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Multiband Metamaterial Antenna with Omega Shaped SRR Structure for Wireless Communication

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ABSTRACT

In this paper, a novel circular patch antenna for wireless communication with omega-shaped SRR has been fabricated and tested. The antenna is fed by microstrip line feeding technique and expends on FR4 epoxy dielectric substrate with the total thickness of 1.58mm and the dimension of 24. 5mm×30mm.The proposed antenna shows that there are wide ranges of multi-bands from 1.4-7.6GHz, 9-11GHz, 11.6-15.15GHz and 15.5-17.6GHz with corresponding bandwidths of 6.2GHz, 2.4GHz, 3.65GHz and 2.1GHz, respectively. The peak gain of the proposed antenna is 11.5dB at 17GHz.

Key words: Metamaterial, split ring resonator (SRR), CPW Fed

INTRODUCTION

Metamaterials offer a very wide range of exciting physical phenomena to be observed, which are not found with natural materials. Artificial magnetism is one of these exotic electromagnetic properties. Metamaterials are known as artificial materials having negative permittivity, negative permeability or both negative[1-2]. For such values of the formative parameters the material offers masterly properties of the antenna especially for coplanar waveguide[3]. Resonant magnetic response can be achieved from the periodic arrangement of non-magnetic inclusions[3],[5]. These inclusions can be designed as electrically small resonators with distributed capacitive and inductive elements[4]. The best example of this type of metamaterial structure is a split ring resonator (SRR)[5]. There are different types of metamaterial structures present which give negative value of the permittivity and permeability[6]. The metamaterial structures are used to increase the performance of miniaturized i.e. electrically small antenna system[7-10]. Metamaterial antenna incorporates specially engineered microscopic structures and shapes to produce a different or unusual physical properties rather than conventional antennas[11-12]. Using the metamaterial structure in antenna designing, it's step-up the antenna's radiation behaviour[11-12],[14]. To print these metamaterial structure elements on a PC board, many techniques are used in which lithography technique is very famous in antenna fabrication [6] due to fine structure fabrication.

PROPOSED ANTENNA DESIGN

Fig.1 shows the design of proposed antenna along with the parameters symbols whose chosen values are depicted in table 1. The proposed antenna is fabricated on FR-4 substrate of relative permittivity of 4.4. Initially a simple microstrip patch antenna with circular patch designed by transmission line model. Gain of antenna was slightly increased by designing partial ground. The antenna consists of omega shaped structure along with metamaterial structure (SRR) on the circular patch fed by coplanar microstrip line feed. For the calculation of ε and μ values, Nicolson-Ross-Weir Method (NWR)[13] is used. Partial ground plane has been used on either side of this feed [15]. The inside corners of the ground plane portion have been made curved that enhanced the S_{11} (return loss) characteristic of the antenna.

In the circular patch, a slot is created which is hexagon shaped SRR structure gives wider bandwidth of the antenna. SRR behave like an artificial dipole which is magnetic in nature, gap present in between hexagon behaves like a capacitor and the metal behave like an inductor. These capacitor and inductor produces an LC resonant circuit. The proposed antenna has an overall size of 24.5mm×30mm×1.55mm. The antenna setup frequency has been set at 6.6

GHz. Two omega shaped SRR structures with rectangular slots are used to enhance the gain. Fig. 2 depicts the fabricated view of proposed antenna. The proposed design is fabricated on FR4 substrate using the photolithography method. SMA connector is used to excite the antenna and the antenna is tested on a PNA (precision network analyser) through probe for the measurement of S_{11}.The radiation pattern is measured in an anechoic chamber with horn antenna as reference. The measured results are then compared with simulated results.

