Golden Ratio Approach to Gain Enhancement of DGS Based Thin Rectangular Ring Microstrip Antennas

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***Abstract*—Microstrip antennas are essentially used in all the spheres of modern wireless communication systems. This paper presents a novel antenna, which is designed to enhance antenna gain at 2GHz frequency. The defective ground structure on bottom ground plane formed by placing mender lines, dumbel shapes, inverted E shapes below feed line. Upper DGS formed by etching two horizontal slots. Antenna designed, simulated and verified the parameters S11 (return loss), VSWR, Bandwidth Gain, and current distribution with and without golden ratio applied to antenna.**

***Index Terms*— Quarter wave, DGS, Mender lines, VSWR, S11, Bandwidth Current distribution, Golden ratio.**

I. INTRODUCTION

Microstrip antenna play a crucial role in modern wireless communication technologies, providing an efficient and practical solution for wide range of applications. Since for a long time micrstrip ring antenna (RMSA) has been studied by many investigators because of its increased performance compared to conventional antenna. Microstrip rectangular ring antenna is a type of planar antenna characterized by its rectangular ring-shaped radiating element.[1] .In the present work authors have endeavored to design thin lightweight rectangular ring microstrip antenna. The main objective is to apply golden ratio to rectangular ring microstrip antenna and observed the various parameters like return loss, directivity, VSWR, Gain of an antenna with and without golden ratio. Designed antennas finds application in highly integrated CMOS transmitters and L band applications.

Rectangular ring antenna operates by exciting the rectangular ring structure, which generates electromagnetic waves. The ring circumference typically, determines the primary resonate frequency, which is approximately equal to the wavelength of operating frequency.While designing rectangular ring antenna we consider many parameters such as dielectric constant, feeding technique etc.[3]-[7] The dielectric constant of substrate material and loss tangent of substrate material influence the antenna efficiency and bandwidth.[8]-[9] The inner and outer dimensions of the radius of the ring determines the resonant frequency. Feeding methods such as quarter wave feed, microstrip line feed, co-axial probe feed, or aperture coupling affects the impedance matching and overall performance.[10] These antennas `finds applications in wireless communication, Satellite communication in wearable devices and in RFID systems. The main advantages of rectangular ring antenna are, they have low profile. Their thin and flat surface allows for easy integration in to devices in to limited space. This antenna provides specific radiation patterns suitable for targeted communications. They can be designed to operate over a wide range of frequencies by adjusting the ring dimensions and suitable properties.[11]-[17]

Golden ratio is a mathematical concept identified by the Greek letters which is derived from the Fibonacci sequence. This ratio is an irrational number which is the solution of quadratic equation X2 –X-1=0 its value is 1.618. It is also known as the golden section, golden mean, or heavenly proportion. Longer portion (a) divides shorter portion (b) by the sum of (a) + (b) divided by (a). Both of which equal 1.618% i.e. Golden ratio $\phi = (1+\sqrt{5})/2 = 1.618033988$ .This formula helps in antenna design. In antenna, (a) is the length and (b) is the breadth. To determine the length of a patch, the width of a patch with the desired frequency is computed using formulas; dividing width by 1.618 yields the length of the patch (L = W/1.618). With these L and W values.[18]-[22]

The ground structure is an important component in design of antenna it helps to create stable electrical connection with the ground, which is much needed for antenna function. The defective ground structure etched on ground plane, they are periodic or non - periodic structure. That will divert the current distribution of an antenna. Which intern varies the parameter R, L and C of transmission line.

Variety of structures are reported in literature, like U shaped, S shaped, V shaped, H Shaped [6-10].First DGS was implemented below feed line was dumbbell shaped, results are acceptable[11-12].the photonic bandgap (PBG) is a periodic structure, the DGS structure has an advantage over PBG. Compared to PBG the DGS occupies less space on PCB. While compared to PBG,DGS is easy to design and fabricate[13].Shapes like concentric ring ,mender lines ,split ring resonators ,fractals are also reported in and responses are good[14]-[17]. Various geometrical shapes of DGS are contributed in the literature to enhance the parameter of an antenna – like return loss, VSWR, gain and directivity. After applying golden ratio to 1mm and 4mm width antenna started radiating at single frequency due to the current distribution. In these antennas antenna compactness can be easily achieved by without disturbing other parameters. Etching DGS ie mender lines below feed line with two uniform parallel slots on the ground fed with quarter wave has achieved good gain, further achieved better gain when applying golden ratio. The tank circuit consisting of L and C is nothing but equivalent circuit of DGS. The equivalent circuit can be analyzed in four different ways .(a) LC and RLC circuits.(b) π-equivalent circuit (c)Quasi static circuit and (d) Ideal transformer circuit. In these model proposing simple LC circuit with mathematical equation.[18]-[25]

$$fr = \frac{1}{2\pi\sqrt{LC}} \text{ --------------(1)}$$

Based upon the quality factor value, we choose various DGS structures. Presently we used mender lines, dumble shaped structures below feed line with two identical slots below the ring patch are employed [26]

