Design of Bandwidth enhanced compact circular ring monopole antenna for C Band applications

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***Abstract* - In this paper, a compact circular ring monopole antenna for C band applications has been presented. The proposed antenna composed of two circular ring radiating patches separated by a radius of 0.5mm on FR 4 substrate with a dielectric constant of 4.4. The dimensions of the substrate are 20×20×0.8 mm3. It resonates at two frequencies of 4.4GHz and 7.3GHz in C band with the fractional bandwidths of 14.15% and 5.4% respectively. Return loss of the proposed antenna is -19db at 4.4GHz and -21.5db at 7.3GHz. Gain of the antenna is about 2.5db. ANSOFT HFSS13.0 software is used for the simulation of antenna.**

***keywords* - circular ring, monopole antenna, C band, FR 4 substrate, HFSS**

I. INTRODUCTION

In modern wireless communication systems, two or more devices are required to be interconnected in different frequency bands such as communications like WLAN, WIMAX, S band (2 to 4GHz), C band (4 to 8GHz), X band (8 to 12GHz), ku band(12 to 18GHz), Ka band (27 to 40GHz) depending on the type of application. Hence there is a demand for compact antennas which provide multi band operations, high band width and high gain. Recently many studies were conducted on microstrip patch antenna design with different structures to meet the above said challenges. Few existing antenna structures are:

Two split ring antennas are discussed with varying split positions in the arms, which varies the resonant frequencies. They offer two bands which are useful to be operated for WLAN and WIMAX applications[1]. Coplanar waveguide fed circular disk monopole antenna is coupled with three split ring resonator units on it's backside. It covers the WIMAX (2.5GHz,3.5GHz) and WLAN (5.2GHz) bands. A triple band microstrip antenna with one rectangular split ring resonator cells in the ground plane [3].

A two segment SRR Labyrinth meta material is embedded inside the antenna substrate. It is found that the bandwidth increases to about 600 percent after integration, and VSWR rises by approx. 1.5 percent and 400 percent of the antenna is miniaturized. [4]. By using slots and rings in the ground plane and top of the patch dual-band antenna is designed for working at two different frequency bands (15.2 GHz & 23.42 GHz) with a high gain that mainly covers Ku-band and K-band microwave applications [5].

An integrated half-mode wave guide (HMSIW) semi-circular antenna backed by two higher-order modes (TM210 and TM020) was designed for dual-band operation. At the top of the HMSIW structure is carved a semicircular slot forming a cavity that is fed by co-axial feeding to match impedance with the side [6]. High Gain Frequency Reconfigurable Microstrip Patch Antenna for Wireless Local Area Network Applications is discussed [7].

The antenna is a fat monopole made of circular and rectangular patches. A passband of 2.8 to 11.97GHz is measured. Gain and efficiency are 4.34 dbi and 96%[8]. Omni directional microstrip monopole antenna with defected ground plane is designed. The dimensions of the miniaturized antenna and the resonant frequency of the monopole structures are around 18.48 X 21.18 mm^2 and 5.4 GHz respectively. Quite strong characteristics of radiation and impedance were obtained by placing the knots on two corners of the quasi-square radiating area. The frequency parameters of the impedance bandwidth of the realized antenna measured from 5.3 to 22.5 GHz for VSWR value is less than 1.5.Increase in the gain 15.18 dB at 19.3 GHz and achieved 21.73 dB due to the use of the microstrip line feeding, 0.33 GHz return the loss and BW respectively. And the slot antenna has also been proposed to gain 4.41 dB, 1.95 dB for 5.4 GHz and 14.9 GHz respectively [9].

II. PROPOSED ANTENNA DESIGN

The proposed microstrip patch antenna dimensions are identified from the following equations:

$$r = \frac{F}{\sqrt{1 + \frac{2h}{\pi\, \varepsilon r}\left[\ln\left[\frac{\pi F}{2h}\right] + 1.7726\right]}}$$

$$F = 8.791 \times 10^9 / (f_r \sqrt{\varepsilon r})$$

Where r is radius of circular patch, h is thickness of substrate, εr is dielectric constant of the substrate and f_r is resonating frequency.

