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Compact Multiband Rectangular Microstrip Patch Antenna for S, C, And X Band

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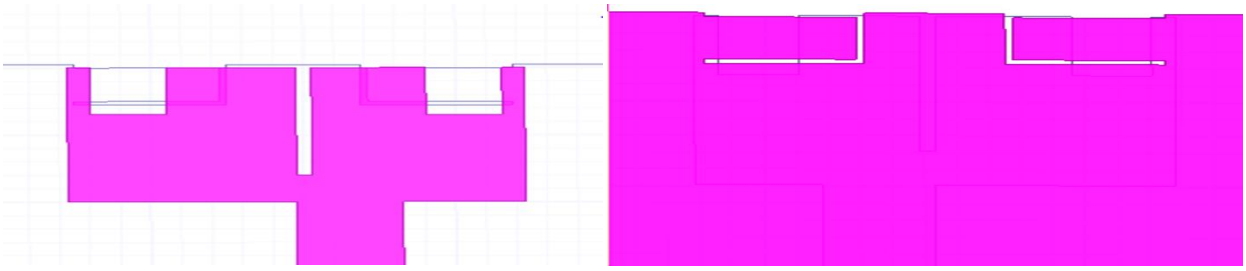
Abstract: ***This paper introduces the novel depiction of rectangular microstrip patch antenna on an affordable FR4 substrate of dielectric constant 4.4 and loss tangent 0.02. Ithas dimension of 40mmX 40 mm X 1.6 mm. The proposed multiband microstrip patch antenna can resonate at 2.55 GHz, 3.96 GHz, 5.38 GHz, 6.37 GHz, 7.78 GHz, 9.34 GHz, 10.89 GHz, 11.60 GHz, 12.17 GHz and 14.43 GHz. To achieve multiband frequency, three rectangular slots have been cut on the patch. The procured bandwidth is satisfactory and voltage standing wave ratio (VSWR) is less than 1.5. The execution of multiband antenna is simulated and attested by estimation. On the contrary, the proficiency of proposed multiband patch antenna has been justified through surface current distribution and efficiency of measured result.***
Keywords: microstrip patch antenna, multiband, gain, U-Slot patch, bandwidth

I. INTRODUCTION

Recent advancement in wireless communication have proliferated the requirement of antenna with compact size and low cost, that can work at various frequencies with enough bandwidth. Microstrip patch antenna has benefit of low profile, light weight, and affordable cost. There are numerous and well known methods to increase the bandwidth of antennas, including increase of thickness, the use of low dielectric substrate, slotted patch antenna, the use of various impedance matching and feeding techniques, and the use of multiple resonators[1]. The design of multi-band antennas was the subject of several research studies [2],[3]. The technology insertion slots is used [4],[5],[6]. In [7], a dual band antenna for GSM1800/1900/ UMTS/ LTE/UWB. In [8], a triple band single slotted microstrip patch antenna is presentedfor WLAN and WiMAX application. In [9], the authors propose a microstrip patch antenna for LTE. In [10] design of planar monopole antenna is designed using L and U shaped slot for WLAN/WiMAX Applications. Microstrip patch antenna had been designed for S and X band [11], [12]. This paper presents microstrip patch antenna with three slots on patch and two symmetrical U-shaped slots for multiband at 1 GHz. The design employs 50 Ω microstrip line feeding and simulated using High Frequency Structure Simulator (HFSS). The proposed design can achieve the reflected power is less than −16 dB for all resonant frequencies. The VSWR is lies between 1 and 2 and very good gain is obtained.

II. ANTENNA DESIGN

The structure of proposed multiband microstrip patch antenna is shown in Fig. 1 (a) and (b), which is designed on FR4 with dielectric constant of 4.4 and loss tangent of 0.02. The total volume of the proposed antenna is about 40×40×1.6 mm^3 and it resonates for 2.55 GHz, 3.96 GHz, 5.38 GHz, 6.37 GHz, 7.78 GHz, 9.34 GHz, 10.89 GHz, 11.60 GHz, 12.17 GHz, and 14.43 GHz . The dimension of the proposed microstrip patch antenna top view is displayed in Table I and back side view is shown in Table II. The top and back side view of proposed design is shown in Fig. 2(a) and (b), respectively.
Several methods are available in the literature to feed the signal source, in which insert fed technique is easier for fabrication. To achieve the multiband operation, a slot can be inserted in a ground plane with a dimension of 40×30.5 mm^2. In order to obtain the lower return losses



