Design And Analysis of Compact Multiband Antenna Using FR4 Substrate for GSM,LTE and ISM Applications

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Abstract- *exceeded fifty crore and nearly 4.4 lakh cell phone towers are used to meet the communication The project presents the Design of Multiband Antenna using FR4 Substrate for The operating frequency ranges of the cell tower are GSM (800 MHz), GSM (1800 MHz) and LTE (2.2 GHz) and ISM (2.4 GHz). In this project an empirical Antenna is designed for GSM900, 1800 band as well as 2.4GHz ISM band. A triple band symmetrical arm dipole antenna is used in this project. The antenna is simulated by HFSS software. The rapid growth of wireless communication over few decades becomes an integral part of modern life. The cellular networks, wireless local and personal area network WLAN, WPAN etc. are the most commonly used wireless technologies. Recent studies show that the number of cell phone users has demand in the developing country like India.*

The operating frequency ranges of the cell tower GSM (800 MHz), GSM (1800 MHz) and LTE (2.2 GHz) and ISM (2.4 GHz). So there is a wide scope in designing of antenna for above frequencies.

Keywords- Fractal, Multiband, planer dipole, GSM shape

I. INTRODUCTION

An antenna is a transducer that transmits or receives electromagnetic waves. By transmitting a Signal into radio waves the antenna transforms electric current into electromagnetic waves and vice-versa by receiving. Antennas are also said to radiate when transmitting. An antenna radiates by changing the flow of current inside a conduction wire. Antenna acts as matching system between sources of electromagnetic energy and space.

II.ANTENNA CONFIGURATION

The proposed T shape Multiband fractal antenna prototype is illustrated in figure 2. In this design, a CPW Fed fractal antenna is presented. The design of the antenna starts with a single element using basic rectangular patch which has the dimension of 27.83mm*36.08mm, operating at frequency 2.45GHz with the help of standard formulae given for rectangular patch antenna. The overall size of the substrate is 56mm*66mm.Simulation has been done using an electromagnetic set up solver FEM. The antenna has design up to the 2nd iteration. It has designed on Epoxy FR-4 substrate with thickness of the substrate is 1.6 mm, dielectric constant of 4.4. The conducting material has chosen as copper clad. For designing an antenna an essential parameters are required can be calculate according to the transmission line method which are width (W), length (L), resonant frequency (fo) and the height of substrate (h). The predictable microstrip Double inverted L shape fractal antenna has designed by adopting the standard measures.

$$w = \frac{c}{2f0\sqrt{\frac{\in r+1}{2}}} \quad \text{…………………(1)}$$

1. Width (W) of antenna, calculate by,
f0 = 2.45 GHz, ε r = 4.4, c = 3 × 10m/s
We get, W = 38.08 mm

2. Effective dielectric constant (ε reff), which is determined by,

$$\in ref = \frac{\in r+1}{2} + \frac{\in r-1}{2}[1+12\frac{h}{w}]^{-0.5} \quad \text{……………….(2)}$$

For εr=4.4, h=1.6mm, W=29.25mm
We get εreff=3.99
Step 2: Calculation of Length of Patch (L)-
The effective length due to fringing is given as:

$$Leff = \frac{c}{2f0\sqrt{\in reff}} \quad \text{…………………...(3)}$$

For c=3*10^11 mm/s, εreff=3.99, f o=2.4GHz
We get Leff =29.25 mm
Due to fringing the dimension of the patch as increased by ΔL on both the sides, given by:

$$\Delta L = 0.412h\frac{(\in reff+0.3)(\frac{w}{h}+0.264)}{(\in reff-0.258)(\frac{w}{h}+0.8)} \quad \text{…………(4)}$$

For W=29.25mm, h, =1.53mm, εreff=3.99
We get ΔL=0.70mm
Hence the length the of the patch is:
L= Leff-2ΔL=28.4 mm
Dimension of ground plane (Ls) and (Ws) are determine by
Ls=L+2*6h=28+2*6*1.6=48mm
Ws=W+2*6h=38+2*6*1.6=56mm

