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J. Math. Comput. Sci. 11 (2021), No. 2, 2123-2135

https://doi.org/10.28919/jmcs/5429

ISSN: 1927-5307

DESIGN OF RECTANGULAR C-SLOT PATCH ANTENNA AT 2.95 GHz AND 4.32 GHz FOR NEXT GENERATION NETWORK

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Abstract: A simple patch antenna using microstrip feed at low frequency 2.95 GHz and 4.32 GHz is proposed. This is obtained by cutting C-shaped slot in the rectangular patch part. The dimension of the C-shaped slot is around half-wavelength of the chosen frequencies. This work is meaningful as a commencement investigation level of next generation network applications. It is designed by using low cost, easily available FR-4 substrate with dielectric loss tangent 0.02, relative permittivity 4.4 and height 1.575 mm. The simulation is done using Ansoft HFSS and the radiation performance such as S_{11}, VSWR, Gain, Radiation Efficiency, Radiation Patterns, and Surface Current Distributions are observed step by step and then final design is proposed. Proposed antenna design has impedance BW 21.05%, 68.51%, good Return Loss -45.42 dB, -23.09 dB, VSWR 1.01, 1.15, acceptable total gain 1.27, 1.45 and high radiation efficiency 103.56%, 90.63% at interest of frequency 2.95 GHz and 4.32 GHz respectively for NGN.

Keywords: dielectric constant; microstrip patch antenna (MPA); returns loss (RL); voltage standing wave ratio (VSWR); next generation network (NGN).

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Received January 14, 2021

2010 AMS Subject Classification: 68M10.

1. INTRODUCTION

The recognition of mobile communication systems has extended remarkably at some stage. In the current scenario the mobile communication is incomplete without understanding the antenna [1-2]. As a fundamental phase of these arrangements, antenna is a main element in current mobile communication systems. In ongoing state of affairs of wireless communication system multiband and low profile antennas are utilizes in the industrial and military purposes. An introduction of communication system is imperfect without knowing of the action of the antenna [2]. An antenna plays the key role in cellular gadget because of its smaller size, light weight and most importantly effective [3].

The development and need of society is increases day by day with respect to data traffic which is fulfilled by NGN by time where intelligence is one of the most important parameter [2, 4].

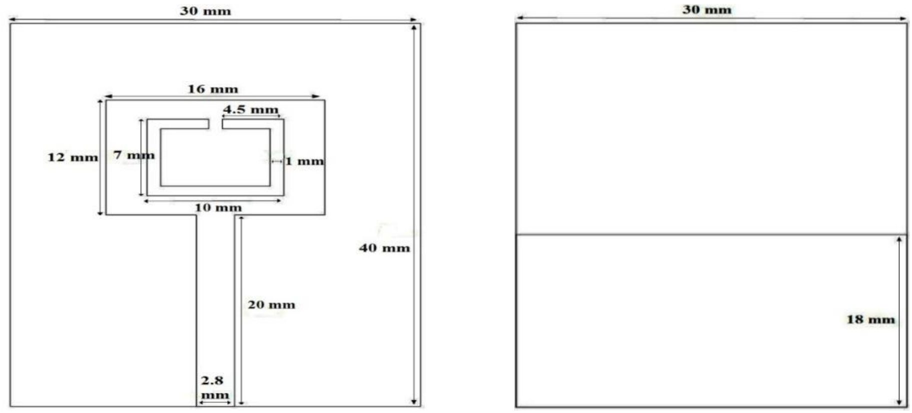
The technological growth in modern era centered our mind status on microstrip patch antenna [2]. MPA has rectangular patch and even circular is also used [3, 5].

Dimension miniaturization of MPA is a challenge in many of the new applications, probably that of Wireless local area networks, Worldwide Interoperability for Microwave Access, mobile cellular handsets, global position satellites and other upcoming wireless terminals [3, 5, 11].

