Gain Enhancement of Fractal Antenna by Using Cut Slots and Ring

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Abstract - Due to the recent interest in multiband antennas a microstrip patch antenna was designed& analyzed to meet the need for a cheap, low profile, multiband antenna. This antenna could be used in a wide range of applications such as in the communications industry for cell phones or wireless communication devices. This report presents the design of a multi band Microstrip patch antenna to operate in the frequency range of WLAN & WiMAX bands i.e. 2.4 GHz, 3.5 GHz & (5.2-5.8) GHz. Slots have been introduced in top radiating patch to achieve desired frequency band and considerable bandwidth. After simulation the antenna performance characteristics such as VSWR, return loss, radiation pattern, Gain plots are obtained. Return loss of -15.60 dB, -15.15 dB and -29.81 dB are obtained at multiple resonant frequencies at at2.6 GHz, 3.7 GHz and 5.5 GHz respectively. The overall gain of 5.25 dB & 3.44 dB are obtained at respective resonant frequencies and the radiation pattern of the proposed patch antenna shows that it is suitable for desired wireless applications. The assessment of VSWR is below 2 that are observed from the graph clearly. It shows 1.92, 2.2 and 1.75at resonant frequencies respectively. The aim of the thesis is to design a multi band Microstrip patch antenna for WLAN &WiMAX applications. Here, Microstrip feed method is used to excite the patch antenna. The performance of Patch antenna is determined by simulated results and these are compared with already proposed antenna structure available in literature. It is found from the analysis that the ring on ground plane and slots on patch improves the gain, directivity, Bandwidth and input impedance of the antenna.

I. INTRODUCTION

In modern wireless communication systems wider bandwidth multiband or triple band and antennas with low summary are in excessive plea for both salable and army applications. An antenna is an important element of the wireless system. An antenna is an electrical device which transmits the electromagnetic waves into the space by converting the electrical power given in the input into the radio waves and at the receiver side the antenna intercepts these radio waves and converts them into the electrical power .There are so many systems that use antenna such as remote controlled television, cellular phones, satellite communications, spacecraft, radars, wireless phones and wireless computer networks. This research gives us an idea about the evolution of microstrip Antennas and various developments in the past for dual and tri band applications.

II. LITERATURE SURVEY

K.P Yang et al. [14] proposed and studied new designs of obtaining dual-band circular polarization (CP) radiation of a single-feed square microstrip antenna. By inserting four T-shaped slits at the patch edges or four Y-shaped slits at the patch corners of the microstrip antenna single-feed and dual-band CP designs are achieved. From experimental results a patch size reduction as large as 36% has been obtained compared to a conventional design without the inserted slits.

V.K. Varadan et al. [15] allied multiple resonant frequencies of fractal geometry based antennas using Koch curves to their fractal dimensions. The study of dipole and monopole antennas based on Koch curves have generally been limited to certain standard configurations of the geometry.

P.H.Rao et al. [16] presented a broadband loop antenna using Koch fractal configuration with a novel Coplanar Waveguide (CPW) feed. Impedance matching is obtained by using a radial stub loaded CPW feed which acts as a lumped matching circuit. Experimental results showed that the antenna has 2:1 VSWR bandwidth of about 19% in the frequency range of 1.26 GHz 1.52 GHz and 3.1 VSWR bandwidth of 57% has been measured in the frequency range of 1.21 GHz to 1.99 GHz.

Krishna et al. [17] proposed a dual wide-band CPW fed modified Koch fractal printed slot antenna for WLAN and Wi-MAX frequencies. The operating frequency of a triangular slot antenna is lowered by the Koch iteration technique which resulted in a compact antenna. Observations on the impedance and radiation characteristics of the proposed antenna indicates the antenna has an impedance bandwidth from 2.38 to 3.95 GHz and 4.95 to 6.05 GHz covering 2.4/5.2/5.8 GHz WLAN bands and the 2.5/3.5/5.5 GHz Wi-MAX bands.

X. D Song et al. [18] presented a miniaturized dual band koch fractal boundary microstrip antenna. The proposed antenna is compact. The simulated results show that the height of the proposed antenna is about 20% less than the prototype antenna and the S11 parameter at high frequency band was improved considerably.