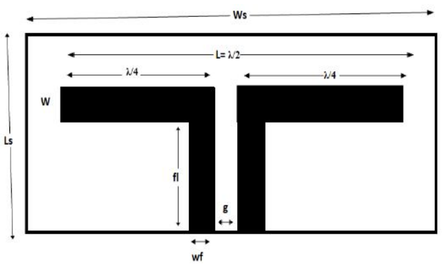
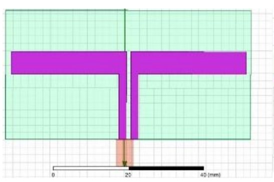
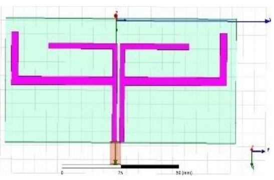


Fig.1 Proposed Multiband Planer dipole Antenna

From fig. 1, the width (Gl) of the ground plane on each Side of the CPW middle. Spacing (g) between ground plane and central patch and the separation (Sp) between ground plane and patch feed line is 3.6 mm.CPW feed has used for exhibiting wide bandwidth toning, coplanar ability lower dispersion at upper frequencies and easiness of design and fabrication. L = 27mm, W = 37mm, L1 = 13mm, L2=8mm W1=8mm, W2 = 4.8mm, Fl = 15mm, Gl = 23mm, g=0.7mm, Ls = 50mm, Gl=8mm and Ws = 58mm and Sp=3.6mm Figure 1 shows the design of both proposed Koch fractal patch antennas and its dimension. As shown in the Figure, the patches are fed by CPW.


Case 1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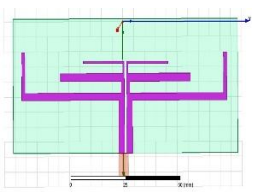
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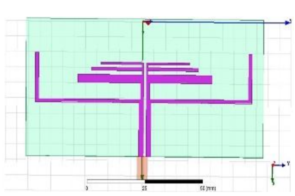

Case 4

Fig. 2. Configuration of the proposed double inverted L shape antenna with CPW Feeding

In our present work we have mainly focused on generating of Multiband characteristics which yields increases the bandwidth and reduced the size of antenna. From fig.1, rectangular patch has used as base shape and in 0th iteration, L shape patch have scaled of the order of 1/3 of base form used as generator. In first iteration one L shape patches have again scaled of the order of 1/3 of base form have been located touching the base shape. Likewise second iteration has taken by further placing four L shape shaped patches at again reduced scale of the order 1/3. It has been established that as the iteration number and iteration factor increases, the resonance frequencies become lower than that of the previous one that represents the double inverted L shape patch.

III.RESULTS AND DISCUSSIONS

The proposed double inverted L shape fractal antenna has simulated and analyzed using HFSS software and verified up to 4th iteration between the frequency ranges 800MHz to 2.4GHz. The 4th iteration is found to have better antenna parameters compared to the 1st and 3rd iteration. From fig.3, the return loss plot has been found that antenna coordinated in three resonant frequencies effectively below -20 dB which is appeared at 2.2GHz respectively. The return loss in Multiband are suitable and all bandwidth are wider as shown in fig.3. From the return loss plot it has observed that antenna has suitable for IEEE GSM (800 MHz), GSM (1800 MHz) and LTE (2.2 GHz) and ISM (2.4 GHz).The finest results are obtained for 4th iteration. Iteration plays significant role in achieving dual frequency and wider the bandwidth. Return loss result after 3rd iteration has shown in fig.3