2. DEVELOPMENT OF PROPOSED DESIGN

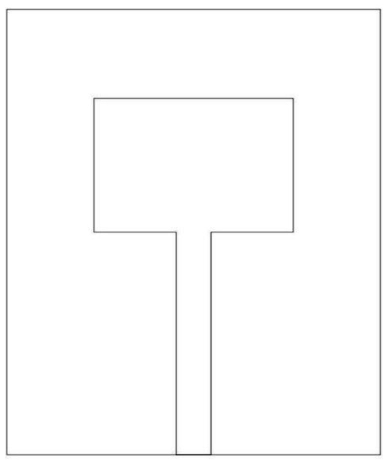
FR-4 dielectric (ε_r= 4.4 and height = 1.575 mm) is used as substrate for proposed antenna. It is showing in figure 1 with optimized value for all parameters with area 40 mm × 30 mm. Proposed antenna consists of C-shaped slot on patch and rectangular ground plane of 18 mm x 30 mm on the other side. A horizontal strip feed-line of dimension 20 mm x 2.8 mm is added. Port dimension is 2.8 mm x 1.575 mm in y-z plane.

To attain sufficient impedance BW, 2 central part formations have been implanted in our proposed design; first is C-shaped slot in patch and the other is a rectangular shaped-strip on ground plane. The dimensions of C-shaped slot are optimized. To check the consequence of adapted structure on design performance, four prototype antennas are defined and shown in figure 2.

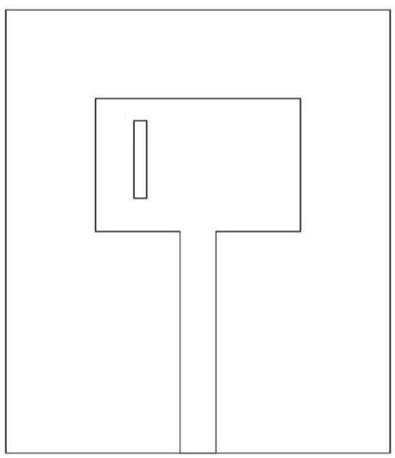


Top View   Bottom View

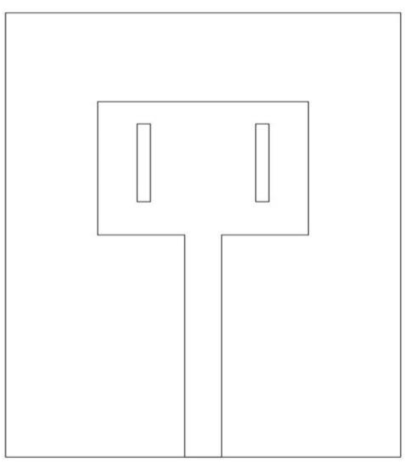
FIGURE 1. Schematic diagrams of the proposed antenna.