The proposed antenna can radiate the circularly polarized waves at two frequency bands by adjusting the widths or the locations of the L-shaped slits have been clarified in [19] and previous Designed a novel dual-band CP pentagonal slot antenna. The circular polarization (CP) radiation characteristics are achieved by loading with proper asymmetry which is placed at the opposite angle of the feed line. The measured results show that good CP characteristics are observed in radiation patterns at the two resonant frequencies have been proposed in [20].

V. Rajya Lakshmi et al. [21] investigated the effects of stacking Koch fractal antenna aperture coupled fed. It is shown that by stacking the antennas the bandwidth can be increased up to 32% at the resonance frequency of 980 MHz which is much larger than the 3% bandwidth offered by a conventional Koch fractal antenna as well as having some 14% less surface area. This antenna has an 8dBi flat gain over the bandwidth.

Sudipta Das et al. [22] presented multi resonant frequency antenna with DGS structure. Introducing slots at the edges of the patch a size reduction of about 57% has been achieved with increased frequency ratio and multi- frequency operation.

Wing et al. [23] studied that a dual or triple-band patch antenna can be designed by cutting U-slots in the patch of a broadband antenna and the method was applied to the L-probe fed patch, the M-probe fed patch, coax-fed stacked patches, and aperture coupled stacked patches. All these cases involve either a rather complicated feed, or more than one patch, or more than one layer.

A.Balanis et al. [28] proposed a substrate design that uses a ferrite ring to enhance the gain of a microstrip patch antenna without compromising the bandwidth is proposed. This design forces constructive interference between the incident and reflected fields inside the substrate. The interference is created by introducing a ferrite ring at a distance d1 from the circumference of the patch with a ring width. Initial values of d1 and d2 of one-quarter of the free-space wavelength (d1 = d2 = $\lambda 0/4$) are selected.

Arvind Yadav et al. [29] proposed a microstrip fed antenna which consists of a rectangular patch with rectangular shaped slot incorporated into the patch for ultra wide band application with enhanced bandwidth. The proposed antenna achieves an impedance bandwidth of 8.9 GHz (2.3-11.2 GHz) with VSWR < 2 for over the entire bandwidth.

N.V.S.N.Sarma et al. [30] proposed a compact fractal boundary microstrip antenna for circular polarization (CP). By replacing the sides of a square patch with asymmetrical pre-fractal curves two orthogonal modes are excited for CP operation. The structure is a symmetrical on the principal axes (x, y). The in dentation parameter of the fractal boundary curve is optimized to design compact CP antennas.

V.V. Reddy et al. [31] proposed a novel single-layer single probe-feed asymmetrical fractal boundary microstrip antenna is considered for tri-band circular polarization (CP) operation. Four different structures without-slot (Ant1), rectangular (Ant2), fractal (Ant3) and optimized fractal-slot (Ant4) are studied for multiband CP radiation.

III. ANTENNA DESIGN

The rectangular patch antenna is approximately a one-half wavelength long section of rectangular microstrip transmission line. The length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increases the electrical length of the antenna slightly [3]. This section describes the design of rectangular microstrip patch antenna satisfying the given specifications.

Table 4.1 Design Specifications of Proposed Antenna

Substrate Type	Rogers RT Duroid 5880
Resonant Frequencies(f_r)	2.6 GHz, 3.7 GHz and 5.5 GHz
Dielectric Constant (ε_r)	2.2
Loss Tangent (δ)	0.0009
Substrate Thickness	3.2 mm

Fig.1 shows Proposed Antenna in Top View whereas fig.2 shows proposed Antenna in HFSS 3D View.

