INTERNATIONAL JOURNAL OF RESEARCH IN COMPUTER APPLICATIONS AND ROBOTICS
ISSN 2320-7345

MICROSTRIP PATCH ANTENNA PERFORMANCE IMPROVEMENT FOR 2.45 GHz APPLICATIONS

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Abstract

Microstrip patch antenna is designed to cover ISM band applications (2.36-2.52) GHz. The operating frequency is chosen at 2.45GHz for the required operation and entire simulation is carried out by FEKO software version 5.5. The return loss, bandwidth, current distributions, Impedance matching, VSWR and gain are generated and computed with the simulation results. In this paper, the rectangular patch antenna (RPA) dimensions is calculated by using transmission line equations and put on the air substrate layer, the antenna and air layer lied on infinite ground plane and fed by coaxial cable 50 Ω matching impedance. Four designs with 29 slot arranged in various shape in each case for improve the performance of the reference antenna, the return loss is reduced to (35, 43, 39, 45 and 77dB) and very distinctive gain up to 9.6 dB at 2.45 GHz centre frequency in the far field.

Keywords*:* Microstrip antenna (MSA), FEKO software, returns loss, bandwidth, gain.

1. Introduction

With the acute demand of wireless communication system, antenna design becomes more significant. Newly microstrip patch antennas have been more commonly used in satellite communications [3] [4], radars, aerospace, and reflector feeds because of its natural characteristics such as low profile [5], light weight, low cost, mechanically powerful, compatibility with integrated circuits [6]. With all these advantages this type of antenna has specific disadvantages such as lower gain, low bandwidth, low efficiency which affect the capability of this antenna. Different researches are being done by the researchers to override these disadvantages by using different geometries of the patch [7]. The designing has been carried out in FEKO software which works on the base of Method of Moments. There are different feeding techniques for designing MSA. In this paper we used co-axial feeding technique which is generally used for proper matching impedance at 50Ω [8]. The geometry of the MSA is shown in the Figure1.The antenna is made of a one patch on top, single layer of substrate and a vertical probe connected from ground to the upper patch [9].

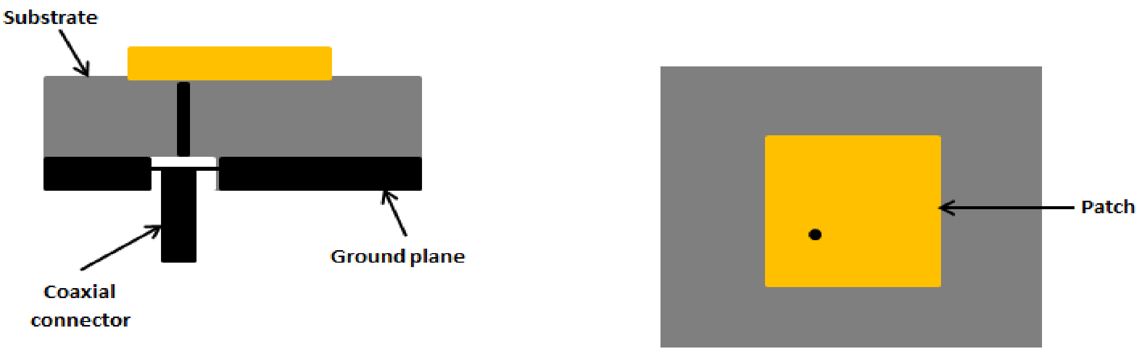

Figure 1: Geometry of microstrip patch antenna

2. Antenna Design

The design procedure of the antenna parameters is explained based on the transmission line model (TLM) [10] [11] as follows:

2.1 Calculation of the Patch Width (W)

$$W = \frac{c}{2f_o}\sqrt{\frac{2}{\varepsilon_r + 1}} \tag{1}$$

2.2 Calculation of effective dielectric constant (ε_{reff})

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}(1 + 12\frac{h}{w})^{-\frac{1}{2}} \tag{2}$$

2.3 Calculation of the effective length (L_{eff})

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \tag{3}$$

2.4 Calculation of the length extension (ΔL)

$$\Delta L = \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{w}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{w}{h} + 0.8\right)} \tag{4}$$