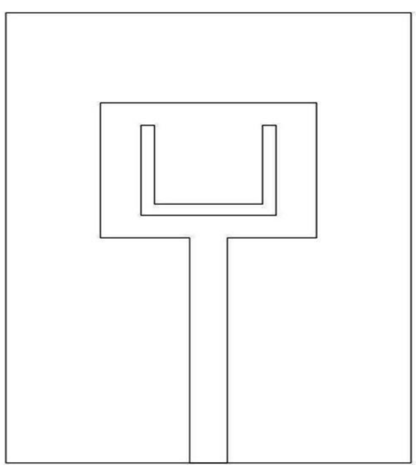
Antenna 1



Antenna 2



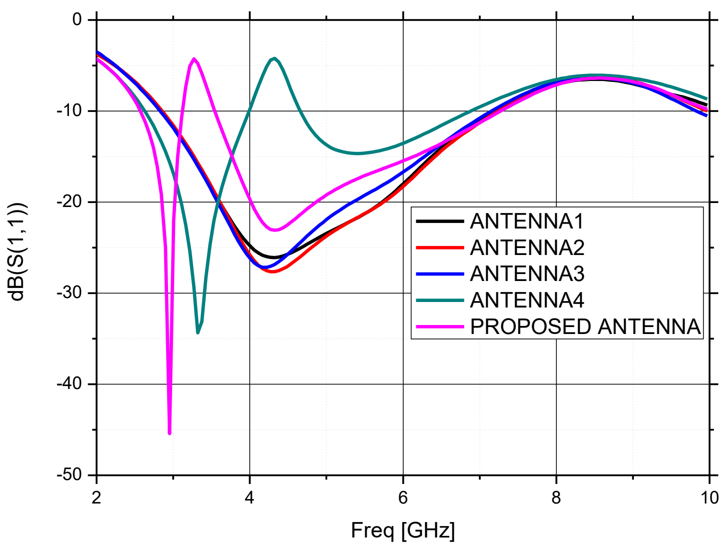
Antenna 3



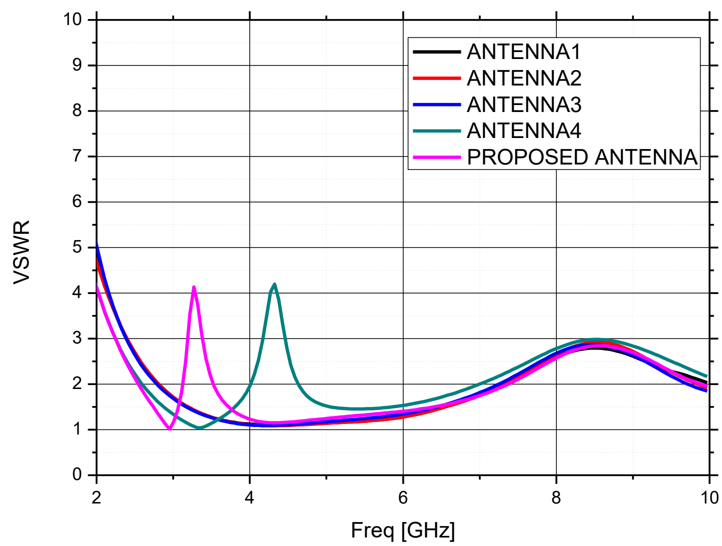
Antenna 4

FIGURE 2. Antenna Prototypes.

Simulated results of S_{11} and VSWR for prototypes and proposed antenna are shown in figure 3. It is observed that the combination of two structures, the C-shaped slot and the rectangular shaped-strip on ground improves impedance BW and other parameters efficiently.



(a)



(b)

FIGURE 3. Simulated Results (a) S_{11}, (b) VSWR, of Antenna 1, Antenna 2, Antenna 3, Antenna 4 and Proposed Antenna

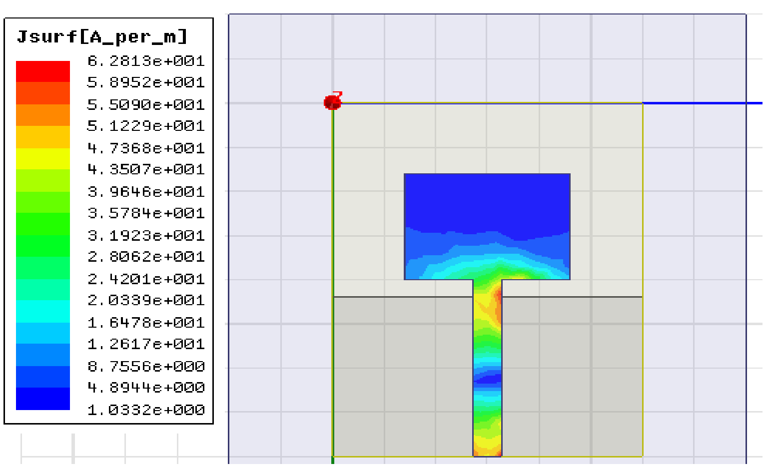
Impedance bandwidth results for antenna 1, antenna 2, and antenna 3 are in increasing order as 86.51% (2.84-7.17 GHz), 86.79% (2.85-7.22 GHz) and 87.14% (2.81-7.15 GHz) respectively with resonating frequency 4.32 GHz. Return loss (S_{11}) is -26.08 dB, -27.63 dB and -26.83 dB respectively for each antenna. VSWR for these prototypes are lies in between 1 and 2 as required. From figure 2 it is very clear that antenna 1 is a simple patch antenna with dimension 12 mm x 16 mm, while antenna 2 has one rectangular strip at left end and antenna 3 has two rectangular strips on both ends of 7 mm x 1 mm.