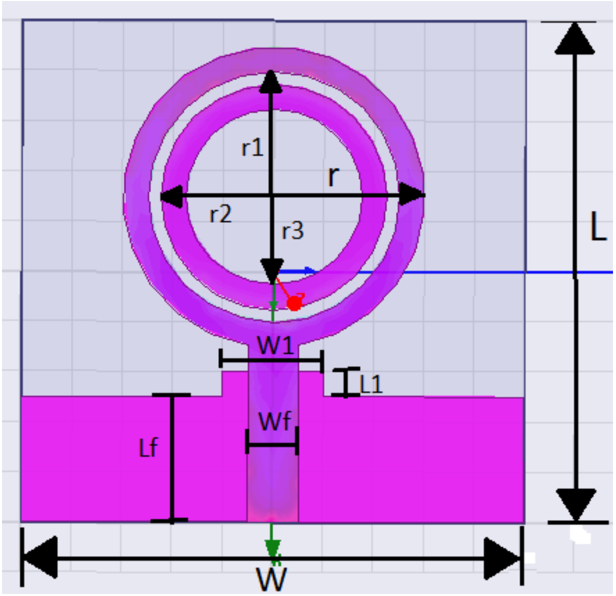

Figure 1: Proposed antenna structure

The proposed antenna composed of two concentric circular rings separated by a radius of 0.5mm and the thickness of each circular ring patch is 1mm. Here the micro strip line feeding is used to radiate the patch antenna. FR 4 substrate of dielectric constant 4.4 with the dimensions of 20×20×0.8 mm3 is used. Partial ground plane of length 7.5mm is used. Also a 3×4 mm2 is used in the center of ground plane, which is appended to the ground plane. The dimesions of the antenna are:

Table1

Parameter	R	R1	R2	R3	Lf	G_1	L1	W1	L	W	h
Value (mm)	6	5	4.5	3.5	7.5	5	3	4	20	20	0.8

III. SIMULATION RESULTS AND DISCUSSION

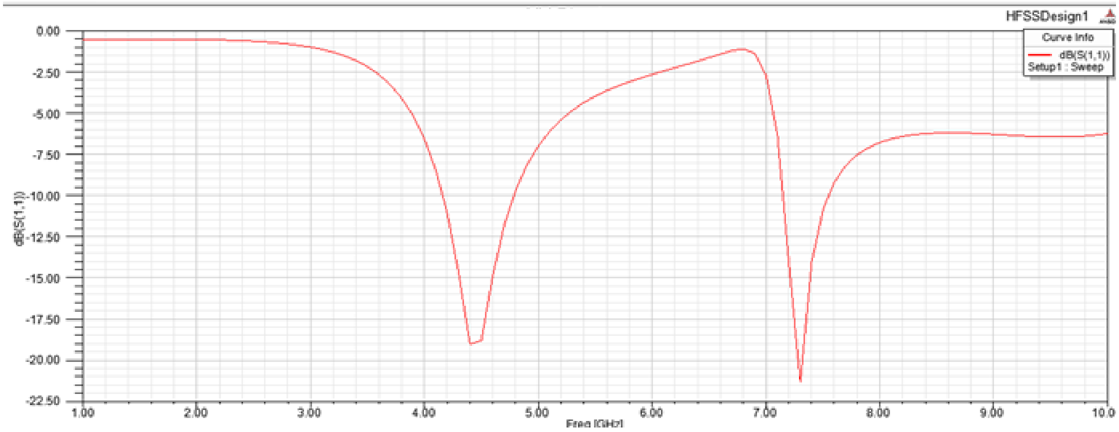

Figure 2: Simulated return loss of the proposed antenna.

Initially, with only outer ring radiating patch, the lower resonating frequency is induced. With the introduction of the inner ring, higher resonant frequency is induced. Parametric study was conducted on the distance between two rings to achieve good return loss. Clearly from the above graph, the proposed antenna can be used to radiate at frequencies of 4.4GHz and 7.3GHz. fractional impedance bandwidth achieved is 14.15% and 5.4% at 4.4GHz and 7.3GHz respectively. The gain achieved at 4.4GHz is 2.45dbi and at 7.3GHz is 1.37dbi. The 3D radiation patterns at both frequencies are plotted.

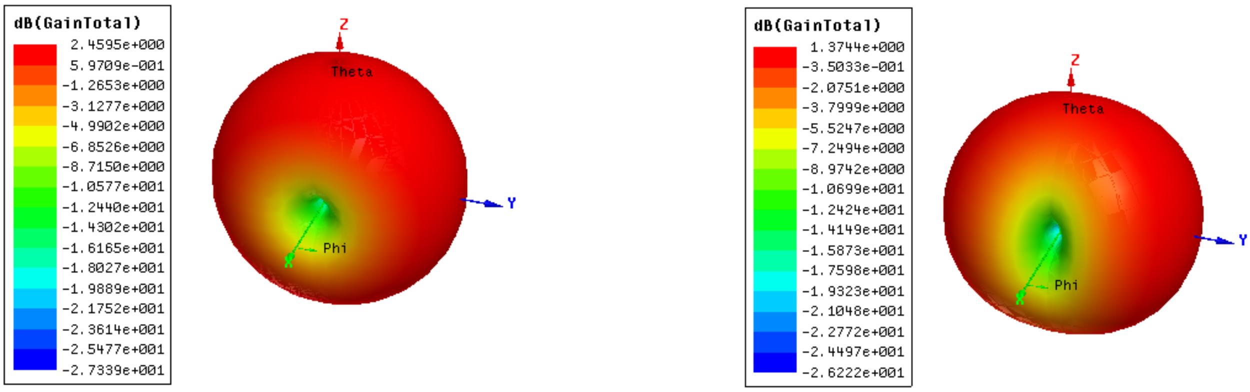

Figure 3: (a)Simulated radiation patterns at 4.4GHz, (b)Simulated radiation patterns at 7.3GHz

E plane in the radiation pattern corresponds to yz plane (ϕ=90₀).

