CIRCULAR MICROSTRIP PATCH ARRAY WITH SMALL CIRCULAR SLOTS LEADING TO MULTIBAND OPERATION FOR WLAN APPLICATIONS

Rajat G. PANDEY
Chandubhai S. Patel Institue of Technology, CHARUSAT campus changa, Gujarat, India
Email: rajatpandey.ec@charusat.ac.in

Abstract: This paper presents the novel design of 4 × 2 circular microstrip patch array antenna centered at 2.4 GHz. Small circular slots are subtracted from the circular patch in order to obtain the multiband operation. The goal of this paper was to obtain multiband operation, reasonable gain and SWR performance for WLAN applications. The proposed design resonates at 2.4 GHz, 3.4 GHz, 3.8 GHz, 5.45 GHz and 6.05 GHz. The size of the antenna is 24 cm × 12 cm. The proposed design includes eight circular patches of identical dimensions with equal spacing between them. Full wave simulation software was used to design and analyze the novel design presented in this paper. The results obtained of Gain, SWR and return loss are depicted in this paper.

Keywords: *Circular microstrip patch, Patch array, WLAN antenna, Antenna, Mutiband.*

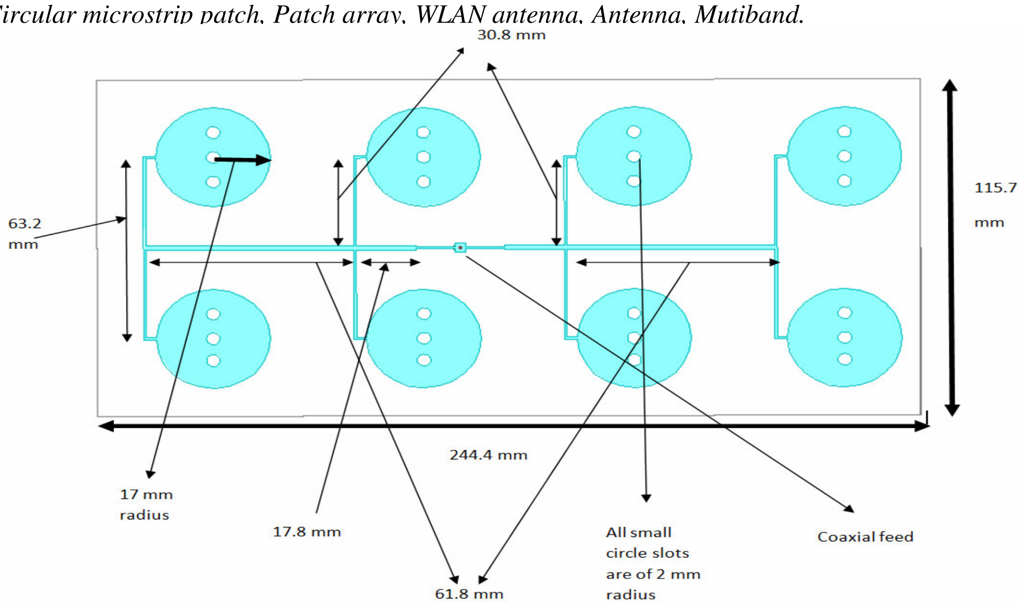

Figure 1: Top view of the proposed circular microstrip patch array with small circular slots