Introducing one more slot of 1 mm x 10 mm (open rectangle from one side) in antenna 4 shifts the resonant frequency at 3.32 GHz and 5.37 GHz and gives dual band with impedance BW 41.94% (2.6-3.98 GHz) and 38.43% (4.65-6.86 GHz). S_{11} and VSWR are good and acceptable in this range. The value for S_{11} is -34.36 dB, -14.65 dB and VSWR is 1.03, 1.45 at 3.32 GHz and 5.37 GHz respectively.

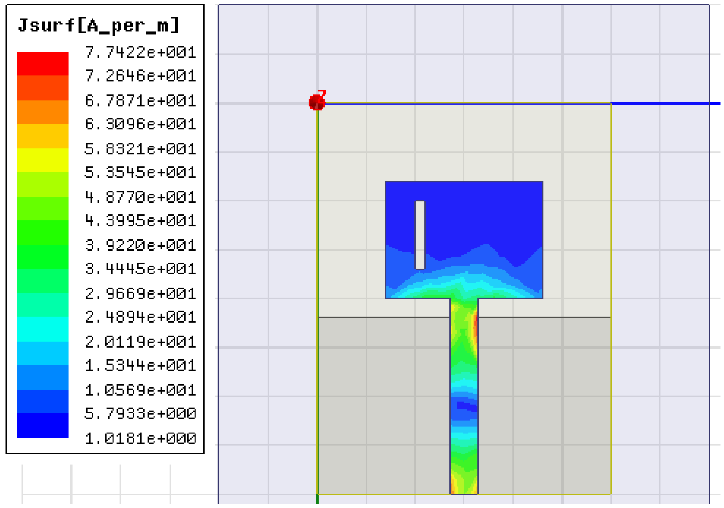
Adding two more slots of 1 mm x 4.5 mm in open end rectangle slot provide our final proposed antenna with C-shaped slot which is shown in figure 1. Impedance BW is 21.05% (2.55-3.15 GHz), 68.51% (3.55-7.25 GHz) with -10 dB S_{11}, i.e. -45.42 dB, -23.09 dB and required VSWR 1.03, and 1.45 at our interest of frequency i.e. 2.95 GHz and 4.32 GHz respectively.

3. ANALYSIS OF SURFACE CURRENT DISTRIBUTIONS

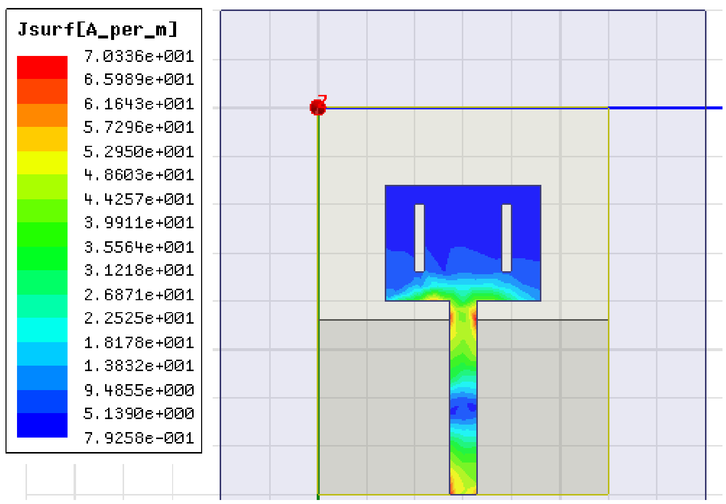
We have proposed our final design by using four prototypes and observed that it may be suitable for NGN applications. The surface current distributions for all prototype and proposed antenna at angle phi = 0° is shown in figure 4.



