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Research paper

A comparative analysis of rectangular cut edge patch antenna on various substrate

Sachidananda Choudhury[1], Veeranki Kalyani[1], R. Sai Teja[1], P. Sreenivasan[1], Sarat K. Kotamraju[2*], K. Ch. Sri Kavya[2]

[1] B.Tech Final Year, Department of ECE, Koneru Lakshmaiah Educational Foundation ,Guntur Dist., Andhra Pradesh, India
[2]Professor, Department of ECE, Koneru Lakshmaiah Educational Foundation,Guntur Dist., Andhra Pradesh, India
**Corresponding author E-mail: kksarat@gmail.com*

Abstract

An analysis of simple microstrip patch antenna has been designed which comprises of various dielectric substrates that is placed in between metallic patch and ground. Substrates used in this design Epoxy (FR4), Rogers duroid 6002 (tm) with various relative permittivity 2.94 and 2.2 and thickness of 3.2mm. Some applications for the designed frequency are wireless fidelity, WLAN application, Bluetooth. The proposed antenna is designed in HFSSV15 Software operating at 2.4 GHz frequency which renders return loss not more than -10dB. The purpose of this paper was analyzation and simulation for the designed antenna with various parameters like gain, peak gain, efficiency, return loss, band-width when the structure and substrate changes.

Keywords: *Bandwidth; Efficiency; Gain; Microstrip patch; Peak gain; Radiation pattern, Return loss.*

1. Introduction

Micro strip radiating element was introduced in the year 1950s. An antenna generally helps in converting an RF signal, conductor that can be travelled through, in free space guided by electromagnetic wave, and vice versa (which means either in receiving mode as well as in transmitting mode also). Antennas mostly depend upon the frequency. Whenever we need to radiate or receive electromagnetic wave we can use antenna. There are various shapes and structure that an antenna can be designed, but the basic principle of operation is electromagnetic. Various portable electronic devices require an actual and effectual antenna for wireless communication. Developments in digital and wireless microchip technology have led to the manufacture of an innovative type of subjective communications equipment affectation unusual problems for antenna designers. Peculiar wireless communication policies have created a bigger request for compressed antennas. Moreover, the development of wireless local area networks at work and home has also demanded the claim for radiating element that is compressed as well as low-cost.

Till date microstrip patch antenna is the maximum successful antenna. Actually microstrip patch antennas are used in broad range frequencies ranging from 1 GHz to 100 GHz. Micro strip patch antenna is planar but it also suitable for non-planar geometries, components are easily integrated, robustness mechanically, association of arrays. The main advantages of microstrip patch antennas are its light weight and low profile, due to these reasons they can be built easily and also the fabrication costs low[13-18]. In parallel there are also disadvantages like inherent narrow bandwidth and low efficiency. The drawbacks of micro strip antennas are overcome by developing the techniques to increase the bandwidth and a very wideband micro strip antennas are presented.

The applications of micro strip antennas are many in number and military applications and commercial applications such as radar, biomedicines, satellite communications, mobile applications, wireless area network, ultra-wide band application and identification of radio frequency.

We generally consider rectangular microstrip patch antenna as the maximum likely antenna that can be required for designing microstrip patch antennas that contains dimension like length and breadth with letter L and B respectively. We can use various types of substrate based on our requirement. The various Substrate used in this paper is FR4 Epoxy with relative permittivity = 4.4, Rogers duroid 5880 (tm), relative permittivity = 2.2 and Rogers RT/duroid 6002 (tm) relative permittivity = 2.94. The substrate is placed in between the ground plane and the patch.

The remaining part of the paper is ordered as follows: where section 2 is on design topology of an antenna. The simulation results of a designed antenna are represented in section 3. Finally, paper is concluded with conclusion and future scope with section 4 and section 5 respectively.

2. Design Topology

The Antenna designed in this paper is printed by three layers, top one is patch which is placed on a substrate and then followed by ground plane. Coaxial feed is given for the designed micro strip patch antenna. The internal conductor is prolongs transversely to the dielectric and is associated at the radiating component, while the external conductor of a coaxial connector attached at ground plane. Fig.1 shows the feeding technique used in this paper.