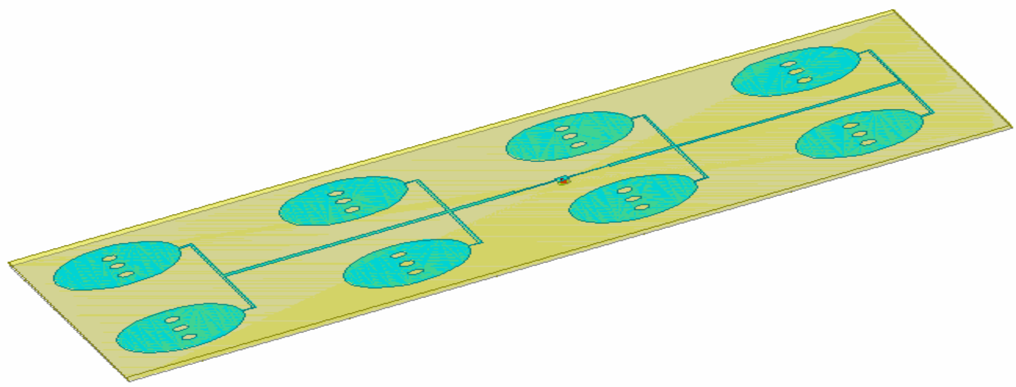

Figure 2: Actual 3D image of the proposed design in HFSS 15

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I. INTRODUCTION

There are many advantages of microstrip antennas such as conformal planar shape. There are extensive quantity of papers within the literature which deals with microstrip antennas. Despite the fact that individual microstrip patch antenna has numerous benefits, it additionally has a few drawbacks, for instance, less gain, narrow bandwidth with low efficiency. These impediments can be overwhelmed by developing an array configuration. The ground plane with slot to reduce the size of microstrip antenna was proposed in [1]. To obtain the multiband operation planar inverted-L antenna was proposed in [2].The methods to obtain the circularly polarized multiband microstrip antenna was proposed in [3]. The advantage of circularly polarized antenna over the linear polarized one is that the orientation of the device on which the antenna is installed does not affect the received power. Antenna array for multiple input and multiple output application was discussed in [4]. The advantages, disadvantages and applications of microstrip antennas were discussed in [5].

Numerous techniques for making multiband Microstrip patch antenna with metamaterial had been proposed in [6].Negative refractive index material load patch antenna for extremely wideband application was proposed in [7].Tunable dual band metamaterial antenna based split ring resonator (SRR) had been proposed in [8].

Antenna array is the combination of similar antenna elements which work together as a one antenna. All the elements presents are fed using the microstripline feeding such that all the individual elements gets excited to radiate. Antenna array has an advantage that it concentrates the power of all the antenna elements in a desired direction and reduce the power radiated in the undesired direction. These results in a higher gain and less interference as compared to an individual antenna element. Antenna array can be classified into two types depending on the direction in which it radiates. If it radiated in a direction perpendicular to its axis such antenna array is named as broadside array. If it radiates in a direction along its axis such an array is called as endfire array [9].

II. PROPOSED MODEL AND DESIGN

This paper examines the antenna array consisting of eight circular microstrip patch of identical size. The microstrip feed line is used to feed the patches using quarter wave transformation technique. Firstly the traditional antenna array was designed using the design equation then small circular slots were subtracted from the patch in order to achieve the multiband operation. Extensive parametric analysis was done using Full wave simulation software in order to reach at the optimum size of patch and slots.

The design equation used to design circular patch is shown below, [9]

The resonant frequency $(f_r)_{nm}$ is given by

$$(f_r)_{nm} = \frac{K_{nm}\ c\ a}{2\pi a_e \sqrt{\varepsilon_r}} \qquad (1)$$

Here, c represents the velocity of light in freespace, a is the actual radius and a_e is the effective radius, where K_{nm} is the mth root of the derivative of the Bessel function of order n. The value of k_{nm} is 1.84118 for TM_{11} mode.

$$a_e = a\left\{1+\frac{2h}{\pi a \varepsilon_r}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{0.5} \qquad (2)$$

For the dominant mode TM_{11} equation (1) can be expressed as

$$(f_r)_{11} = \frac{1.8412\ c}{2\pi a_e \sqrt{\varepsilon_r}} \qquad (3)$$

For the design purpose FR4 sheet having thickness of 0.16 cm was taken which is having a relative permeability ε_r of 4.4.The first step is to find the approximate value of a_e using equation (3), In equation (3), all the variables except a_e is known, The value of resonance frequency f_r chosen is 2.4 GHz. then substitute this value in equation (2) to find the value of a. the approximate value of a obtained is 17 mm. This will lead to an expression as shown below.

$$a = \frac{F}{\left\{1+\left(\frac{2h}{\pi \varepsilon_r F}\right)\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{0.5}} \qquad (4)$$