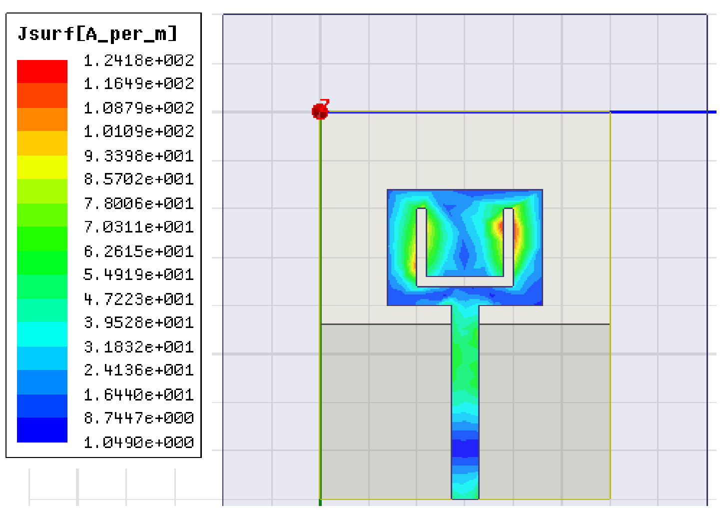
(a)


Jsurf[A_per_m]
7.7422e+001
7.2646e+001
6.7871e+001
6.3096e+001
5.8321e+001
5.3545e+001
4.8770e+001
4.3995e+001
3.9220e+001
3.4445e+001
2.9669e+001
2.4894e+001
2.0119e+001
1.5344e+001
1.0569e+001
5.7933e+000
1.0181e+000

(b)


Jsurf[A_per_m]
7.0336e+001
6.5989e+001
6.1643e+001
5.7296e+001
5.2950e+001
4.8603e+001
4.4257e+001
3.9911e+001
3.5564e+001
3.1218e+001
2.6871e+001
2.2525e+001
1.8178e+001
1.3832e+001
9.4855e+000
5.1390e+000
7.9258e-001

(c)


Jsurf[A_per_m]
1.2418e+002
1.1649e+002
1.0879e+002
1.0109e+002
9.3398e+001
8.5702e+001
7.8006e+001
7.0311e+001
6.2615e+001
5.4919e+001
4.7223e+001
3.9528e+001
3.1832e+001
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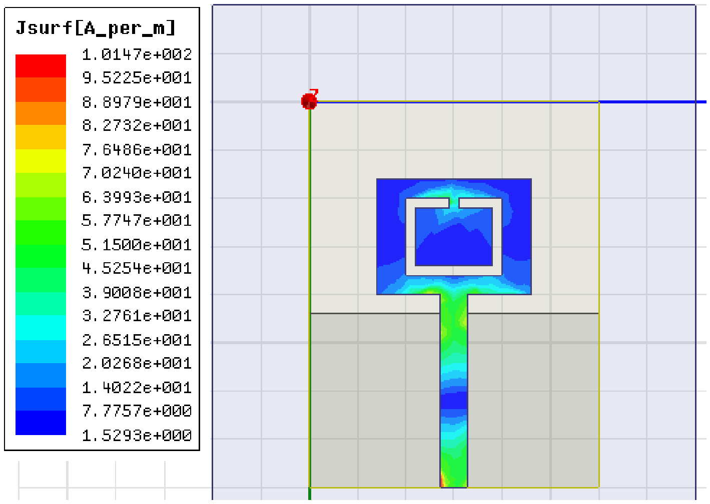
1.6440e+001
8.7447e+000
1.0490e+000

(d)

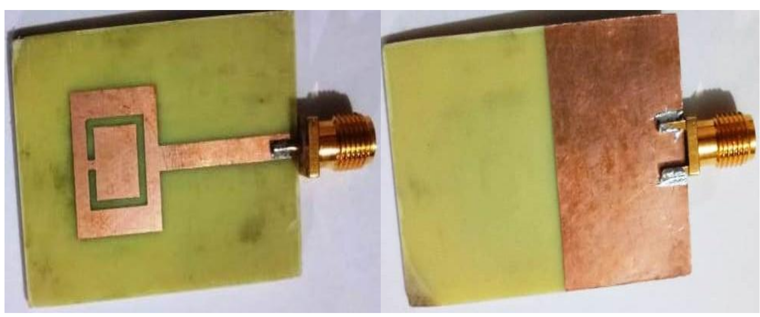


(e)

FIGURE 4. Surface Current Distributions in (a) Antenna 1, (b) Antenna 2, (c) Antenna 3, (d) Antenna 4, and (e) Proposed Antenna