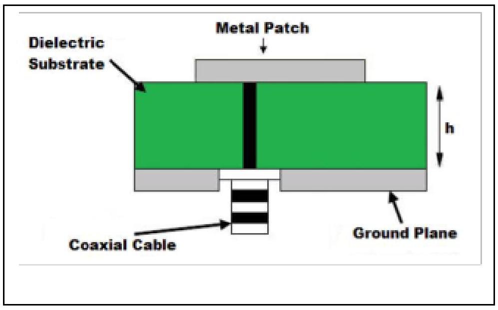

Fig. 1 Coaxial probe feed

But this turn outs a narrow bandwidth and modelling is difficult which is a disadvantage for this technique. Various Substrate were used for the designed such as substrate material like FR-4, Roger RT.

Table 1: Substrate and its Relative Permittivity

Substrate Material	Relative Permittivity
FR4 EXPROXY	4.4
Rogers RT/duroid 5880 (tm)	2.2
Rogers RT/duroid 6002 (tm)	2.94

In the Fig.2, it shows the designed antenna from the top view, Fig. 3 shows the designed antenna from the top view having some cutting edges, Fig.4 shows the side view of the designed antenna. The antenna is fabricated on 100 X 90 mm2 and all the substrate with thickness of 3.2mm. A simple patch antenna is placed on the substrate(Roger Rogers RT/duroid 5880 (tm)) where the coaxial feed position is at (-5,0,-5) named as Antenna 1, patch but with feed position is changed to (-5,5,-5) named as Antenna 2, patch with some cutting edges and coaxial feed position at (-5,0,-5) named as antenna 3, patch with some cutting edges and coaxial feed position at (-5,5,-5) named as antenna 4. Now the substrate used is FR4 Epoxy and patch placed on it at feed position (-5,0,-5) is named as Antenna 5, patch but with feed position changed to (-5,5,-5) named as Antenna 6, patch with some cutting edges and feed position at (-5,0,-5) named as antenna 7, patch with some cutting edges and feed position at (-5,5,-5) named as antenna 8. Another Substrate Rogers RT/duroid 6002 (tm) and the patch placed on it at coaxial feed position (-5,0,-5) is named as Antenna 9, patch but feed position is changed to (-5,5,-5) named as Antenna 10, patch with some cutting edges and feed position at (-5,0,-5) named as antenna 11, patch with some cutting edges and feed position at (-5,5,-5) named as antenna 12.

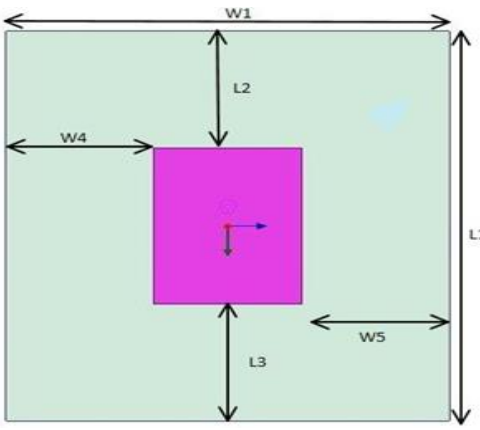

Fig. 2: Designed antenna from top view

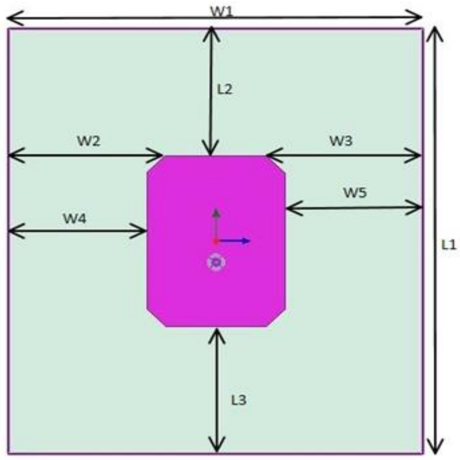

Fig. 3: Designed antenna with cutting edges from top view

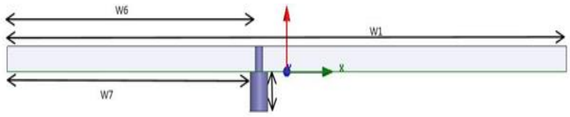

Fig.4: Designed antenna from side view

Table 2: Dimensions for designed antenna

	Dimensions in mm	
W1	W2	W3
90	34	34
W4	W5	W6
30	30	45
W7	L1	L2=L3
43.5	100	30

3. Results and Discussion

3.1 Return Loss

It is the power loss when the signal is reverted by transmission lines discontinuity. Its relation is based on reflection coefficient and standing wave ratio (SWR). We can express return loss in form of, RL= -20 log [L]