2.5 Calculation of the actual patch length (L)

$$L = L_{eff} - 2\Delta L \tag{5}$$

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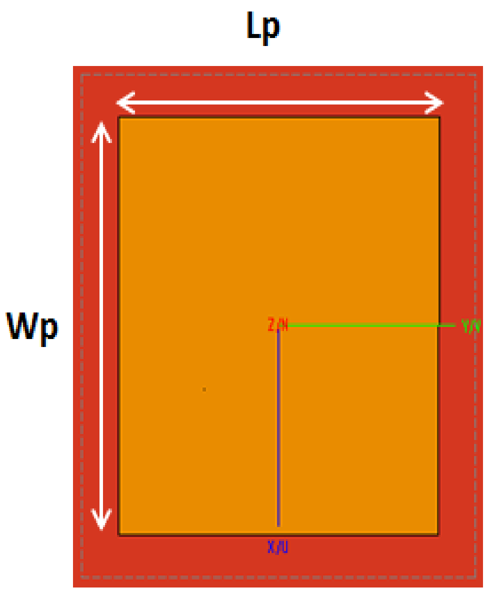
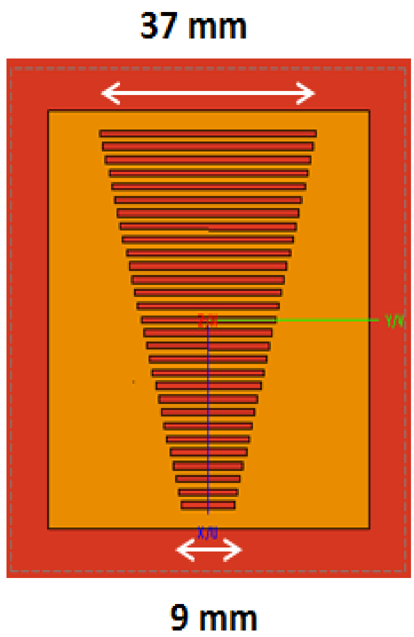
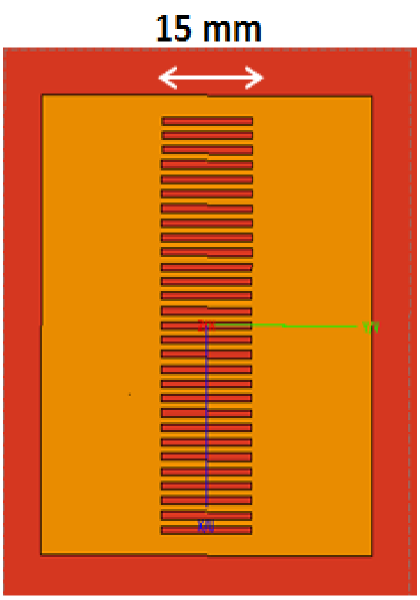
3. Geometry of Proposed Antenna

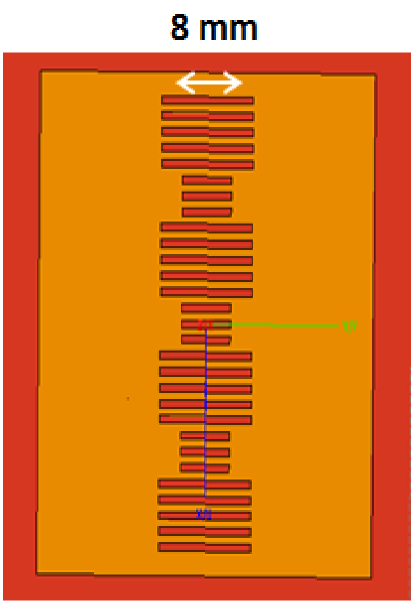
The structure of reference antenna consist of patch layer with dimensions (Wp X Lp), substrate layer with thickness = 5 mm and infinity ground plane below them [12]. In suggested designs each one have 29 slots, which they arranged in different shapes and the distance between each two slots = 1 mm. The antenna is fed by a coaxial cable at the point (9.5, -12.7) in (x-y) plane. All the parameters and the other dimensions are explained clearly in Figure 2 and Table 1.