4. RESULTS AND DISCUSSIONS

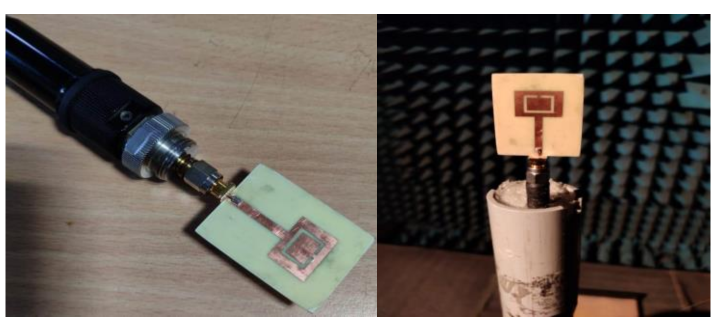
Figure 5 shows the fabricated proposed antenna.



Top View　　　　Bottom View

FIGURE 5. Schematic diagrams of the fabricated proposed antenna.

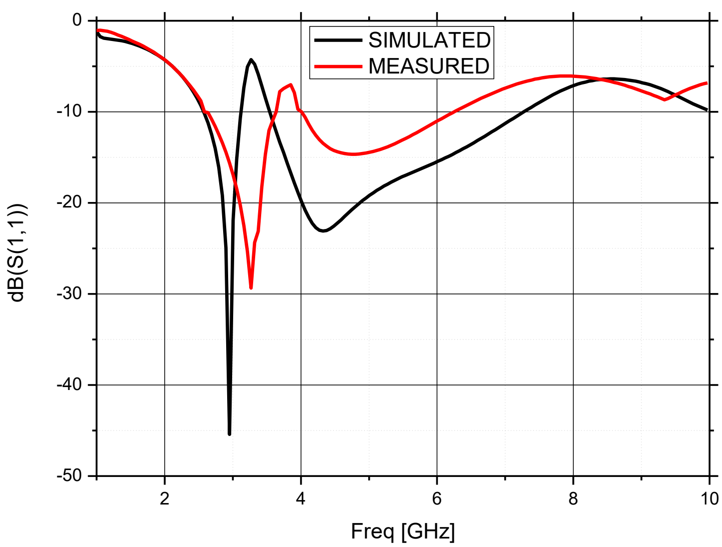
Figure 6 shows the measurements of proposed antenna for validation of our work.



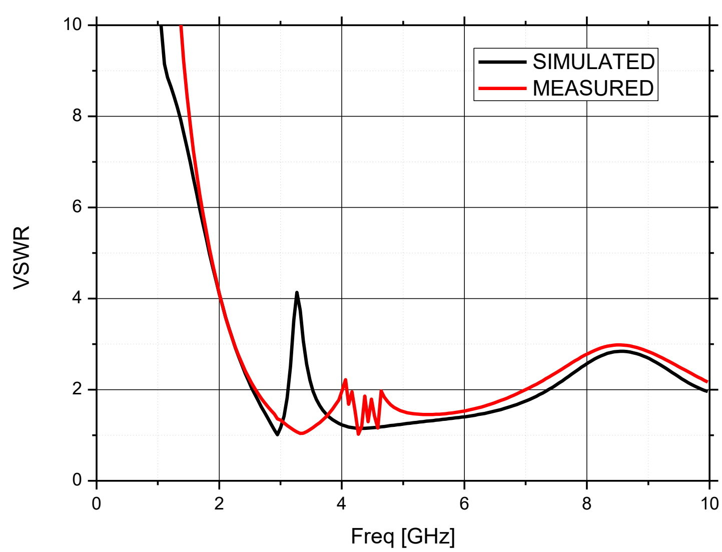
VNA Measurements　　　　Anechoic Chamber Measurements

FIGURE 6. Measurements of proposed antenna.