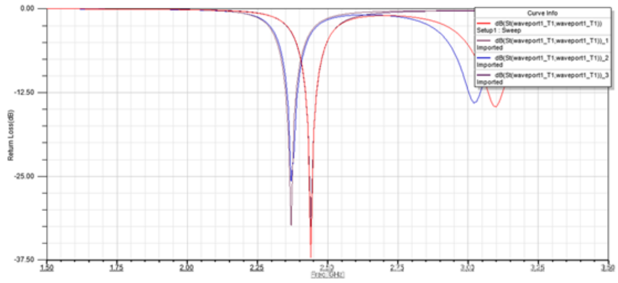

Fig. 5: Return loss for microstrip patch antenna (Roger RT/duroid 5880 (tm))

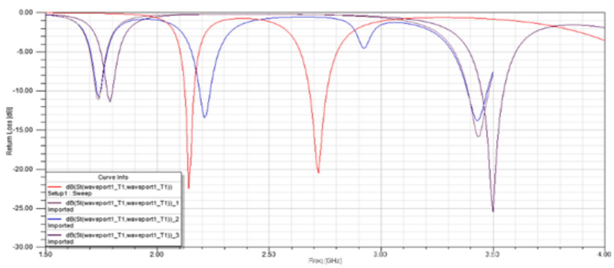

Fig. 6: Return loss for microstrip patch antenna (FR4 Epoxy)

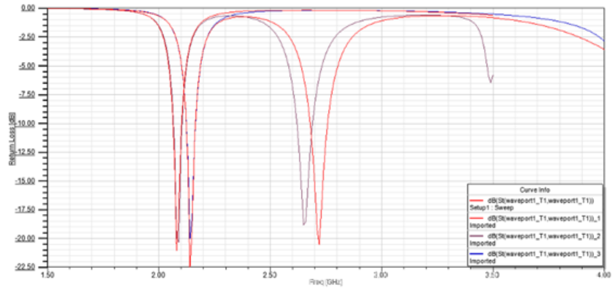

Fig. 7: Return loss for microstrip patch antenna (Roger RT/duroid 6002 (tm))

3.2 Gain

Gain is defined as the ratio of radiation field intensity of test antenna to that of the reference antenna.