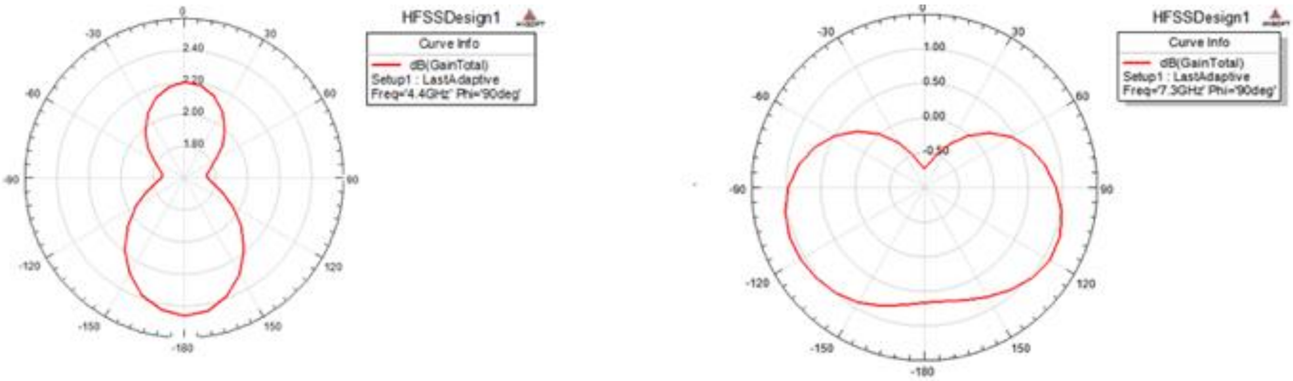

Figure 4: (a) Simulated radiation pattern at 4.4GHz, (b) Simulated radiation pattern at 4.4GHz

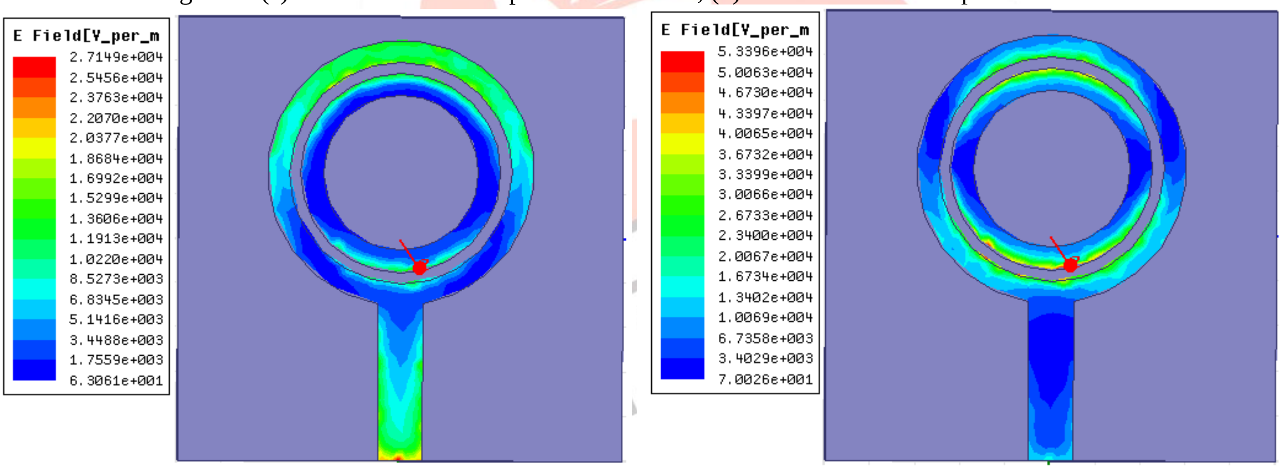

Figure 5: (a) E field pattern at 4.4GHz, (b) E field pattern at 7.3GHz

IV. CONCLUSION

Bandwidth enhanced compact circular ring monopole antenna for C band applications is presented. Return loss of the proposed antenna is -19db at 4.4GHz -21.5db at 7.3GHz and fractional bandwidth achieved is 14.15% at 4.4GHz and 5.4% at 7.3GHz. Also, the compact size of antenna proves to be a good candidate for C band applications.

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