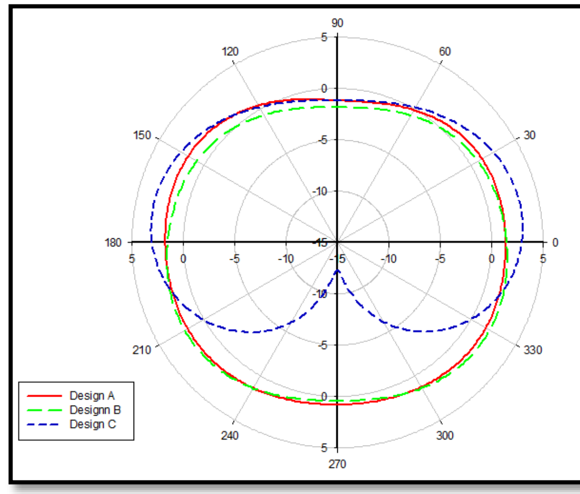


Figure 9 Simulation radiation pattern for all designs at 2.4 GHz

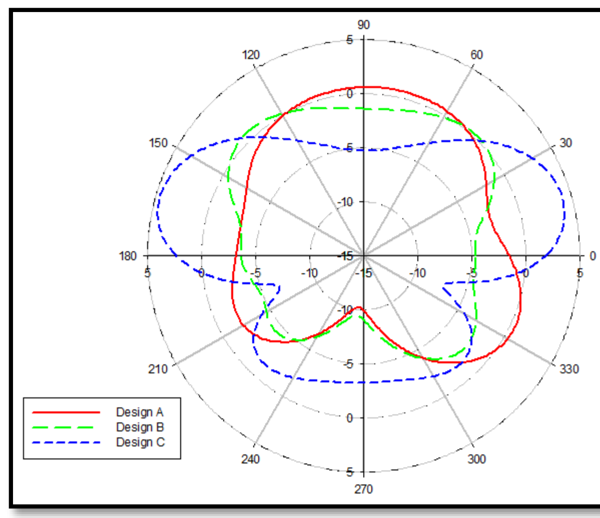


Figure 10 Simulation radiation pattern for all designs at 5.2 GHz

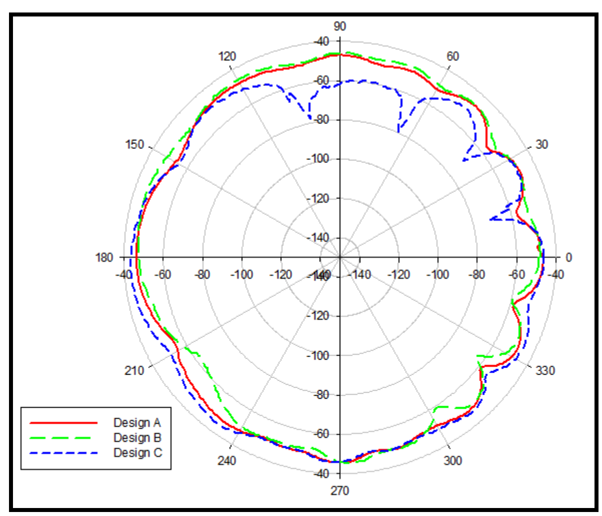


Figure 11 Measurement radiation pattern for all designs at 2.4 GHz

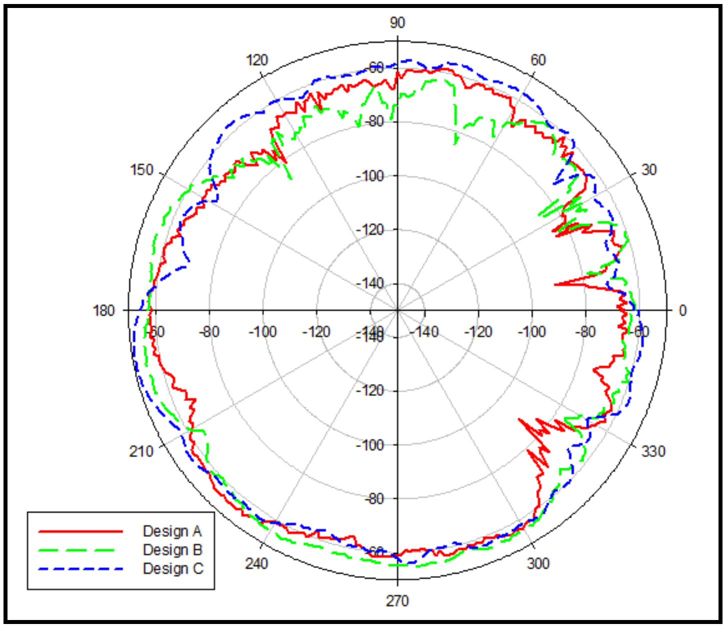
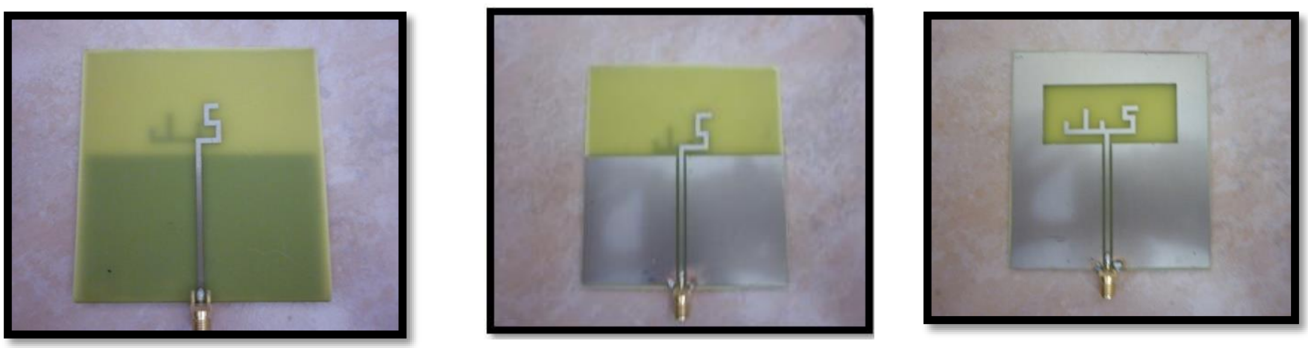
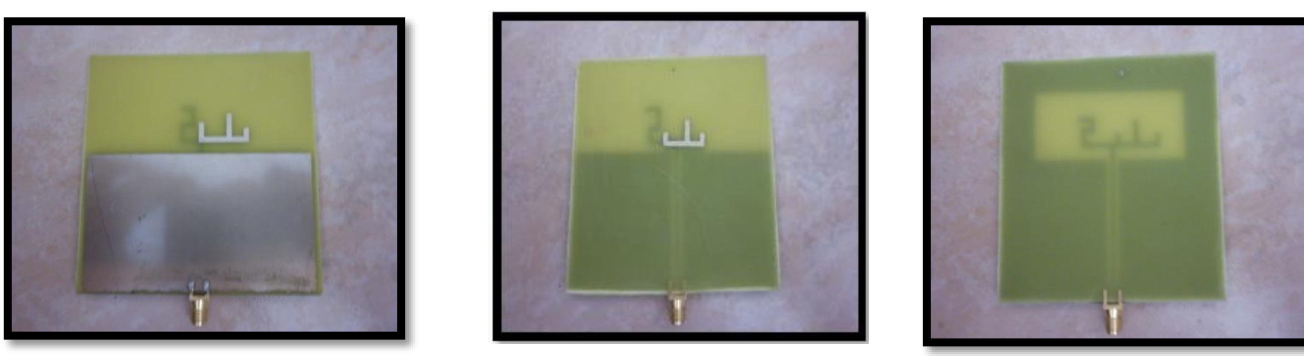


Figure 12 Measurement radiation pattern for all designs at 5.2 GHz



(a) (b) (c)

Figure 13 Antenna prototype from front view (a) Design A(b) Design B (c) Design C



(a) (b) (c)

Figure 14 Antenna prototype from back view (a) Design A(b) Design B (c) Design C

■4.0 CONCLUSION

The design of *3.5* antenna for dual band application at 2.4 GHz and 5.2 Ghz is proposed in this paper. Design *C* which design based on CPW techniques show the wider bandwidth more than 1 GHz for both frequencies band. Furthermore, the gain for Design C is more than 2.7 dB and 3.3 dB at frequency of 2.4 GHz and 5.2 Ghz respectively. The proposed antenna is a very attractive solution for small portable devices due to the compact design dimensions.

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