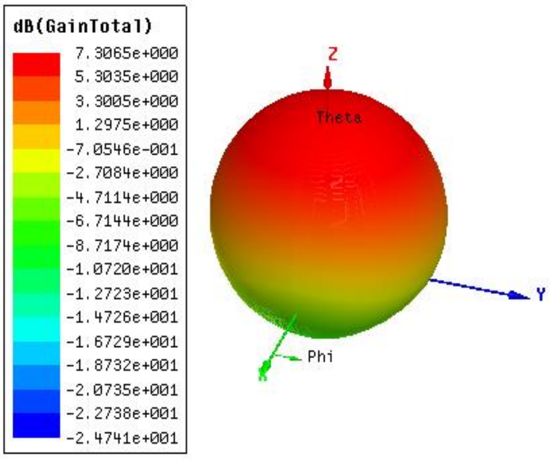

Fig: 8: Gain for Antenna 1

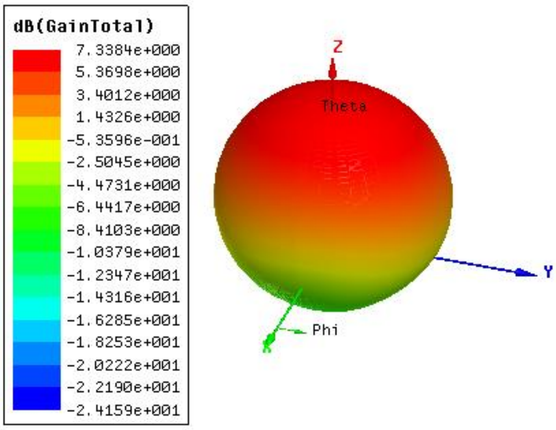

Fig: 9: Gain for Antenna 2

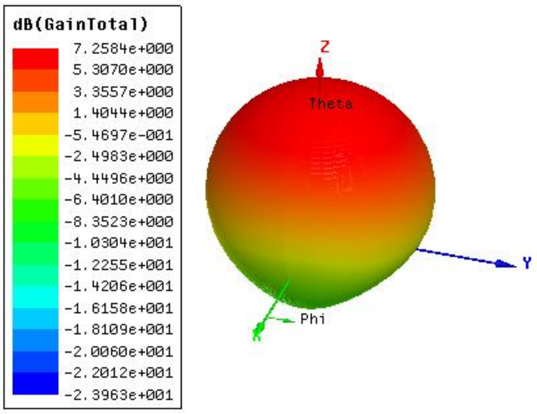

Fig: 10: Gain for Antenna 3

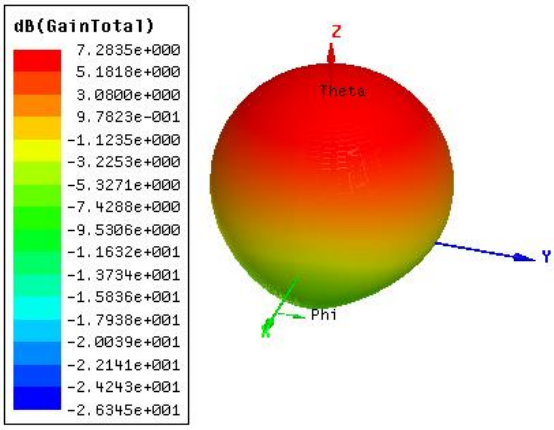

Fig: 11: Gain for Antenna 4

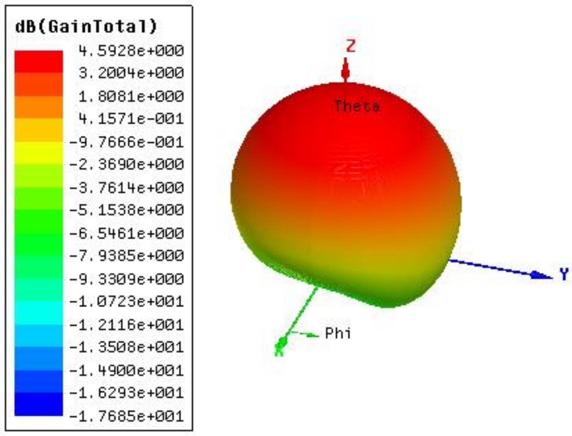

Fig: 12: Gain for Antenna 5

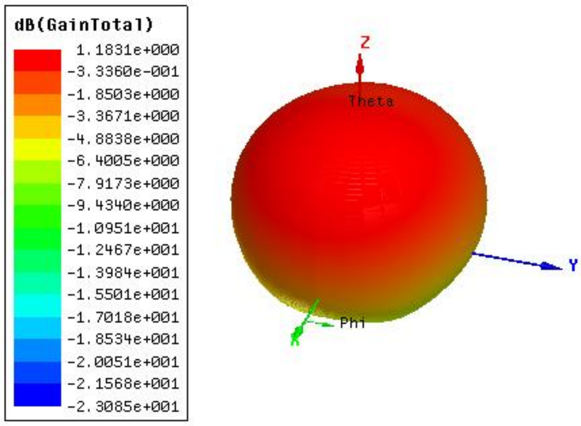

Fig: 13: Gain for Antenna 6

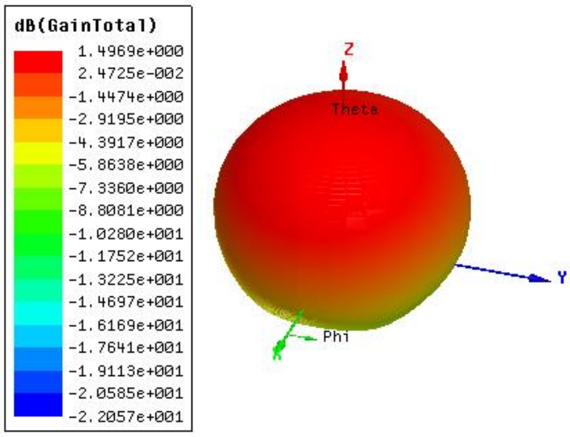

Fig: 14: Gain for Antenna 7