(a) (b)

Fig 1 Design of proposed microstrip patch antenna: (a) top side view (b) back side view

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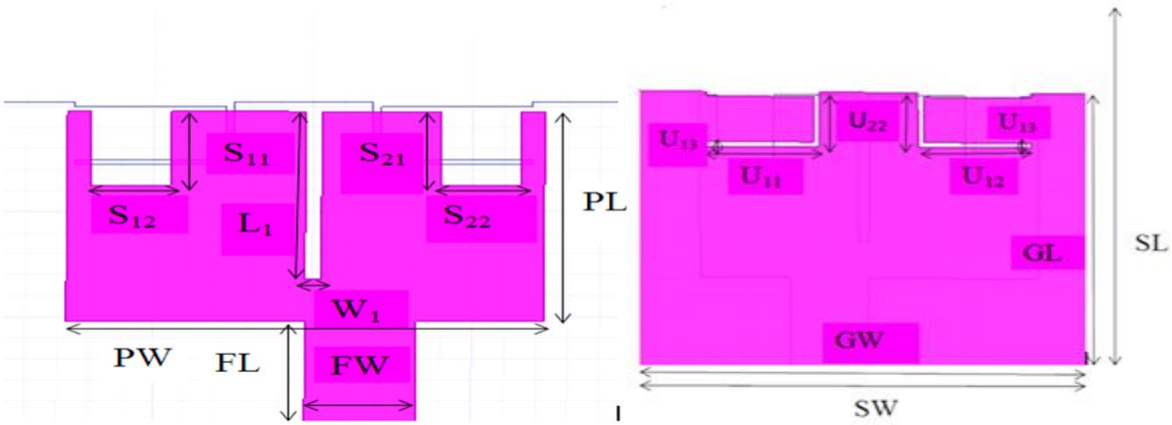


(a) (b)

Fig 2 Dimension of proposed microstrip patch antenna: (a) top side view (b) back side view.

Table I Parameter of top side view of antenna

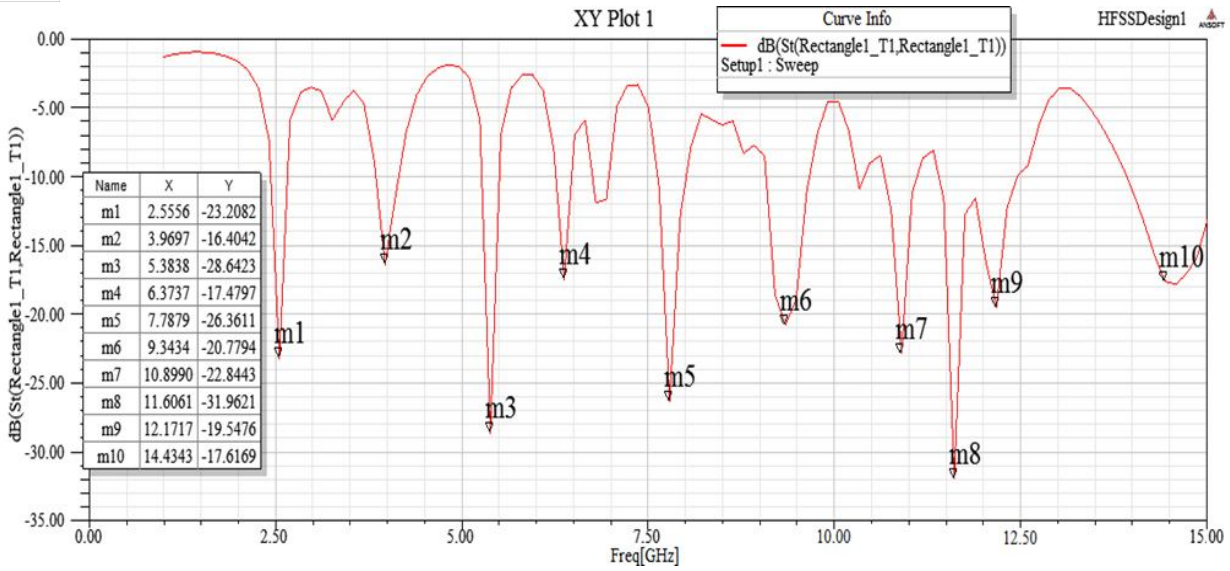
PARAMETERS	VALUES(mm)
Patch length(PL)	20
Patch Width(PW)	30
Feed Length(FL)	10
Feed Width(FW)	7
Slot(S_{11})	7
Slot(S_{12})	5
Slot(S_{21})	7
Slot(S_{22})	5
Slot(L_1)	16
Slot(W_1)	1