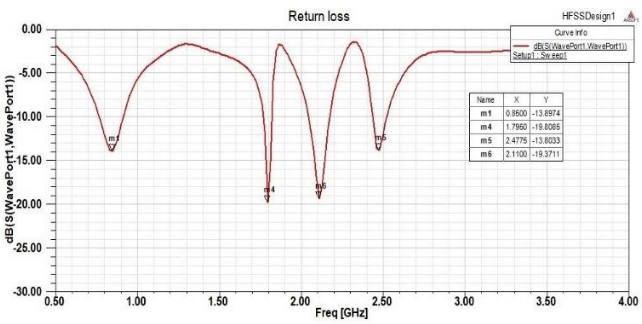


Fig 3: Return loss of the proposed Double inverted L Shape fractal antenna

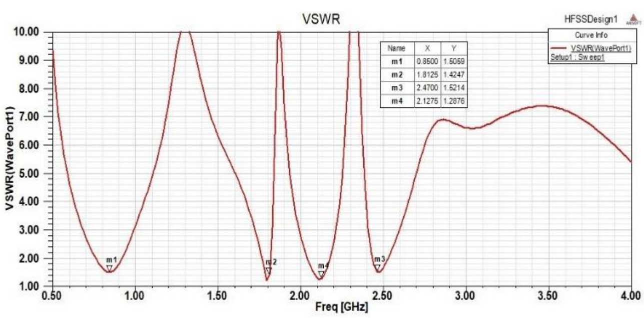


Fig.4 VSWR of proposed antenna

The value of VSWR is not as much of 2 for the antenna to work efficiently. Fig.4 shows, VSWR vs. frequency plot, it is found that the VSWR is in between 1 and 2 at each frequency bands. GSM (800 MHz), GSM (1800 MHz) and LTE (2.2 GHz) and ISM (2.4 GHz).

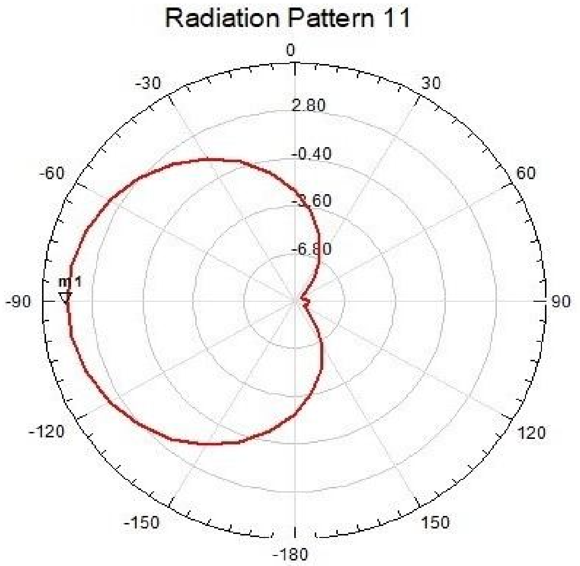
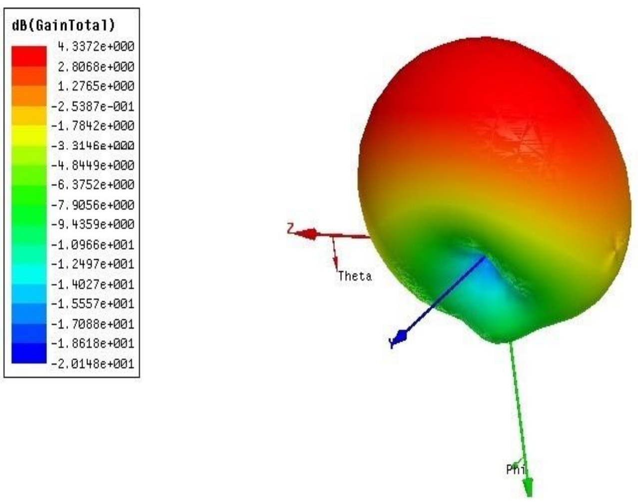


Fig.5 Radiation pattern

Fig.5 it is observed that the radiation patterns of antenna are Omnidirectional in H-plane & bidirectional in E plane at frequency 2.4GHZ.



The simulated gain of the antenna at 2.45 GHz is presented in Figure 6.The maximum gain is 4.1 dBi at 2.45 GHz.

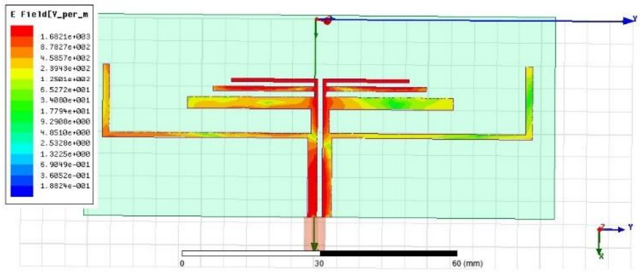


Fig.7 Surface current distributions

The current distribution of the antenna at 2.4 GHz is presented in Figure 7. it has been seen that the magnetic current at the middle gap and the electric current on the patch section of the antenna around the gap is crucial for resonance and radiation characteristics of such antenna Red arrow indicates maximum current along the edge of radiating patch.