Table -1 Design Parameters of Proposed Antenna

Parameter	Length(mm)	Parameter	Length(mm)
L	24.5	f	13.5
W	30	g	0.5
a	10.14	h	9
b	7	r_1	7
c	1.7	r_2	4
d	5	r_3	3
E	3	r_4	1.5

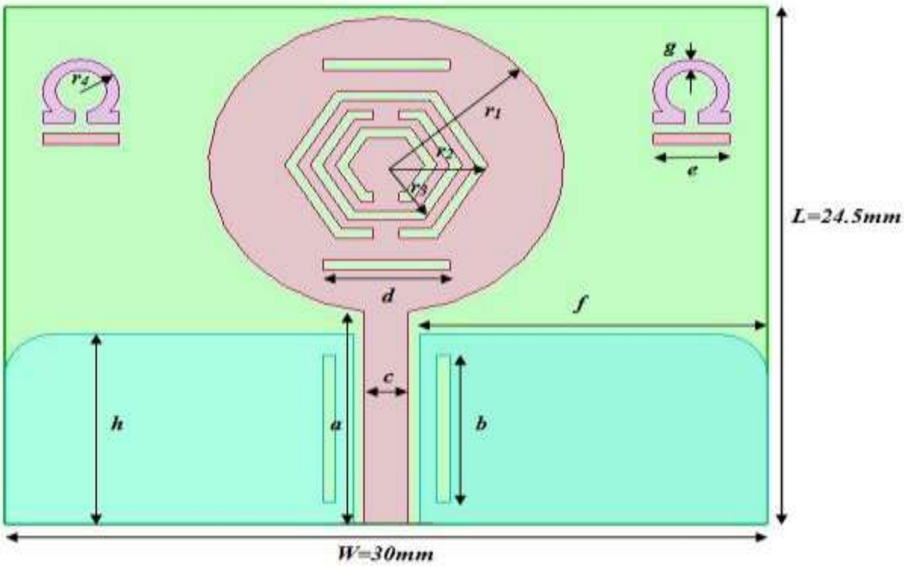


Fig.1 Design of proposed antenna

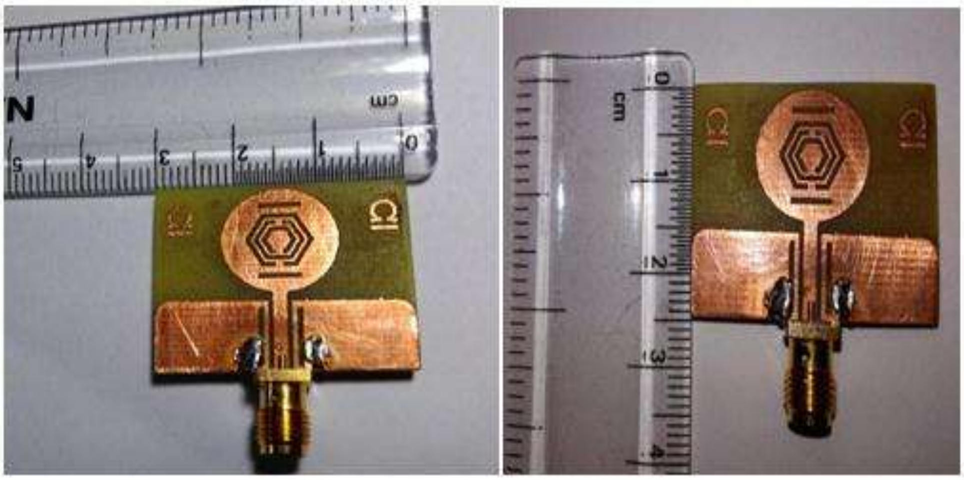


Fig.2 Fabricated view of proposed antenna

RESULTS AND DISCUSSION

The proposed antenna is simulated at the setup frequency of 6.6 GHz. Fig.3 shows the comparison between the simulated and fabricated values of S_{11}. There are four bands that appear in the measured results with the bandwidth of 6.2GHz, 2.4GHz, 3.65GHz and 2.1GHz at the frequency range of 1.4-7.6 GHz, 9-11.4 GHz, 11.6-15.2 GHz, and 15.5-17.6 GHz, respectively. Fig.4 shows the simulated and fabricated peak gain of the proposed antenna having maximum value of 10.5 dB at 17 GHz. Fig.5-Fig.7 shows the comparison of simulated and fabricated radiation patterns at different frequencies. Fig.8 shows the simulated 3D plots of the proposed antenna at different frequencies.