II. DESIGN GEOMETRY WITH DGS

Proposed antenna designed for 2GHz frequency by using basic design equations to calculate length and width of patch antenna on FR4 substrate, having dimensions of 70.88(L)mm2 x91.28(W)mm2,loss tangent (tan□) of 0.02, dielectric constant □=4.4.Rectangular ring shaped patch forms top layer on substrate, of thickness t=1.6mm.

Then started designing rectangular ring antenna of width 1mm and 4mm .1mm width slim antenna can be designed by subtracting smaller dimension on larger dimensions resulting slim rectangular ring antenna. Slender 1mm ring antenna results by subtracting dimension 34.44mm (L) X 45.64 mm (W) on 35.44mm (L) X 45.64mm (W) patch. Similarly, 4mm width rectangular ring antenna can be formed by etching 31.44 mm (L) X 41.64mm (W) on 35.44mm (L) X45.64mm (W) patch. Feed line length FL=10.27mm Feed width FW=1.5mm.Quarter wave length Lq=10.28mm, quarter wave width Qw=0.5mm Makes rectangular ring antenna resonating at fr=2GHz as per mathematical analysis.[1] .Mender lines below feed line with two parallel slots below conducting patch i.e. Top side DGS has been etched to form DGS on ground plane. The dimensions of DGS are listed in Table 1.The antenna structure is shown in Fig1.fig b, fig c, fig d shows S11 plot, VSWR, total gain respectively.S11 plot indicates DGS has effect slightly higher frequency means that DGS has more inductive component governing on capacitance, hence tuned up towards high frequency. Antenna produces total gain of 2.9299dB with and 641MHz bandwidth.

III. SIMULATED RESULTS:

Table: 1 Ground plane DGS dimensions with all structures for 1mm ring antenna

Parameter		Dimensions in (mm)
Top side DGS.	L1	52mm
	W1	2.1mm
	L2	48mm
	W2	2mm
Vertical mender lines,	L	5mm
	w	1mm
Horizontal mender lines L1=L2=L3=L4=L6=L7=L8=L9	L	1mm
	w	0.5mm
Horizontal length	L5	4mm
	W	0.5mm