Table IIParameter of Back view

Parameter	VALUE
Ground Length(GL)	30.5
Ground Width(GW)	40
Substrate Length(SL)	40
Substrate Width(SW)	40
U_{11}	10
U_{12}	10
U_{13}	0.5
U_{22}	5

III. SIMULATION RESULT

The simulation results are carried out to test the performance of proposed microstrip patch antenna. The simulation results of reflected power and VSWR of the proposed microstrip patch antenna are shown in Fig. 3.This microstrip patch antenna simultaneously resonates for the frequency 2.55 GHz, 3.96 GHz, 5.38 GHz, 6.37 GHz, 7.78 GHz It can be seen from Fig. 3, a very low return loss of -31.96 can be achieved at the frequency of 11.60 GHz. The outcome of simulated results of return loss confirms the good performance for proposed design of multiband patch antenna.



Name	X	Y
m1	2.5556	-23.2082
m2	3.9697	-16.4042
m3	5.3838	-28.6423
m4	6.3737	-17.4797
m5	7.7879	-26.3611
m6	9.3434	-20.7794
m7	10.8990	-22.8443
m8	11.6061	-31.9621
m9	12.1717	-19.5476
m10	14.4343	-17.6169

Fig. 3 Simulated results of proposed patch antenna for Return loss

Fig. 4 shows the gain for various frequencies. It can be seen from Fig. 4, 8.3 dB is the maximum gain obtained at -12.1 GHz.

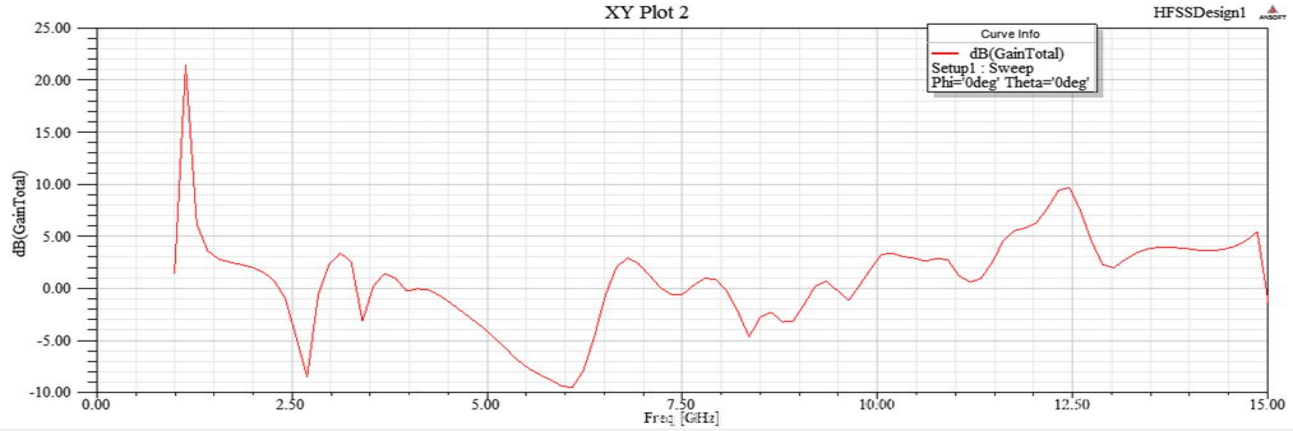


Fig 4 Simulted result of proposed patch antenna for Gain

Under various resonant frequencies, the performances of return loss and gain displayed in Table III.

Table IIIReturn loss and Gain at various frequency

Resonance Frequency	Return Loss	Gain
2.55	-23.20	Below 0
3.96	-16.40	0.30
5.38	-28.64	Below 0
6.37	-17.47	Below 0
7.78	-26.36	1.3
9.34	-20.77	0.81
10.89	-22.84	3.1
11.60	-31.96	5.07
12.17	-19.54	8.3
14.43	-17.61	3.7

The performance of VSWR for the proposed microstrip patch antenna is shown in Fig. 5, which lies between 1 and 2 for all resonant frequency with minimum reflected power of less than −16 dB. Table IV shows VSWR at various frequency.