Where,

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon_r}} \qquad (5)$$

The design of the proposed novel circular patch array with three circular slots of identical radius and having equal distance between them is shown in figure 1. HFSS 15 was used to design and analyze the proposed design. Figure 2 shows the actual 3D image of the proposed design in HFSS. The coaxial feeding technique was used to feed the patches. The point where the structure has the 50 ohm impedance was chosen using parametric analysis in full wave simulation software, The feed was given at that point as the cable also has a 50 ohm impedance, hence the maximum power can get transferred to the antenna from the feeding cable and there should be minimal loss at the cable and antenna juncture. Array module method was used to feed all the patches in the design [10]

Table 1. Materials chosen for the design

	Material chosen	Thickness
Patch	Copper	0.035 mm
Substrate	FR4 (glass reinforced epoxy)	1.6 mm
Ground	Copper	0.035 mm

Table 1 delineates the material chose for patch and substrate. The material utilized for patch and ground is copper while for the substrate FR-4 (Glass epoxy resin) sheet having relative permeability of 4.4 and loss tangent of 0.019 was used. The Thickness chosen while simulating the design of patch and ground was 0.035 mm.

III. SIMULATION RESULTS

This section depicts the results obtained after simulating the proposed design using High frequency simulation software (HFSS 15). Figure 3 depicts the return loss result for 4× 2 circular microstrip patch array without circular slots. Figure 4 shows the return loss versus the frequency plot of the proposed antennas with the slots. It can be observed from the figure 4 that the proposed design resonates at multiple frequencies such as 2.4 GHz, 3.4 GHz, 3.8 GHz, 5.5 GHz and 6 GHz, while the design without slots resonates only at 2.4 GHz. The return loss values obtained at this different frequency has been summarized in table II.

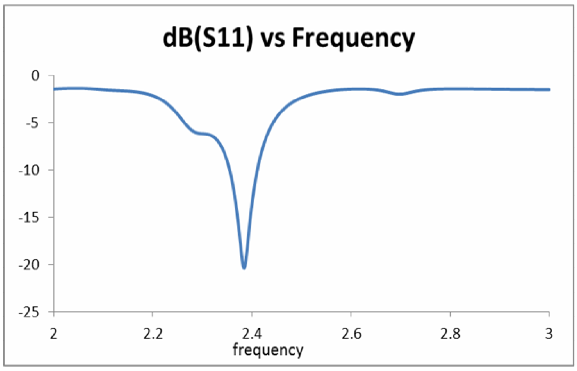

Figure 3: Return loss result for 4× 2 circular microstrip patch array without circular slots.

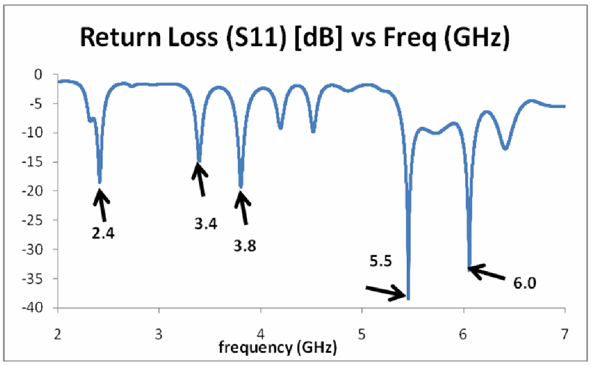

Figure 4: Return loss result of proposed design

Table 2. Return loss obtained at different frequencies

Centre Frequency (GHz)	Return loss (dB)
2.4	-18.5
3.4	-14.3
3.8	-19.3
5.5	-38.5
6.0	-33.5

Figure 5 depicts the VSWR obtained at different frequencies. The VSWR values obtained at different frequency has been depicted in Table III.