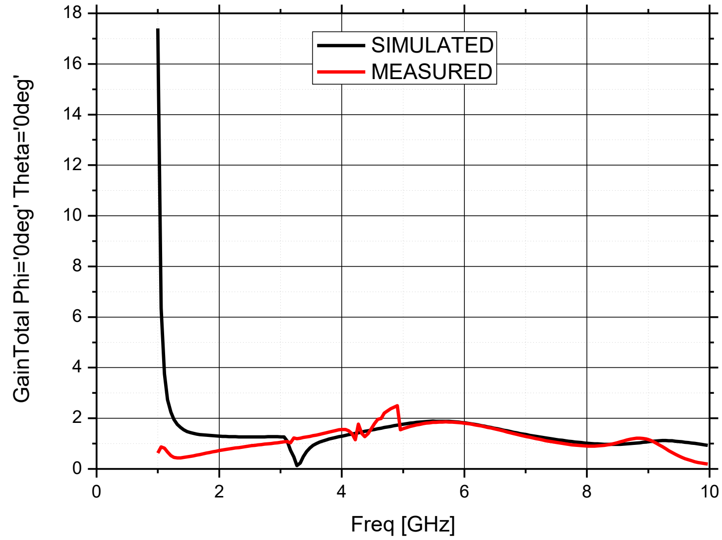
Figure 7 shows the S_{11}, VSWR, Gain Total, Radiation efficiency, and radiation patterns plots for simulated and measured proposed antenna. In which we can find that the value of experimental and simulated results are approximately matches. A little difference is observed between simulated and measured results and this is known as fabrication tolerances.



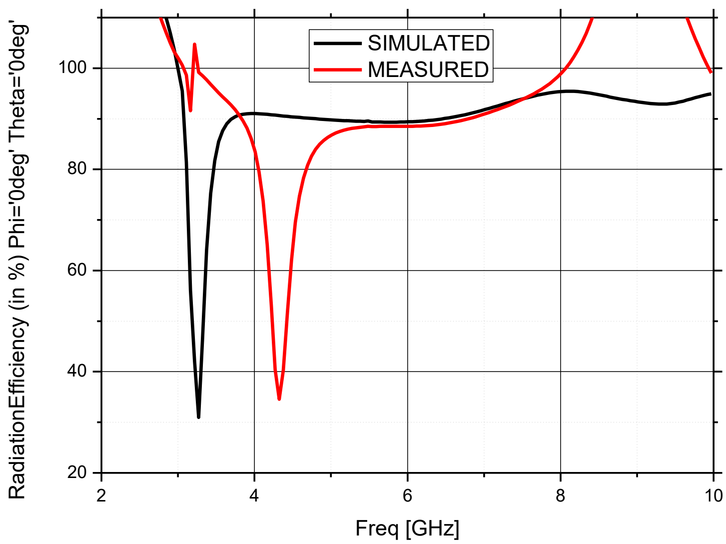
(a)



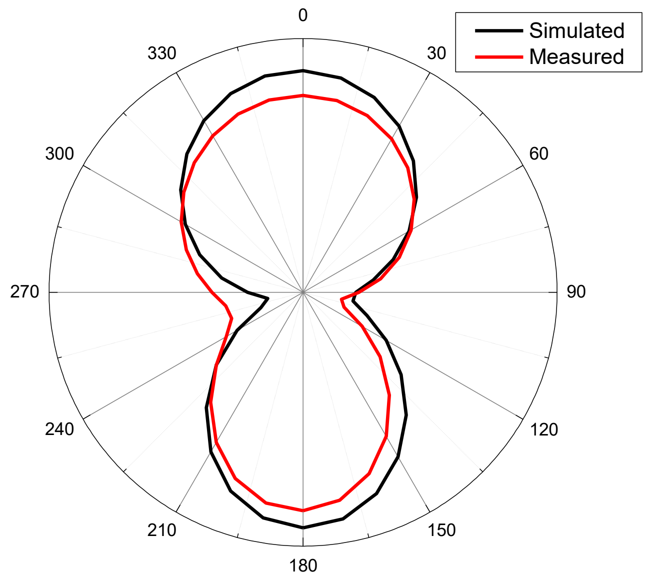
(b)


SIMULATED
MEASURED
GainTotal Phi='0deg' Theta='0deg'
Freq [GHz]
0
2
4
6
8
10
12
14
16
18