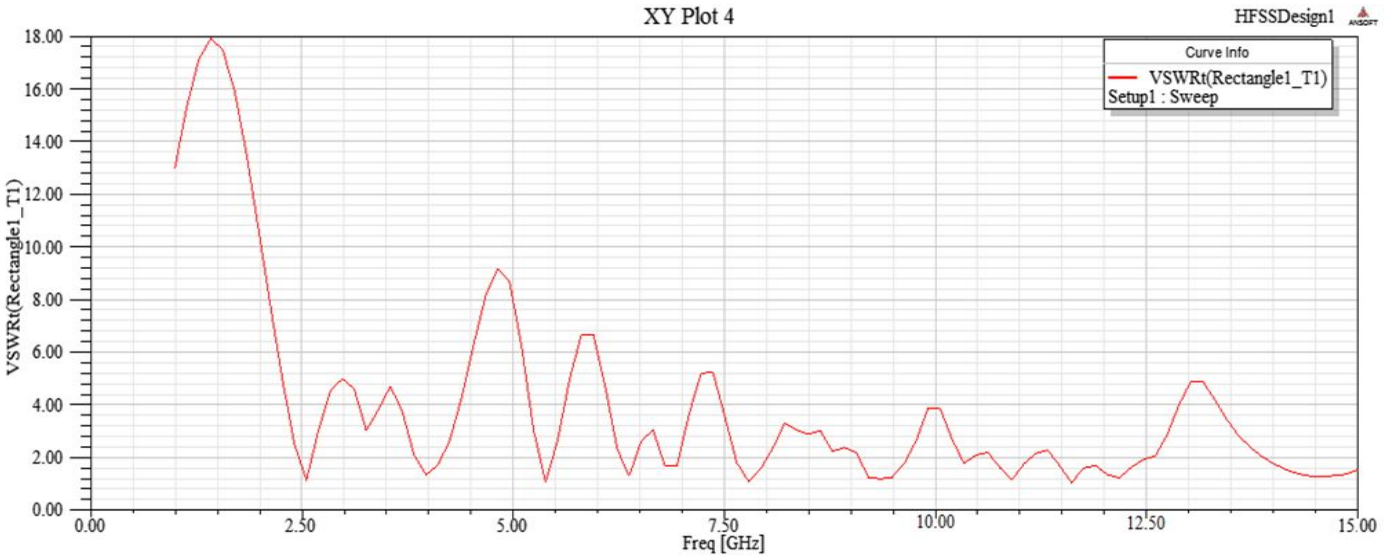
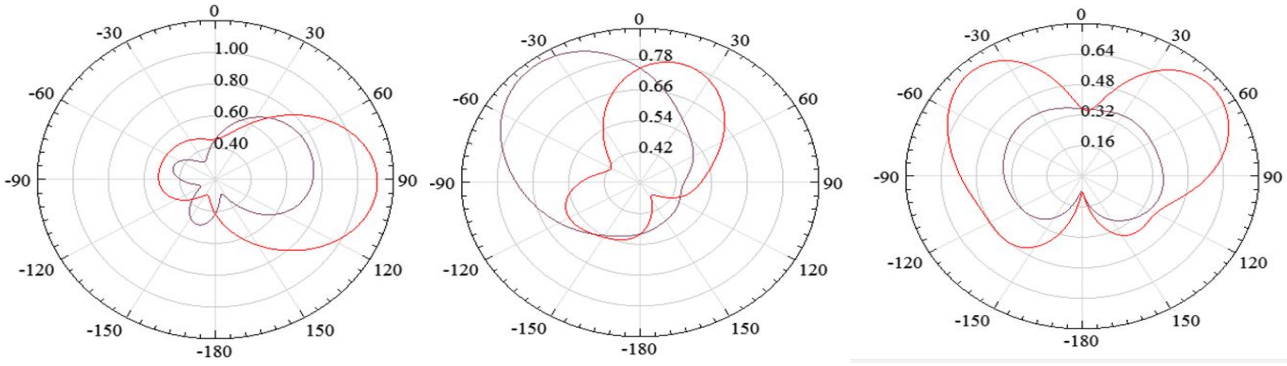


Fig 5 Simulated VSWR of proposed antenna

Table IV VSWR at various frequency.