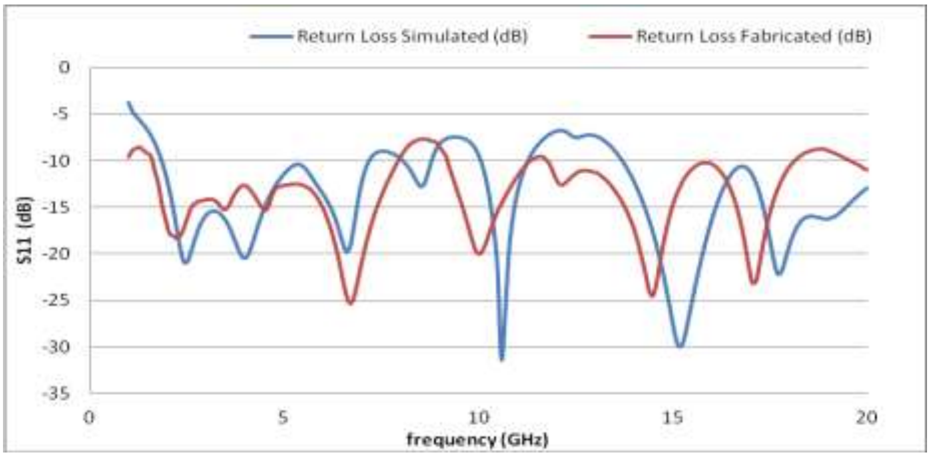


Fig.3 Comparison between simulated and measured values of S_{11}

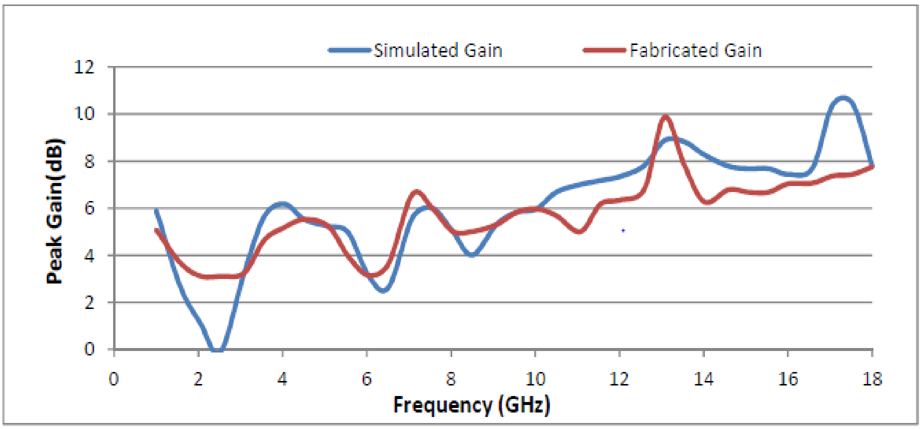
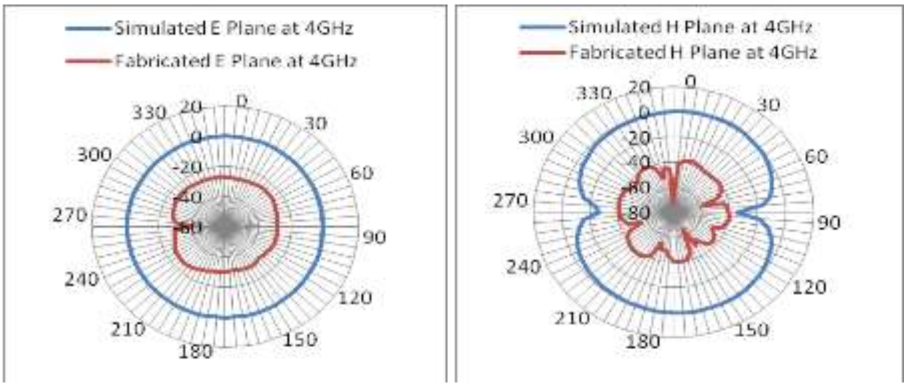
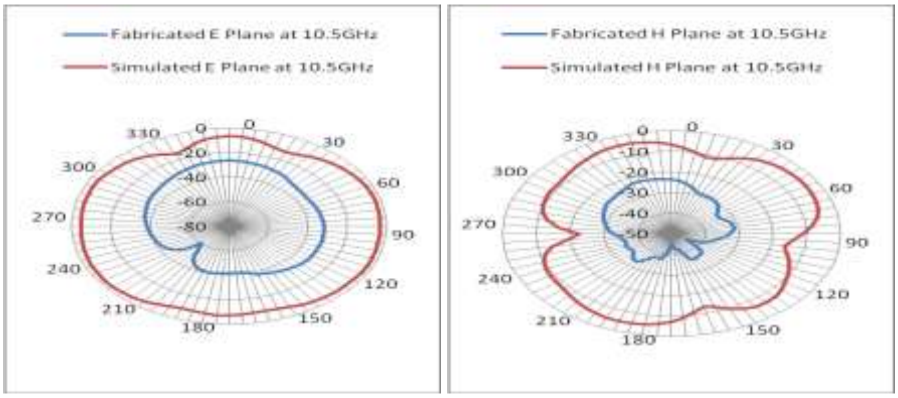