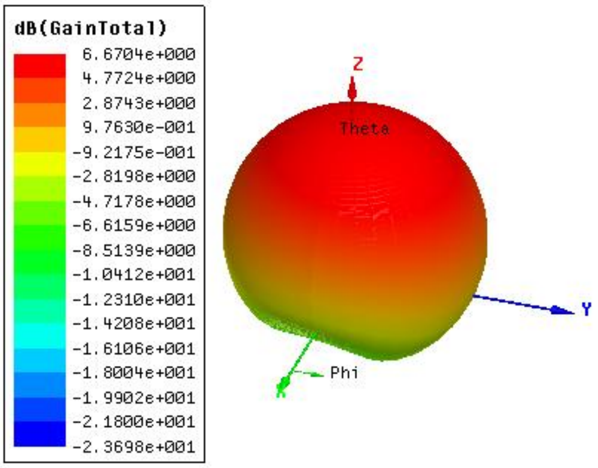

Fig: 15: Gain for Antenna 8

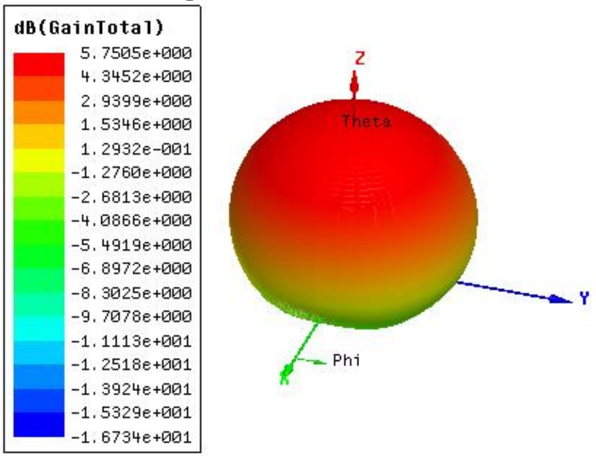

Fig: 16: Gain for Antenna 9

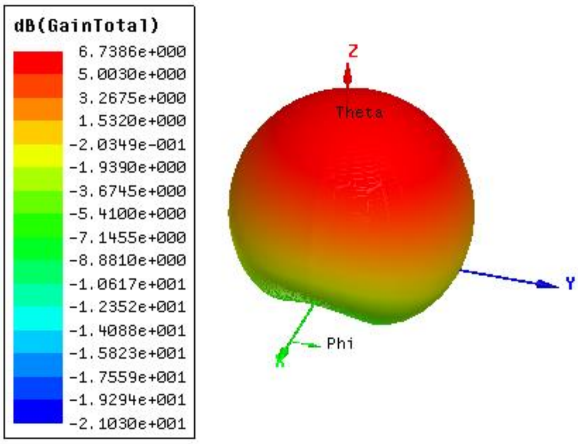

Fig: 17: Gain for Antenna 10

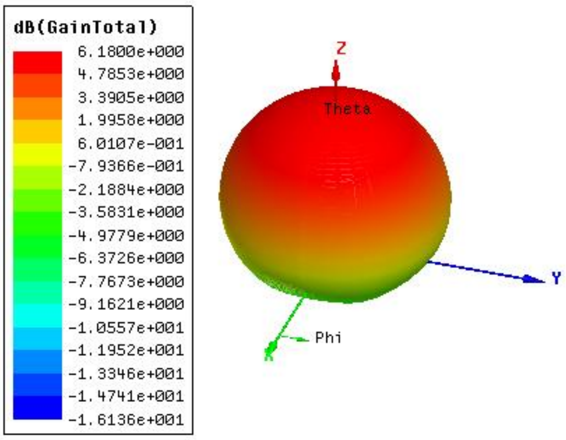

Fig: 18: Gain for Antenna 11

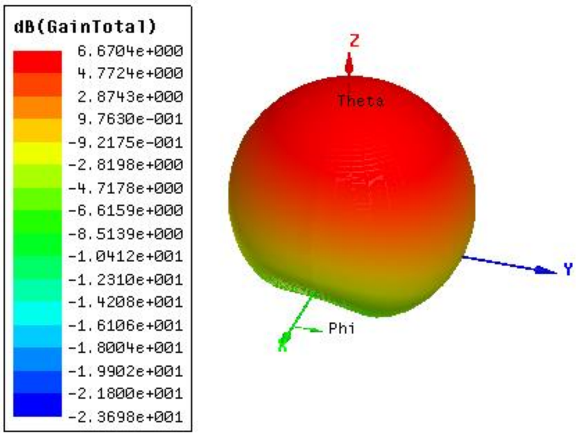

Fig: 19: Gain for Antenna 12

3.3 Radiation Pattern

The graphical representation of the electromagnetic power distribution in free space is defined as Radiation pattern.