Resonance Frequency	VSWR
2.55	1.31
3.96	1.41
5.38	1.11
6.37	1.36
7.78	1.11
9.34	1.16
10.89	1.16
11.60	1.15
12.17	1.26
14.43	1.41

Fig. 6 shows the radiation pattern for the microstrip patch antenna, (a).2.55 GHz, (b).3.96 GHz, (c). 5.38 GHz, (d). 6.37 GHz, (e). 7.78 GHz, (f). 9.34 GHz, (g). 10.89 GHz, (h) 11.60 GHz, (i) 12.17 GHz, and (j) 14.43 GHz. Omni directional radiation pattern is obtained for 11.60 GHz, 12.17 GHz and 14.43 GHz resonant frequencies. Bi-directional radiation pattern is obtained for 5.38 GHz, 6.37 GHz and 9.34 GHz resonant frequencies. Directional radiation pattern is obtained for 2.55 GHz, 3.96 GHz, 7.78 GHz and 10.89 GHz resonant frequencies.



(a) (b) (c)

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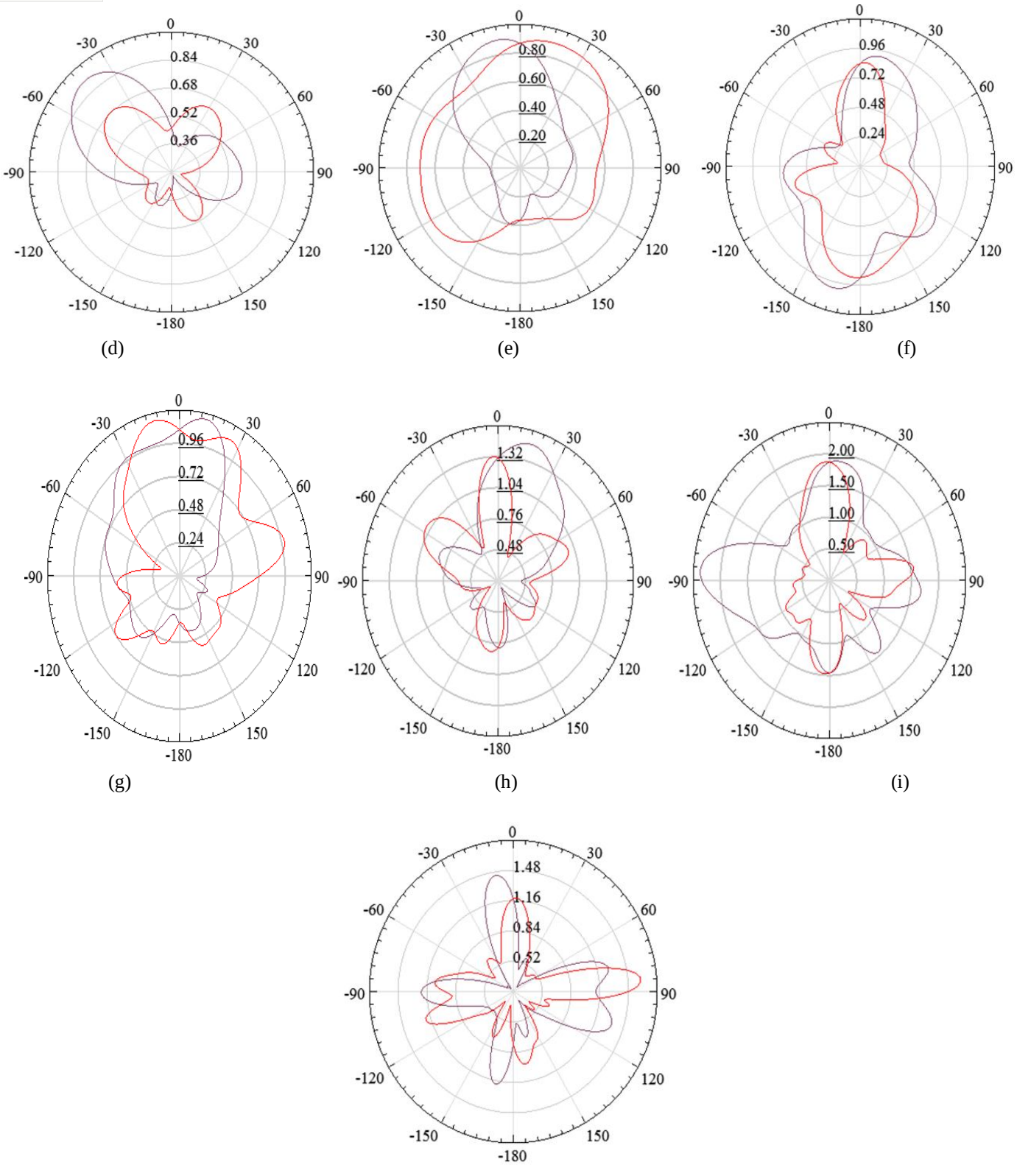
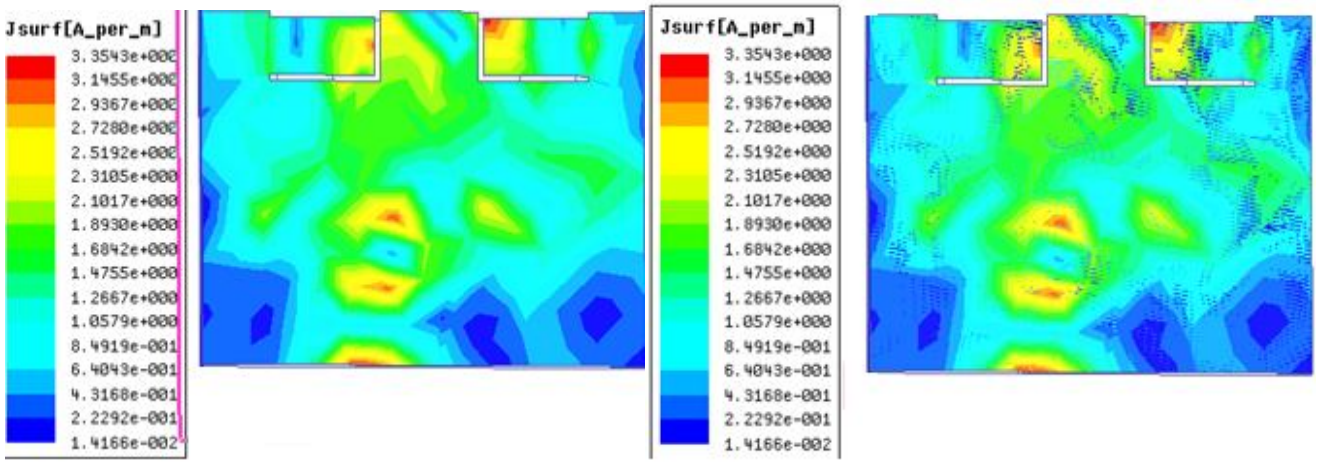
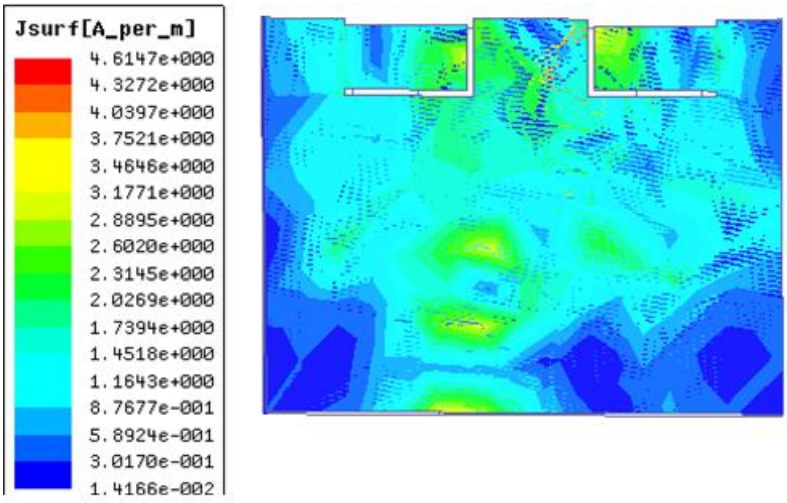


Fig. 6Radiation pattern for the microstrip patch antenna (a).2.55 GHz, (b).3.96 GHz, (c). 5.38 GHz, (d). 6.37 GHz, (e). 7.78 GHz, (f). 9.34 GHz, (g). 10.89 GHz, (h) 11.60 GHz, (i) 12.17 GHz, and (j) 14.43 GHz

Fig. 7 shows the surface current distribution on the microstrip patch antenna is, 11.60 GHz, 5.38 GHz, and 7.78 GHz.