Fig.4 Comparison of simulated and fabricated peak gain of proposed antenna



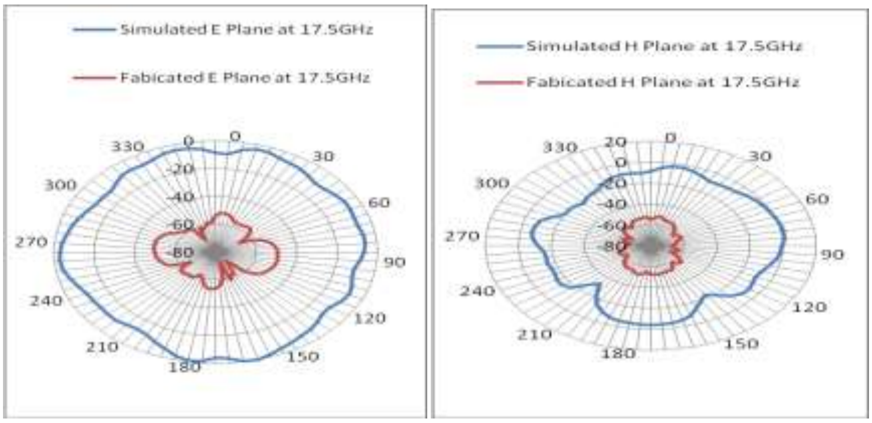
(a) (b)

Fig.5 Radiation pattern at 4GHz, (a) E Plane (b) H Plane



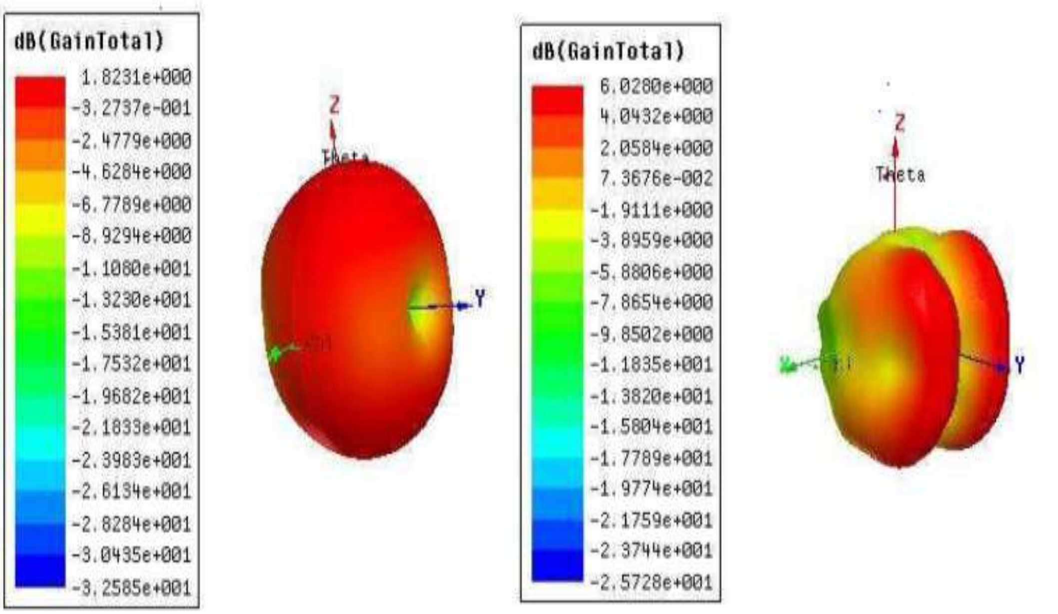
(a) (b)