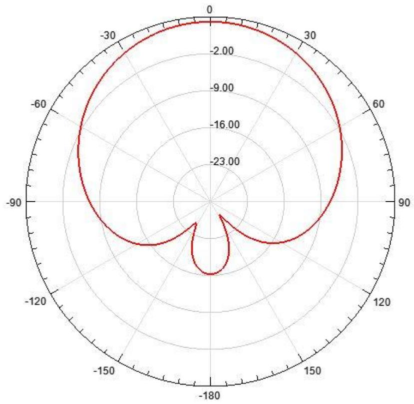

Fig: 20: Radiation Pattern for Antenna 1

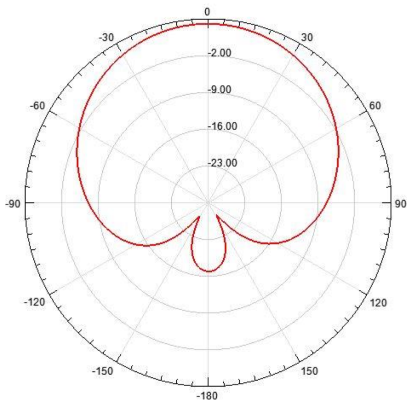

Fig: 21: Radiation Pattern for Antenna 2

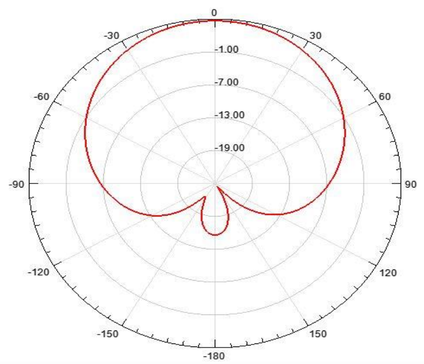

Fig: 22: Radiation Pattern for Antenna 3

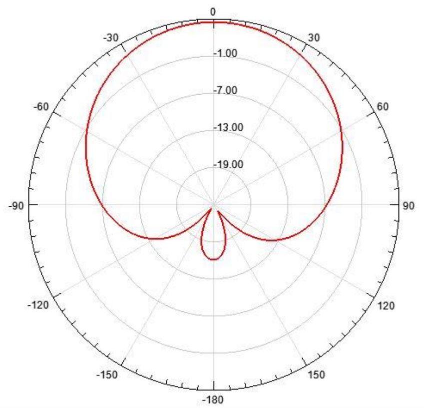

Fig: 23: Radiation Pattern for Antenna 4

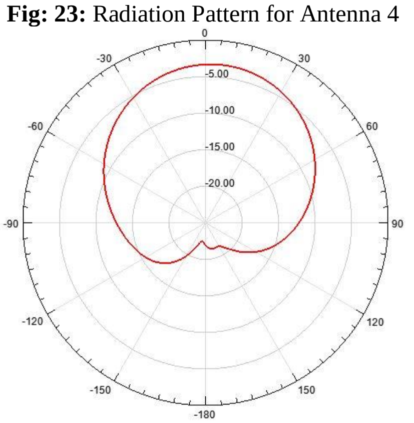

Fig: 24: Radiation Pattern for Antenna 5

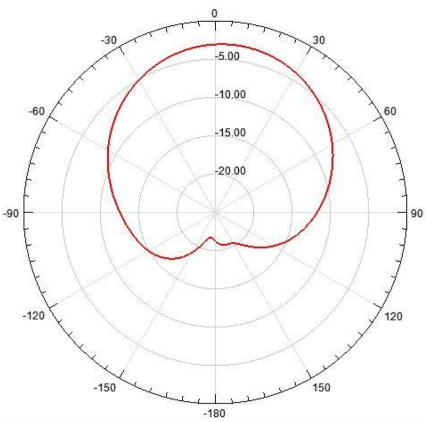

Fig: 25: Radiation Pattern for Antenna 6

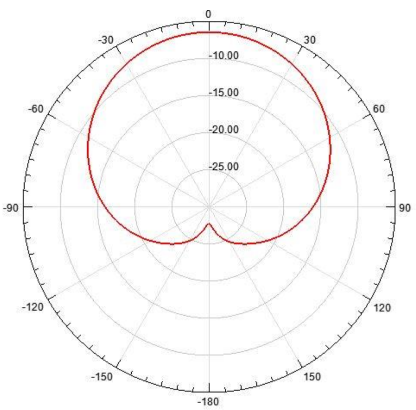

Fig: 26: Radiation Pattern for Antenna 7

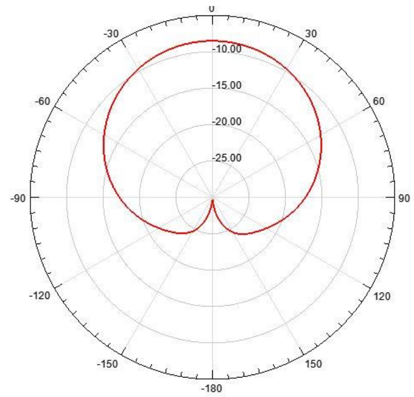

Fig: 27: Radiation Pattern for Antenna 8

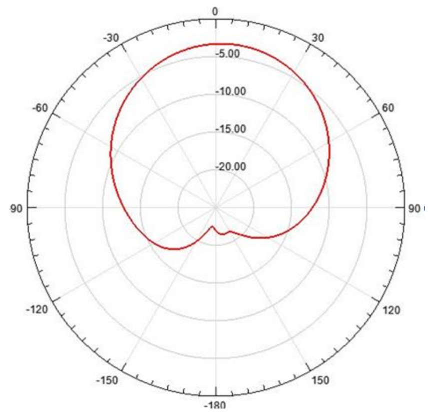

Fig: 27: Radiation Pattern for Antenna 9