(a) (b)





(c) (d)

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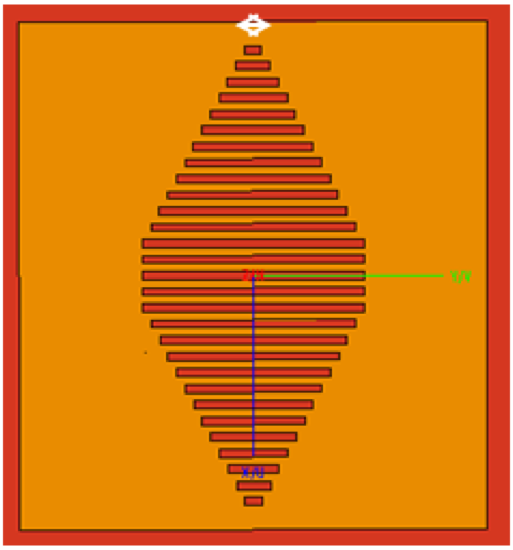

(e)

Figure 2: (a) Reference antenna, (b) Design 1 (c) Design 2 (d) Design 3 (e) Design 4

Table 1: Design parameter of microstrip patch antenna

Parameter	Value
Patch width (Wp)	62.96 mm
Patch length (Lp)	54.92 mm
Dielectric constant	1.001
Substrate thickness	5 mm
Feed point	(9.5 , -12.7) mm
Ground plane	Infinity plane

4. Results

4.1 Return losses and Bandwidth

Return loss is an appropriate way to characterize the input and output signal sources. It can be defined in dB. Bandwidth is another essential parameter. Bandwidth describes the range of frequencies over which the antenna can duly receive energy or radiate [13] [14].

This reference antenna has shown 30 dB return loss at 2.45 and obtained bandwidth is 150 MHz this value of return loss is improved by the four suggested design which is shown in Figure 3. A maximum power is radiate at the resonant frequencies 2.45 dB with return loss (77dB). All the other results of return losses and bandwidth are shown in Table 2 and Table 3.

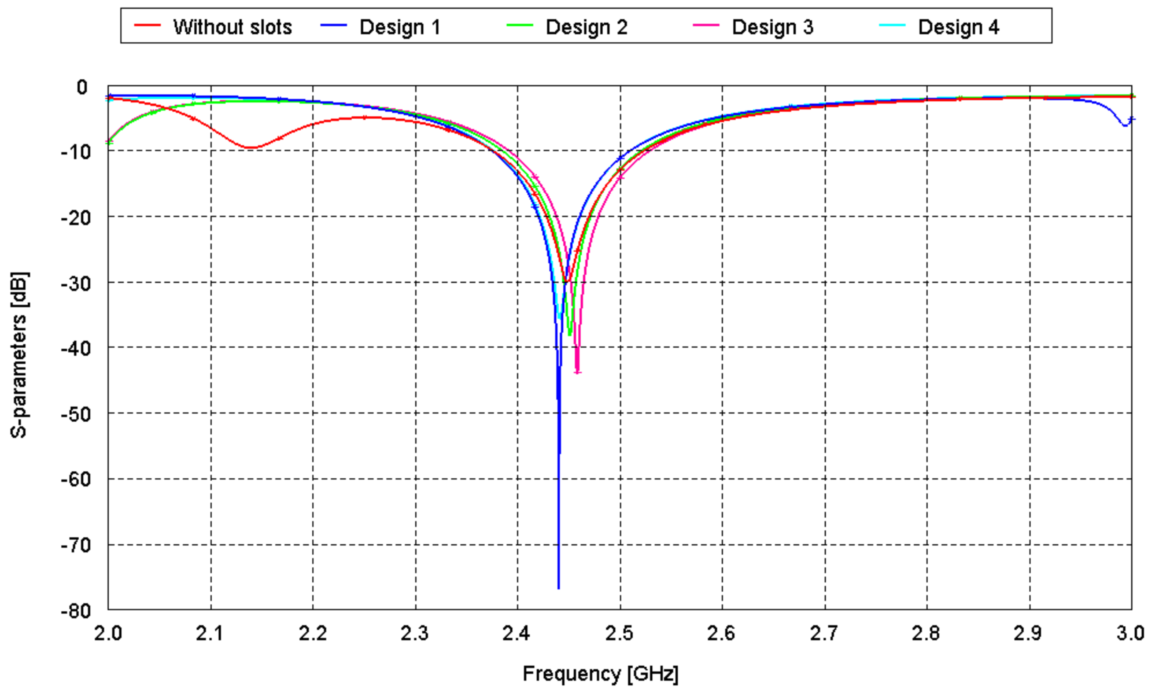

Figure 3: Return losses results of different design of MSA

TABLE 2. Return Losses results for different cases

Case	Resonant frequency (GHz)	S-parameter (dB)
Reference antenna	2.45	30
Design 1	2.45	77
Design 2	2.45	39
Design 3	2.46	45
Design 4	2.44	30