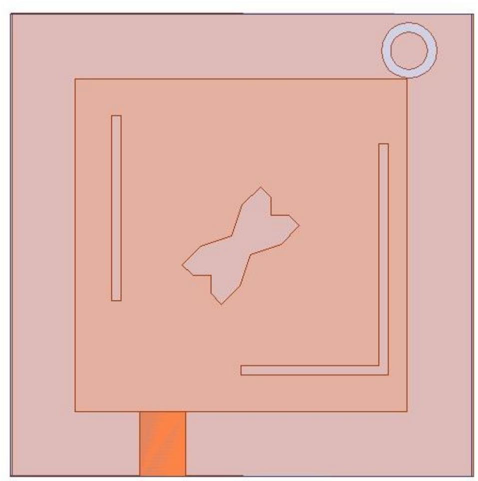


Fig.1: Proposed Antenna in Top View

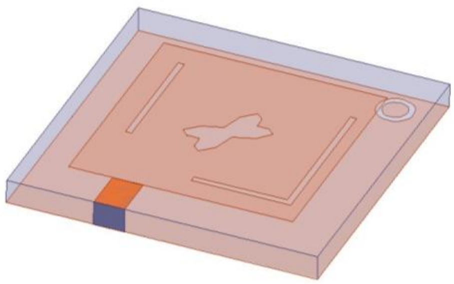


Fig.2: Proposed Antenna in HFSS 3D View

The basic geometry of the proposed patch antenna is shown in above figures. The detailed dimensions are labeled in fig.3 and fig.4 as given below:

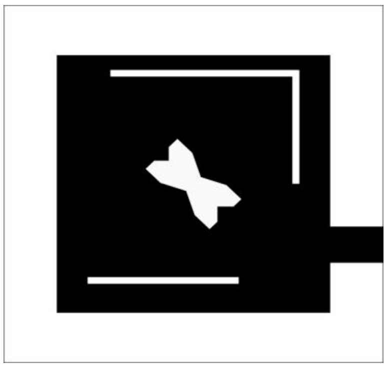


Fig.3: Detailed Dimension of Top Patch

The satisfactory dimensions have been ascertained as follows: Lg = 48 mm, W_g = 48 mm, L_p = 36 mm, W_p = 36 mm, S_l = 6 mm, Sw = 2 mm.

Fig.4: Detailed Dimensions of Ground Plane

IV. RESULTS

The software used to model and simulate the Micro strip patch antenna is High frequency structure simulator (HFSS). It analyzes 3D and multilayer structures of general shapes. It has been widely used in the design of MICs, RFICs, patch antenna, wire antenna and other RF/wireless antennas. It can be used to calculate return loss plot, gain, current distributions, radiation patterns, VSWR and smith chart etc.

The simulated results of the proposed antenna are presented as figures given below:

A. *Return Loss and Antenna Bandwidth*

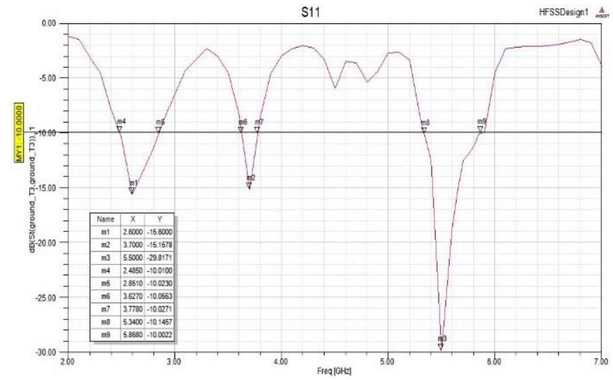


Fig.5: Simulated S11 Plot

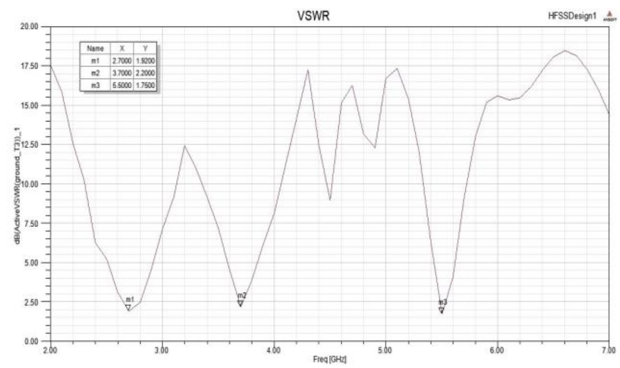
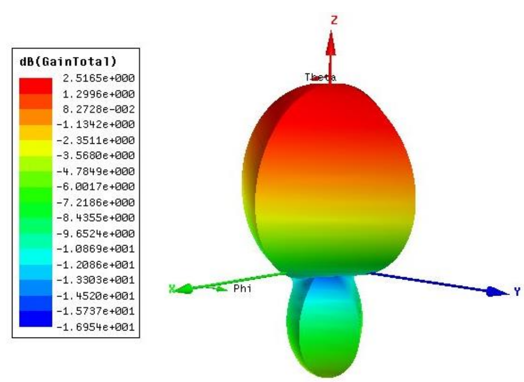