Fig.6 Radiation pattern at 10.5GHz, (a) E Plane (b) H Plane

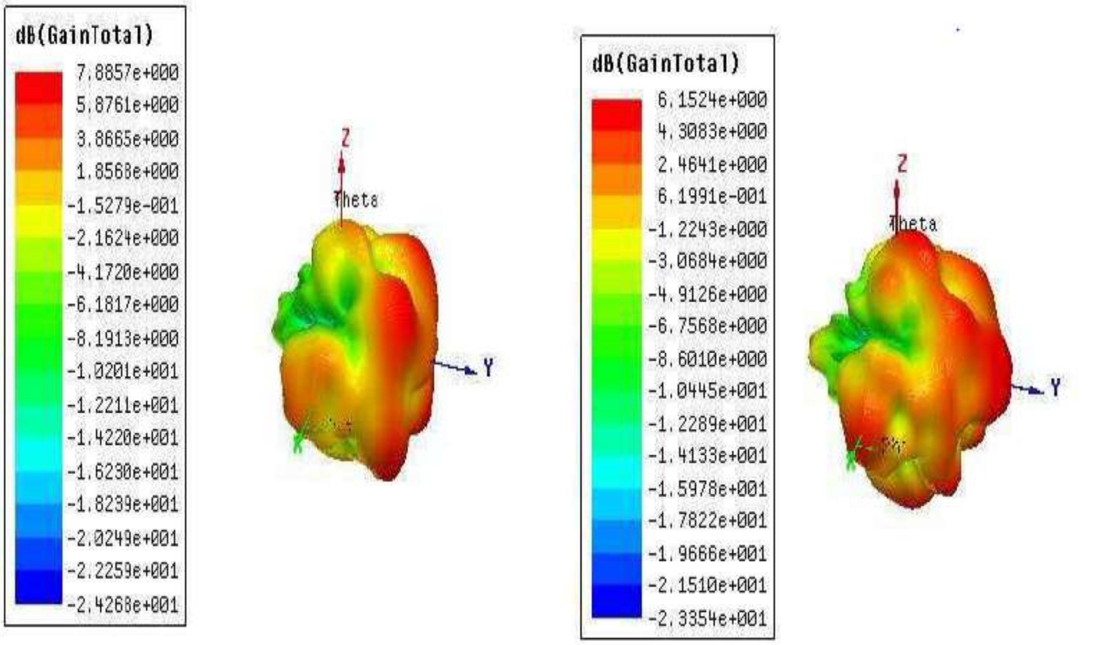


(a) (b)

Fig.7 Radiation pattern at 17.5GHz, (a) E Plane (b) H Plane



(a) **4GHz (b) 10.5GHz**



(a) 15.07GHz (b) 17.05GHz

Fig.8 3D Plots of proposed antenna

Table-2 Comparison between Proposed Antenna and Reference Antenna

Antenna	Proposed fabricated antenna	Rajkumar&Kiran (2016) [10]	Huang et al (2014) [9]	Malik&Kartikeyan (2012) [11]
Frequency (GHz)	1.4-7.6 9-11.4 11.6-15.2 15.5-17.6 (Multiband)	2.12.6 3.2-7 8-8.7 (Multiband)	2.39-2.69 3.38-3.73 5-5.99 (Tri band)	3.5-3.7 5.8-6.0 (Dual band)
Bandwidth (GHz)	6.2 2.4 3.6 2.1	0.5 3.8 0.7	0.3 0.35 0.99	0.2 0.2
Peak Gain (dB)	10.5	5.63	6.3	4.2 6.3

Table- 2 shows the proposed antenna gives more number of frequency bands, higher bandwidth and higher gain compared to the reference antenna.

CONCLUSION

A novel circular patch having two omega shaped structure along with metamaterial (SRR) structure has been demonstrated, by simulation and fabrication. The antenna has been fabricated and tested. The results show that the antenna exhibits as large bandwidth as of 6.2GHz and smaller bandwidth of 2.1GHz. Total 4 bands have been obtained with good radiation pattern and very high gain values up to 11.5dB at 17GHz frequency. The proposed antenna can be used to work in wireless communication like WLAN and WiMAX (2.3/2.5/3.5/5.8 GHz) application, in biomedical area radar and satellite communication etc.

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