TABLE 3. Bandwidth results for different cases

Case	Bandwidth MHz
Reference antenna	150
Design 1	137
Design 2	130
Design 3	140
Design 4	145

4.2 Voltage standing wave ratio (VSWR) and Impedance

Voltage Standing Wave Ratio (VSWR) is defined as the ratio of the maximum to minimum voltage of the antenna [15]. From the Table 4, the best value of VSWR is satisfied in design 1, which is represented that a minimum power reflected from the antenna. Figure 4 show that all the values of the voltage standing wave ratio for each designs. also the characteristic impedance is calculated by FEKO and its observe that from the Figure 5 and Table 5, all the values of characteristic impedance gives a good matching for the proposed designs.

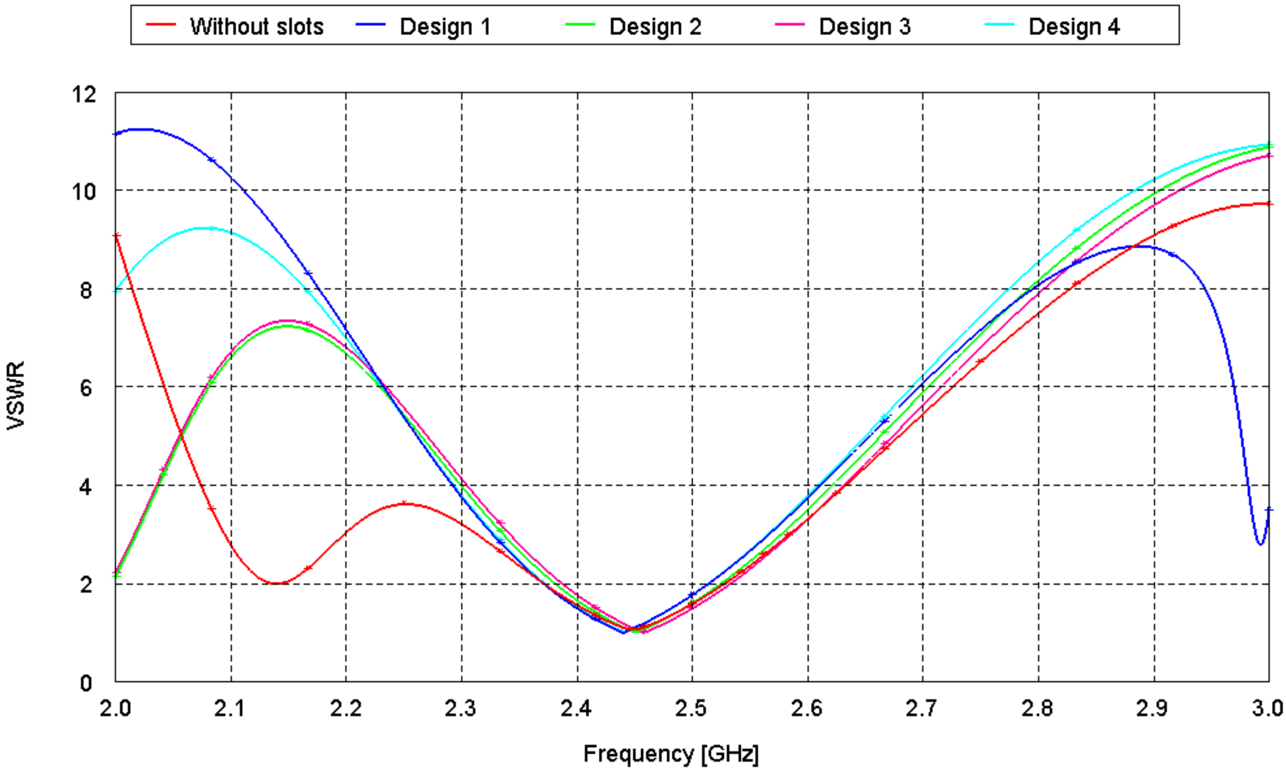

Figure 4: VSWR results of different design of MSA

TABLE 4. VSWR results for different cases

Case	Resonant frequency (GHz)	VSWR
Reference antenna	2.45	1.1
Design 1	2.45	0.92
Design 2	2.45	0.98
Design 3	2.46	0.94
Design 4	2.44	1.01