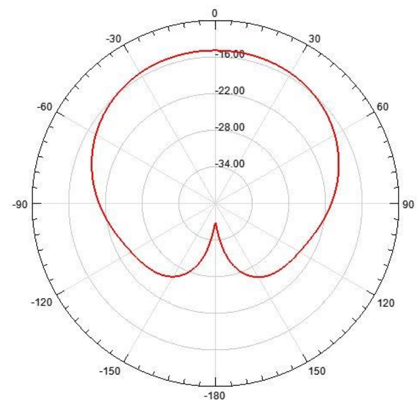

Fig: 28: Radiation Pattern for Antenna 10

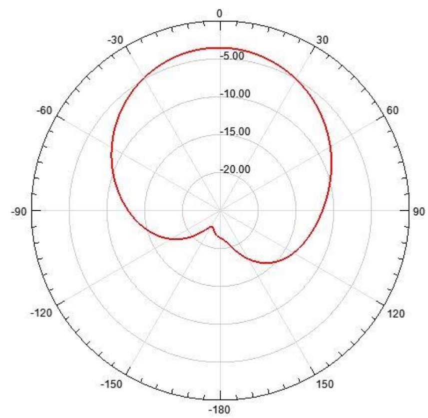

Fig: 29: Radiation Pattern for Antenna 11

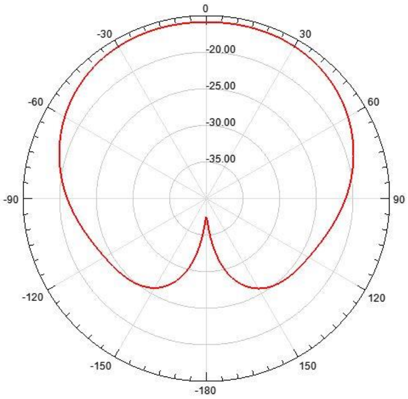

Fig: 30: Radiation Pattern for Antenna 12

4. Comparative Analysis

All models that are designed are compared along with their characteristics and has been presented. Actually, if it is seen, four antenna models are designed with three substrates each. The substrates that are used to design the four antenna types are as follows; (1) Rogers RT/duroid 5880 (tm) with Relative permittivity of 2.2, (2) FR4 EPOXY with relative Permittivity of 4.4, (3) Rogers RT/duroid 5880 (tm) with Relative permittivity of 2.94.