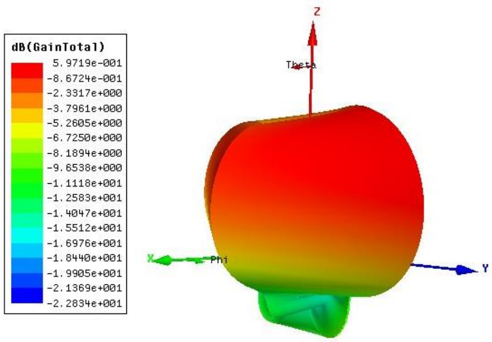
Fig.6: Simulated VSWR Plot

B. *Gain*

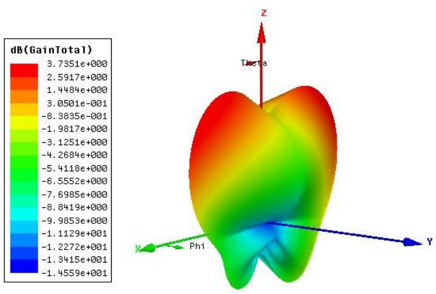
The Gain plot gives the average peak gain = 3.44dB. The gain of the antenna in a particular direction is more as compared to isotropic antenna radiating in all directions which is very useful for various applications providing a better performance.



(a)



(b)



(c)

Fig.7 3D Gain plot of the Proposed Antenna (a) 2.6 GHz (b) 3.7 GHz (c) 5.5 GHz

C. Radiation Pattern

From 2D plot & polar plot view of radiation pattern as shown in fig. 4.12 & 4.13 it can be seen that at resonant frequencies radiation pattern obtained is Omni directional.