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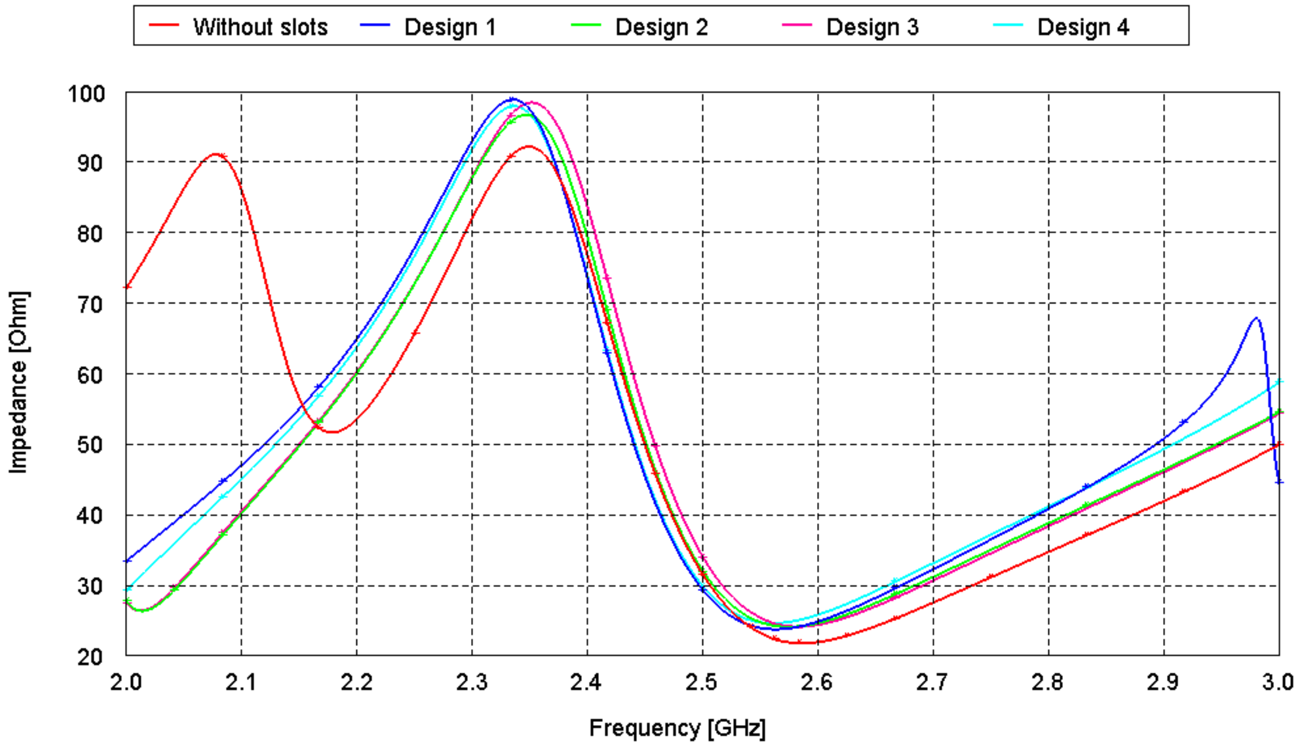

Figure 5: Impedance matching results of different design of MSA

TABLE 5. Impedance matching for different cases

Case	Resonant frequency (GHz)	Impedance Ohm
Reference antenna	2.45	50
Design 1	2.45	57
Design 2	2.45	55
Design 3	2.46	48
Design 4	2.44	50

4.3 Current distribution and Gain

Current distribution is described the output current of microstrip patch antenna at a given resonant frequency. The gain of an antenna is defined as the radiation intensity in a given direction divided by the radiation intensity that is obtained. It's not that, the gain is achieved a good values at resonant frequency 2.45 dB and these values remain constant and it's not affected for all designs which is equal about 9.6 dB. All the results of the current distribution and gain are shown clearly in Figures and tables below.