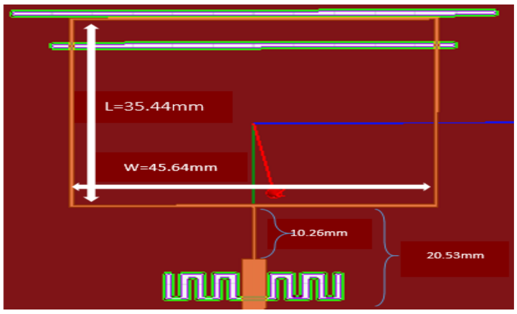

Fig.1 1mm ring antenna top view

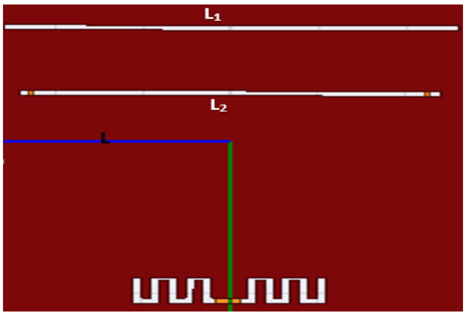

Fig a.Bottam view

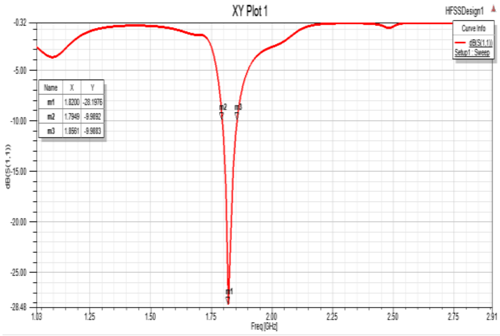

Fig b.S11 plot

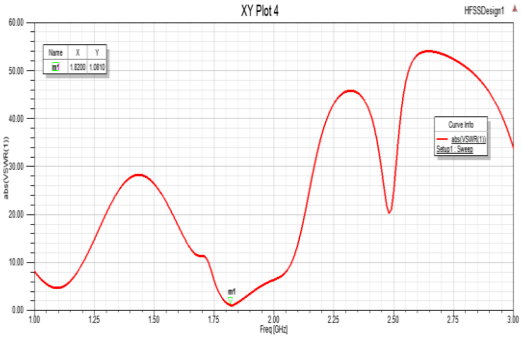

Fig c.VSWR

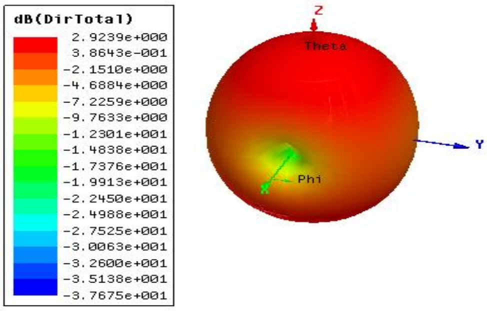

Fig d. directivity

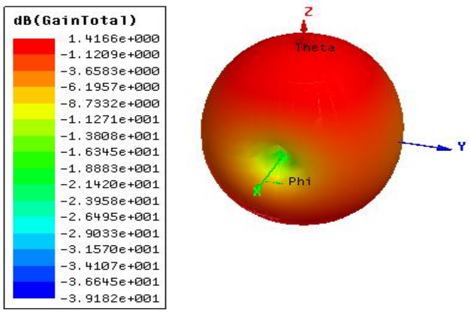

Fig e. gain total

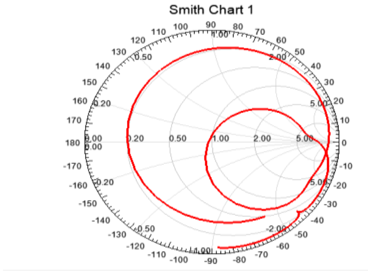

Fig f.Smith chart

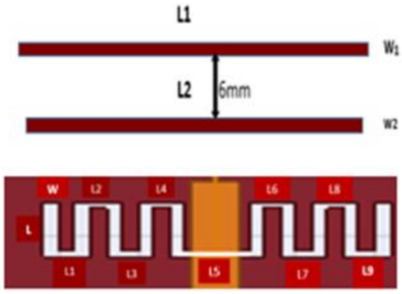

Fig g. Upper and Lower Mendor lines

1mm RING ANTENNA WITH GOLDEN RATIO.

Proposed 1mm ring antenna fabricated on FR4 substrate, formed by applying golden ratio i.e. by dividing larger section by 1.618.In rectangular ring antenna width will be the larger section. Therefore the patch length L=W/1.618=26.97mm and width W=44.64mm. Subtracting patch dimension 26.97mmX 44.64mm on 35.55mmX45.64mm patch yields 1mm rectangular ring antenna with golden ratio as shown in fig2.To form DGS on ground plane, mender lines are etched below the feed line and two horizontal slots are etched below ring patch as shown in fig b. The dimensions of DGS are listed in table2. With increase in dimensions of DGS. Fig b, fig c, fig d and Fig e shows S11 plot, VSWR, total gain of an antenna and directivity. Observed that DGS has effect on lower frequency means that the antenna has more inductance component dominating on capacitance. Hence, antenna radiates at lower frequency. After applying golden ratio antenna radiates in 2.16GHz frequency. The total gain obtained from this antenna is 2.3500dB.

Table 2.Dimensions of DGS

Parameter		dimensions in (mm)
Top side DGS	L1	52mm
	L2	48mm
W1=w2	W	1mm
Vertical mender lines	L	5mm
Width left & right side	W	1mm

Horizontal mender lines L1=L2=L4=L5=L6=L7=L8=L9 W1=d	L1 w	1mm 1mm
3 D3	L W	4mm 1mm