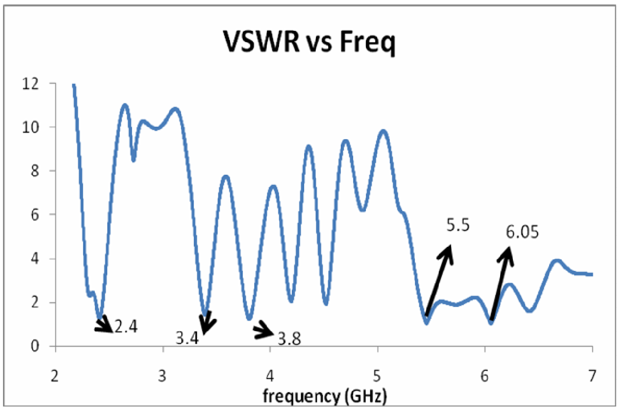

Figure 5: VSWR result for proposed design

Table 3. VSWR values obtained at different frequencies.

Centre frequency (GHz)	VSWR
2.4	1.27
3.4	1.44
3.8	1.25
5.45	1.02
6.05	1.05

Figure 6 depicts the 3D Radiation pattern in HFSS of the 4×2 circular patch microstrip antenna array without circular slots in patch.It can be observed from the figure 6 that the gain wihout circular slot is 9.88 dB. Figure 7 shows the 3D radiation pattern obained in HFSS of the proposed design.it can be clearly observed that the maximum gain obtained is 9.66 dB and the antenna array radiates in broadside direction.Comparing figure 6 and figure 7, it can easily be inferred that due to the presence of circular slots even though we are achieving multiband band still the Gain obtained has not reduced much.

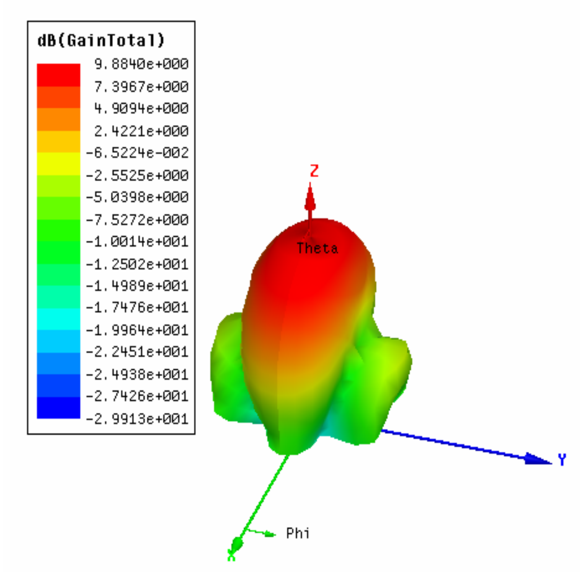

Figure 6: 3D Radiation pattern of the 4× 2 circular patch microstrip antenna array without slots.

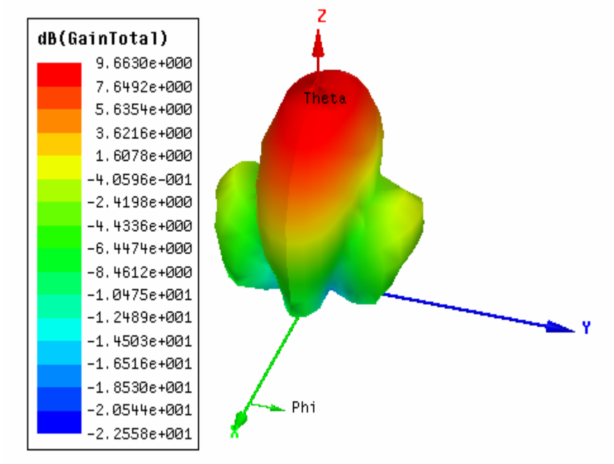

Figure 7: 3D radiation pattern of the proposed design

IV. CONCLUSION

A novel design of circular patch array having small circular slots have been introduced. The proposed antenna array has been intended to be utilized as a part of WLAN framework applications. The proposed antenna is resonating at multiple frequencies of 2.4 GHz, 3.4 GHz, 3.8 GHz, 5.5 GHz and 6 GHz.The simulation was carried using HFSS 15 and the chosen centre frequency was 2.4 GHz.The proposed design was compared with the 4×2 circular patch microstrip array without circular slots in patch.The return loss and vswr results obtained was presented. The gain obtained was 9.66 dB.it can be clearly inferred from the simulation results that by introducing small circular slots multiband can be achieved without sacrificing the gain

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