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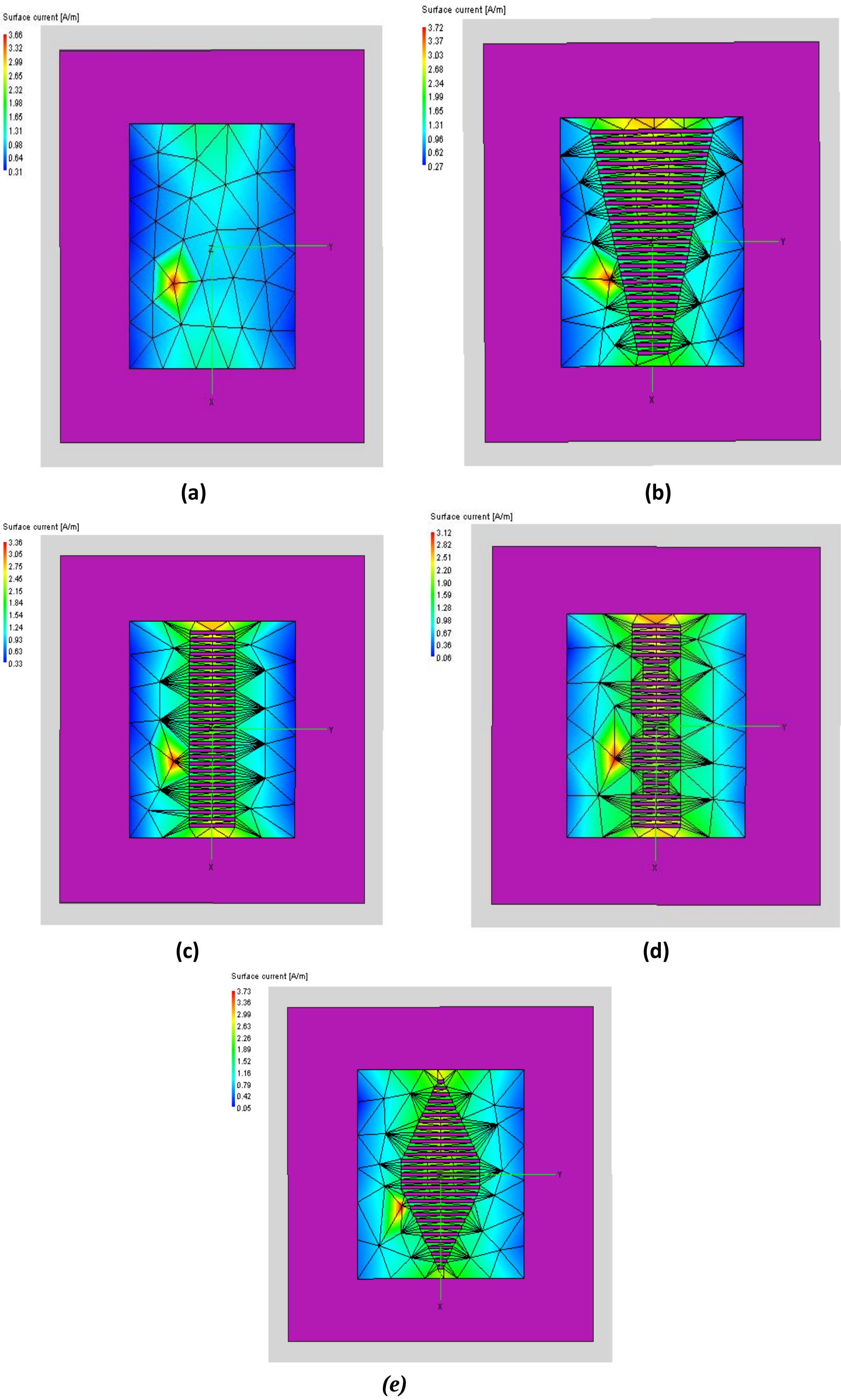

Figure 6: Current distribution in MSA, (a) without slots (b) Design 1 (c) Design 2 (d) Design 3 (e) Design 4

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TABLE 6. Output current for different cases of MSA

Case	Resonant frequency (GHz)	Current A/m
Reference antenna	2.45	3.66
Design 1	2.45	3.72
Design 2	2.45	3.36
Design 3	2.45	3.12
Design 4	2.45	3.73