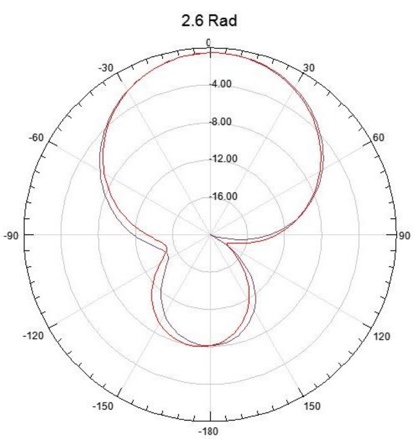


Fig.8 (a) Radiation Pattern of the designed Antenna at 2.6 GHz

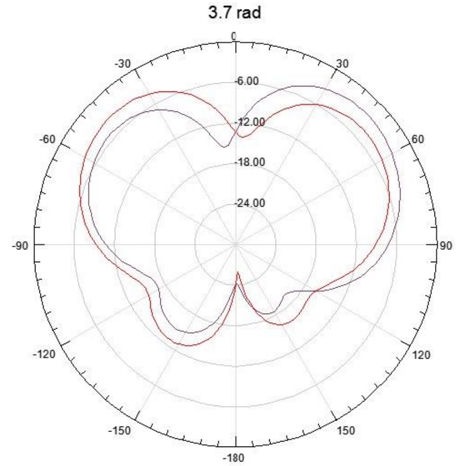


Fig.8 (b) Radiation Pattern of the designed Antenna at 3.7 GHz

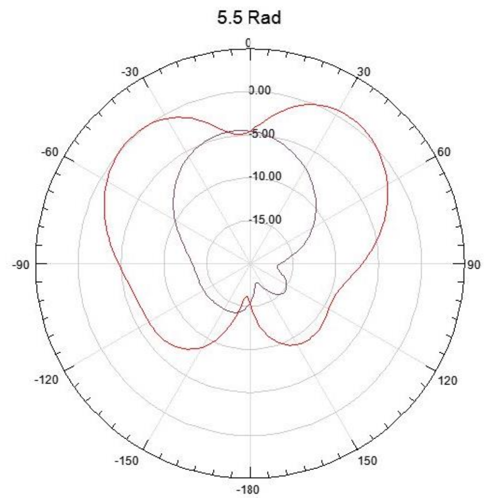


Fig.8 (c) Radiation Pattern of the designed Antenna 5.5 GHz

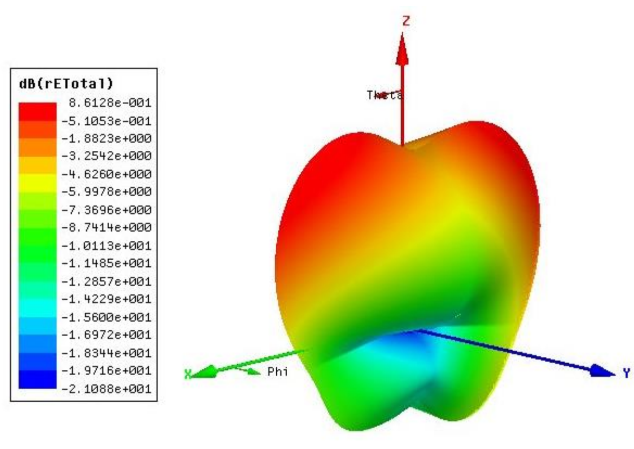


Fig.9: Radiation Pattern of the designed Antenna (3D view)

D. Comparison of Proposed Antenna with Already Implemented Patch Antenna

Parameters	Proposed Work
Type of Antenna	A Tri-band Microstrip Patch Antenna
Resonating frequency (GHz)	2.6 GHz, 3.7 GHz and 5.5 GHz
Return loss(dB)	-15.6 dB, -15.15 dB and -29.81 dB respectively
Gain(dB)	5.25 dB & 3.44 Db
Antenna Size	48 mm× 48 mm
Overall Bandwidth	1035 MHz

It is clear from the data given in table given above that there is overall size reduction of 8% as compared to the proposed design in [31].

% Size reduction = 100 – (2304/2500)*100 = 8

V. CONCLUSION

In this report, a compact tri-band patch antenna with enhanced bandwidth is designed and analyzed. Overall dimensions of the proposed antenna are 48 mm × 48 mm × 3.2 mm. The simulated Return loss of the proposed antenna is shown in Fig 4.1. Return loss of -15.60 dB, -15.15 dB and -29.81 dB are obtained at multiple resonant frequencies at 2.6 GHz, 3.7 GHz and 5.5 GHz respectively. Simulations results show that the proposed antenna covers impedance bandwidth of 1035 MHz in WLAN & Wi-MAX frequency range. There is considerable reduction in overall size, improvement in bandwidth and gain using the proposed patch antenna with slotted patch. The physical parameters examined in this study include the substrates and their dielectric constants feed line and ground plane circular ring. The antenna parameters like operating frequency, VSWR, Bandwidth, Return loss, radiation pattern and gain are determined for the antenna configuration. Simulation results indicate that all the parameters of the proposed microstrip patch antenna has considerably been improved by using slots & rings on ground plane and top patch. Average peak gain is 3.44 dB which is considered to be good.

VI. FUTURE SCOPE

The designed antennas in this thesis report is used in various applications like WLAN, WiMAX and 4G LTE etc.
Various techniques can also be used in future to design antenna which are as follows:

- **Split-ring resonator structure (SRR):** A split-ring resonator (SRR) is a component of a Negative index Metamaterial (NIM), also known as Double negative Metamaterial (DNG) or Left-handed medium (LHM). SRRs are also used for research in Terahertz Metamaterial. A single cell SRS has a pair of enclosed loops with splits in them at opposite ends. The loops are made of nonmagnetic metal like copper and have a small gap between them. The loops can be concentric, or square, and gapped as needed.
- **Electromagnetic band gap structure (EBG):** Electromagnetic Band Gap (EBG) substrates for patch antennas significantly reduce the effect of surface waves as a function of frequency and are able to provide relatively broadband frequency performance. EBG structures are 3-D periodic objectives that prevent the propagation of the EM waves in the specified band frequency for all angles and for all polarization states. In EBG only one out of Єr and µr is negative.
- **Other feeding techniques:** the other feeding techniques of microstrip patch antenna like coaxial feed, aperture coupling and CPW can also be used in future to design microstrip patch antenna.

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