(a) (b)



(c)

Fig 7 Surface current distribution on the microstrip patch antenna, (a) 11.60 GHz, (b) 5.38 GHz, (c) 7.78 GHz.

IV. CONCLUSION

In this paper, a design of multiband microstrip patch antenna is proposed, which covers the frequency range between 2 GHz and 14 GHz. The return loss for all resonant frequency is less than −16 dB and also the proposed design achieves Omni directional and bi-directional radiation pattern. The obtained peak gain is greater than 5 dB and the simulation results of proposed antenna provide the better outcome for S, C and X band frequency applications.

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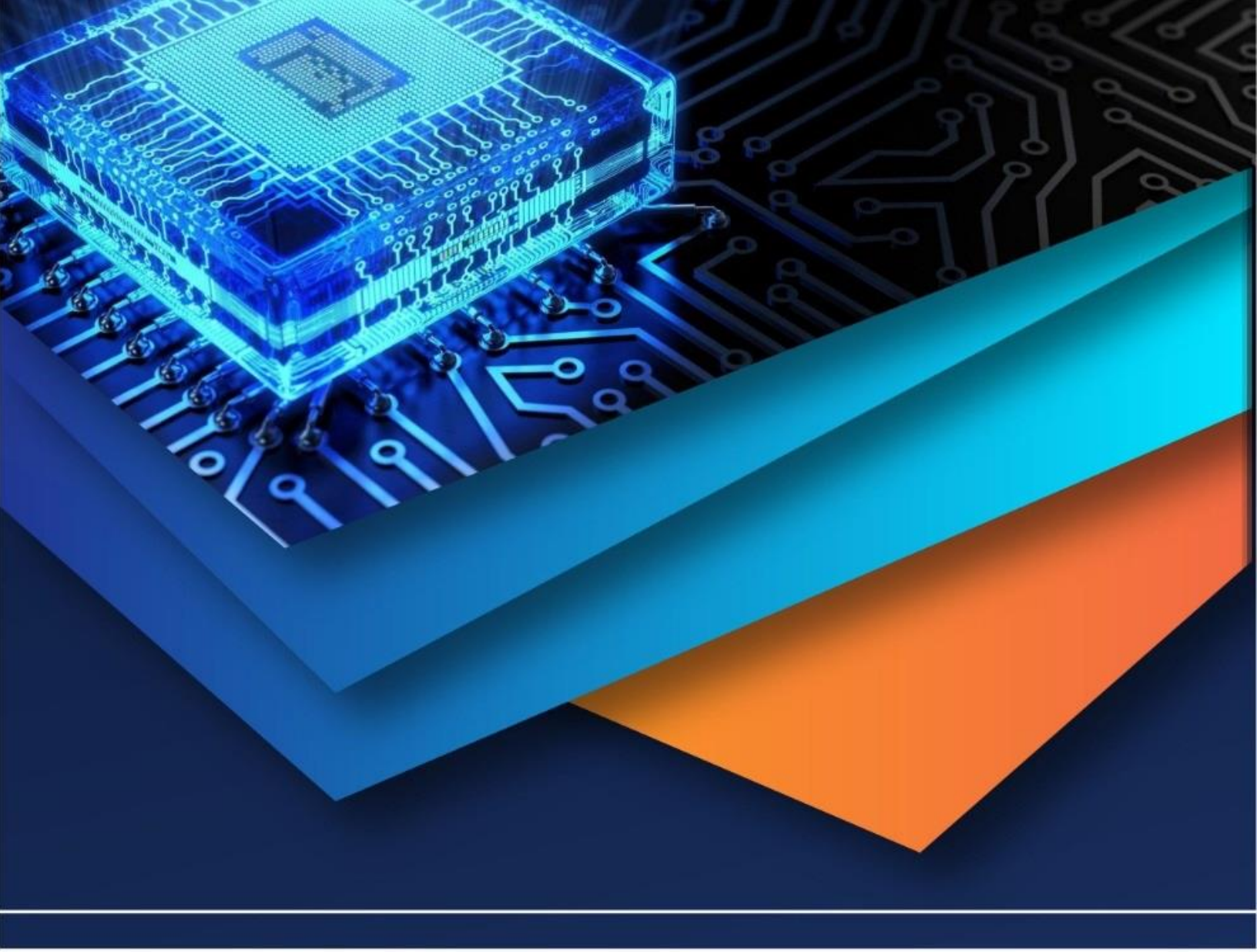

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