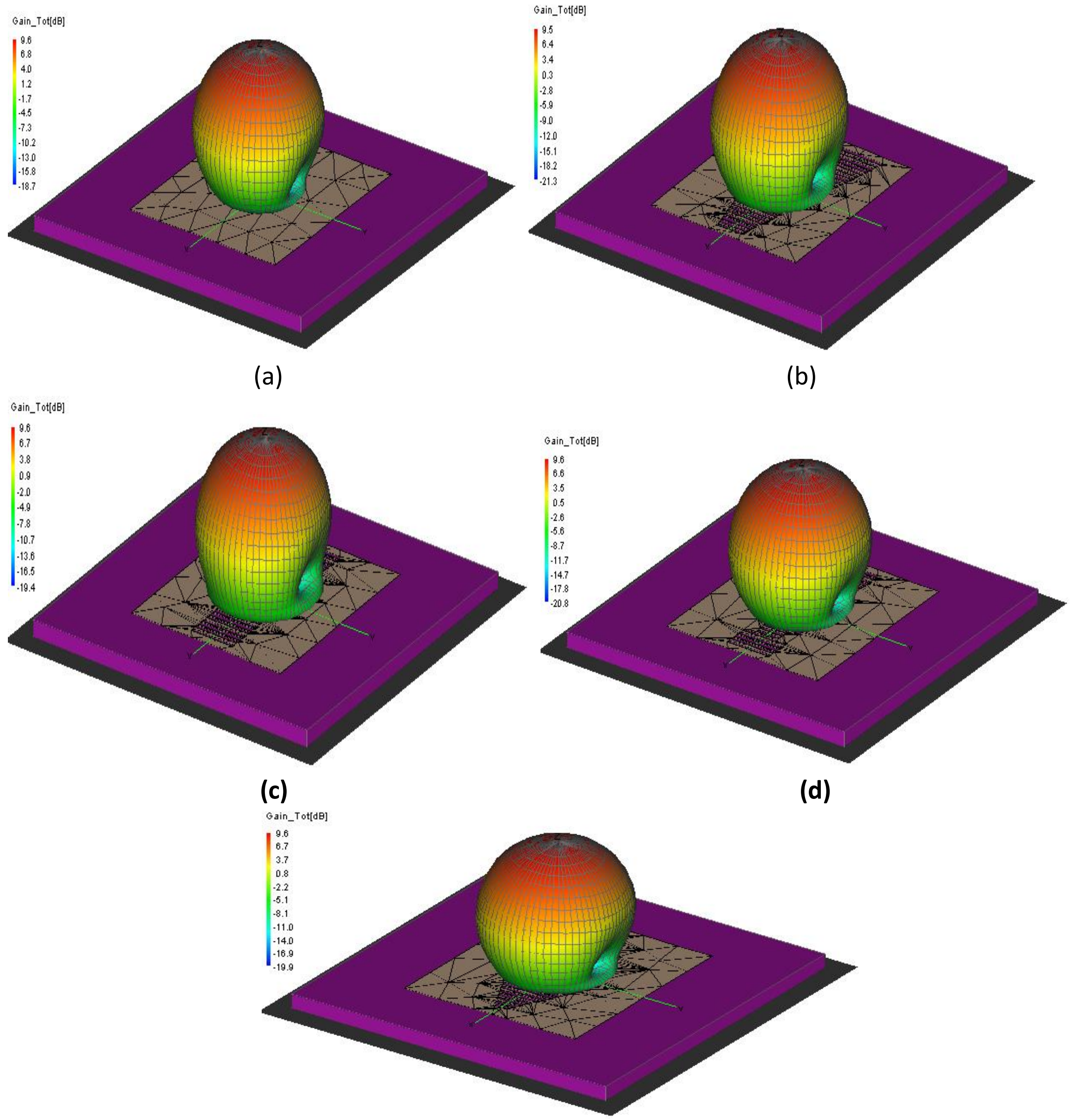

Figure 7: 3D gain in x-y plane, (a) without slots (b) Design 1 (c) Design 2 (d) Design 3 (e) Design 4

TABLE 7. Gain for different cases of MSA

Case	Resonant frequency (GHz)	Gain dB
Reference antenna	2.45	9.6
Design 1	2.45	9.5
Design 2	2.45	9.6
Design 3	2.45	9.6
Design 4	2.45	9.6

5. Conclusion

Rectangular patch antennas with 29 slots arranged in various shape for each case and fed by coaxial cable has been designed and studied. All such antennas have been designed for wireless applications and energy transfer. Simulation results shows the antenna impedance are matched with feeding line and the return loss are (30, 77, 39, 45, 35.43 dB) respectively. The resonant frequency to the proposed antenna is 2.45 GHz within the frequency bandwidth (2.37-2.52) GHz. The characteristics of antenna proposed are creating in terms of antenna with high gain and low reflection coefficient.

6. Future work

Using another way for fed the antennas instead of coaxial cable that suggested in this paper and make a comparison between the results in terms of return loss, VSWR and other parameters.

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