In table 3, four models designed using the substrate Rogers RT/duroid 5880 (tm) has an average gain of 7 dB and efficiency of 98.percent has been noticed in the proposed models. The applications of the proposed models are for industrial, scientific and medical radio bands, and Wi-Fi.

Substrate	Model Type	Operating Frequency(GHz)	Return Loss	Band width (-10dB) GHz	Gain	Efficiency	Peak Gain
Rogers RT/duroid 5880 (tm) Permittivity =2.2	Antenna1 (-5, 0, -5)	2.37	-32.401	0.0505	7.3065	0.98406	5.3282
	Antenna2 (-5, 5, -5)	2.37	-25.7983	0.0497	7.3384	0.98758	5.3599
	Antenna3 (-5, 0, -5)	2.44	-32.4827	0.55	7.2584	0.9826	5.4468
	Antenna4 (-5, 5, -5)	2.44	-37.0901	0.0541	7.2835	0.98926	5.4785

Substrate	Model Type	Operating Frequency(GHz)	Return Loss	Bandwidth (-10dB) GHz	Gain	Efficiency	Peak Gain
FR4 EPOXY Permittivity =4.4	Antenna1 (-5, 0, -5)	3.43	-15.891	0.0941	1.1831	0.43725, 0.66836	1.4298, 3.4779
	Antenna2 (-5, 5, -5)	2.21, 3.43	(-13.4812); (-13.8713)	0.0483, 0.0896	4.5928	0.58784, 0.72252	2.665, 3.7531
	Antenna3 (-5, 0, -5)	1.79, 3.5	(-11.4319); (-25.5499)	0.1001	1.4969	0.45177, 0.64404	1.5456, 3.4837
	Antenna4 (-5, 5, -5)	2.27, 3.49	(-13.9041); (-17.2371)				

Substrate	Model Type	Operating Frequency(GHz)	Return Loss
Rogers RT/duroid 6002 (tm) Permittivity =2.94	Antenna1 (-5, 0, -5)	2.082	-21.0561
	Antenna2 (-5, 5, -5)	2.14	-20.0216
	Antenna3 (-5, 0, -5)	2.09, 2.65	(-20.3314); (-18.8164)
	Antenna4 (-5, 5, -5)	2.14, 2.7200	(-22.5); (-20.5538)

In table 4, four models designed using the substrate FR4 EPOXY has a gain ranging from 1 dB to 4 dB and efficiency ranging from 43.percent to 72 percent has been noticed in the proposed models. The applications of the proposed models are the band 3.4 – 3.55 GHz was allocated for FWA for areas outside the main cities in Canada.

In table 5, four models designed using the substrate Rogers RT/duroid 5880 (tm) has a gain of 6 dB and efficiency of 95 percent has been noticed in the proposed models. The applications of the proposed models are

5. Conclusion

The designed antenna provides a return loss of -32.405dB. The antenna was designed and simulated using HFSS software. As noticed that by increasing the number of slots we could find improvement in the antenna parameters like gain and return loss, with increase in decrease in return loss which was obtained by simulation using HFSS15. Based on the substrate chosen and relative permittivity values, the antenna parameter values varied. We could observe that the antenna designed with lower relative permittivity has better efficiency than the antenna designed with more relative permittivity. Twelve outline of antenna is projected. The first outline is rectangular patch antenna configuration. The second outline is rectangular antenna structure with change in feed position. The third outline is rectangular antenna structure with original feed position and with some cutting edges on the patch. The Fourth outline is rectangular antenna structure with change in feed position and with some cutting edges on the patch. This design outline is repeated with two more substrate and analyzation and simulation is displayed.

Acknowledgements

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