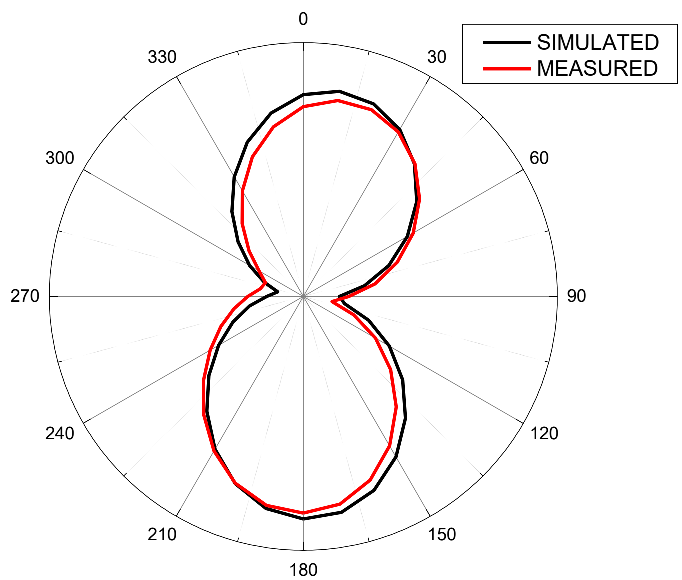
(c)


SIMULATED
MEASURED
RadiationEfficiency (in %) Phi='0deg' Theta='0deg'
Freq [GHz]
20
40
60
80
100
2
4
6
8
10

(d)



(e)



(f)

FIGURE 7. Simulated and measured results for Proposed Antenna (a) S_{11}, (b) VSWR, (c) Gain Total, (d) Radiation Efficiency, (e) Radiation Pattern at 2.95 GHz at phi = 0°, and (f) Radiation Pattern at 4.32 GHz at phi = 0°.

A comparative analysis of simulated and fabricated antenna is shown in Table 1.

TABLE 1. Comparison of Simulated and Fabricated Antenna.

Antenna Parameters	Outcomes			
	Simulated		Measured	
Band (GHz)	2.55-3.15	3.55-7.25	2.58-3.63	4.00-6.22
RF (GHz)	2.95	4.32	3.26	4.74
%BW	21.05%	68.51%	33.81%	43.44%
S_{11} (dB)	-45.42	-23.09	-29.36	-14.65
VSWR	1.03	1.45	1.07	1.74
Gain Total	1.27	1.45	1.19	2.29
Radiation Efficiency (%)	103.56%	90.63%	99.18%	82.61%

A comparative analysis with existing designs is shown in Table 2.

TABLE 2. Comparative Analysis with Existing Design.

Ref. Paper	Feed Method	Impedance BW (%)	Antenna Size (in mm^3)	RF (GHz)	S_{11} (dB)	BW (GHz)	VSWR	Gain Total
[7]	Microstrip Line Feeding	26.7%, 11.3%	80x80x1.52	1.5, 2.59	-20.10, -21.25	0.38, 0.29	1~2	3.31, 4.2
[8]	CPW Feeding	8.7%, 23%	70x70x1.6	1.6, 2.2	-17.5, 24.5	1.09, 0.51	1~2	2.40, 2.48
[9]	Microstrip Line Feeding	18.2%, 18.4%	100x100x1.57	1.58, 2.66	-28.89, -27.52	0.28, 0.48	1~2	2.11, 2.23
[10]	Microstrip Line Feeding	13.8%, 9.7%	40x40x1	2.38, 4.43	-22.2, -36.5	2.38, 4.43	1~2	2.23, 1.99
Proposed design	Microstrip Line Feeding	21.05%, 68.51%	40x30x1.575	2.95, 4.32	-45.42, -23.09	0.6, 3.7	1.01, 1.15	1.27, 1.45

5. CONCLUSIONS

A simple patch antenna using microstrip feed at low frequency 2.95 GHz and 4.32 GHz is proposed. The radiation performance such as S_{11}, VSWR, Total Gain, Radiation Pattern, Radiation Efficiency and Surface Current Distribution are observed and validated experimentally. Our design may be useful for the next generation network applications. This work will be further extended by doing some modifications in patch and ground structure. Gain may be improved for more exposure by decreasing the dielectric value and loss tangency.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

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