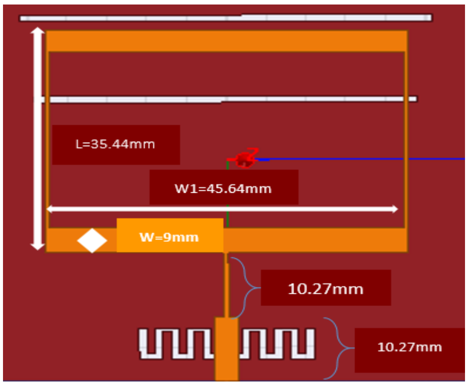

Fig 2.Top view

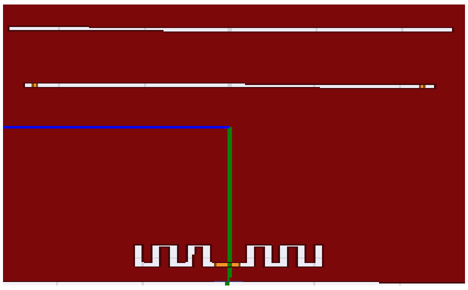

Fig a, Bottom view

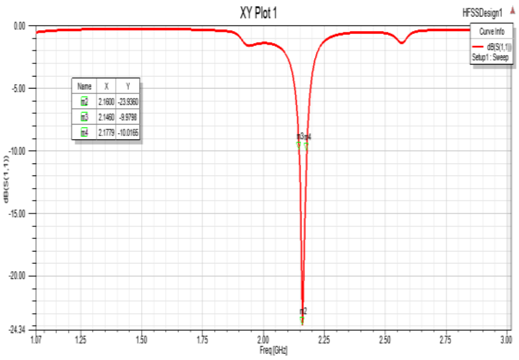

Fig b.S11 plot

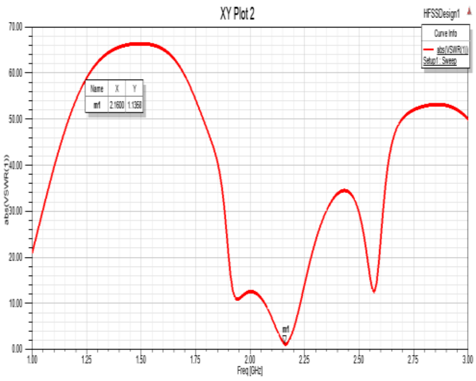

Fig c.VSWR

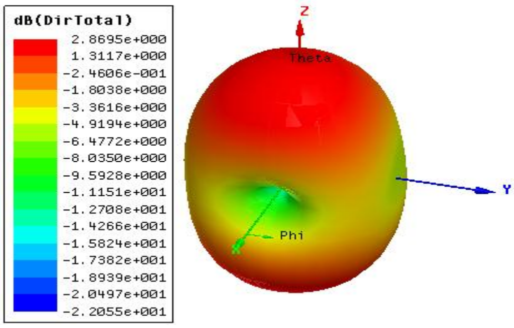

Fig d.Directivity

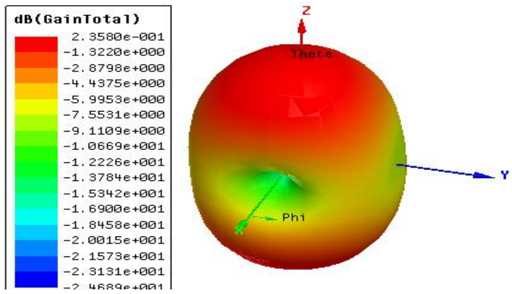

Fig e.Gain total

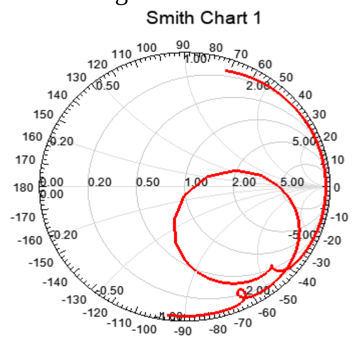

Fig.f Smith chart

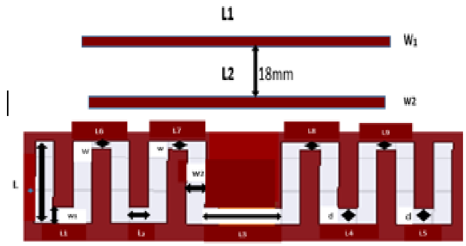

Fig g. Upper and lower mander lines

Resonating frequency	Ret–Loss S11	VSWR	Directicity in dB	Gainin dB	Bandwidth in GHz
1.82GHz	-28.1976	1.08	2.92	1.41	0.071.24
When Golden ration applied					
2.1600	-23.9360	1.1358	2.8695	2.3580	0.03198

Parameter Results

4. CONCLUSION

Thus, the rectangular ring 1mm ring microstrip antenna with defective ground structure designed and simulated for L and S band applications. Obtained return losses graph covers the frequency 1.82GH. with golden ratio covers 2.16GHz frequency. The other antenna parameters like gain, VSWR and current distribution obtained for depicted model gives satisfactory performances. The defected ground included in the model, enhances the radiation characteristics.When we apply golden ratio enhances gain from 1.41dB to 2.35dB. Such antennas finds applications in L and S band.

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