IV.COMPARISON TABLE

To improve the performance of this antenna, double inverted L shape asymmetric shape is introduced .As seen from the table, number iterations increases then higher freq is shifted to lower side. It conclude that proposed patch antenna technique's both bandwidth & compact size of antenna has been improved.

Sr.	Type of Antenna	Freq (GHZ)	Return Loss(dB)	VSWR	Bandwidth (MHZ)	Gain [dB]
1	Single band	2.4	-26.88	1.15	360	6.6
2	Dual band	0.90 1.84	-14.23 -11.14	1.55 1.78	360 210	5.4
3	Triple Band	0.93 1.84 2.47	-11.29 -16.47 -15.71	1.77 1.51 1.53	150 155 175	6.4
4	Four Band	0.85 0.93 1.80 2.45	-13.89 -19.80 -13.80 -19.37	1.50 1.421 1.52 1.28	135 90 85 70	4.33

Table 1 Comparison table of iterations

VI. TESTING RESULTS

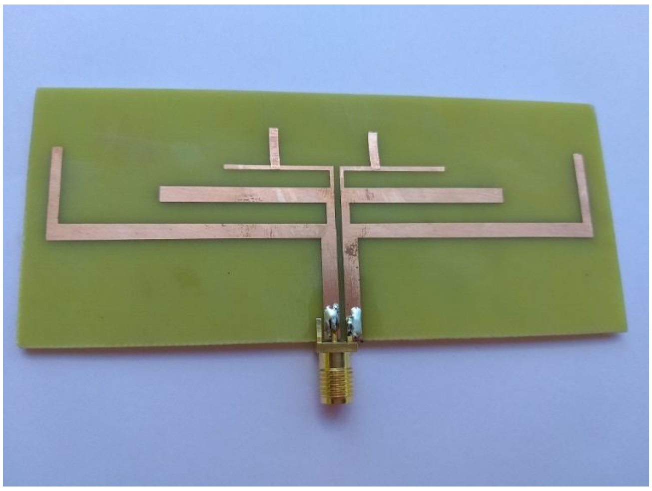


Fig7. Multiband Antenna 1

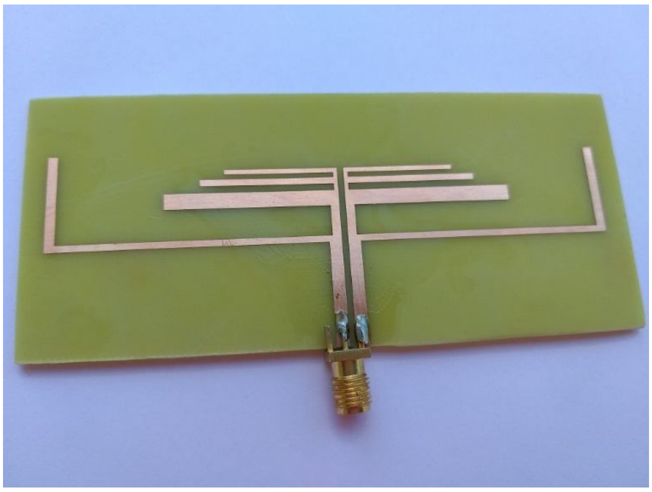


Fig8. Multiband Antenna 2

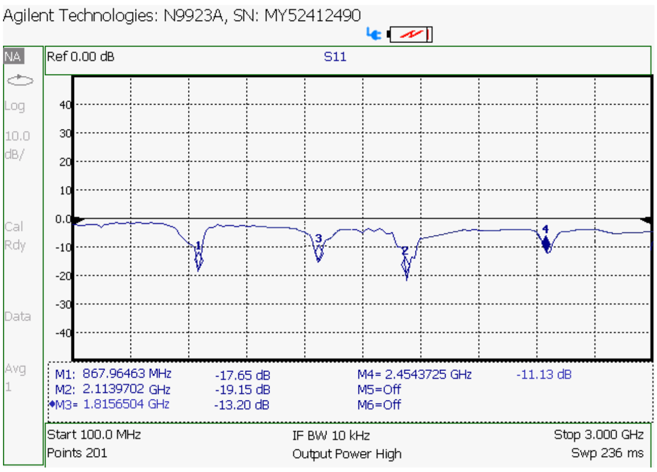


Fig. 9 Return loss of final Antenna

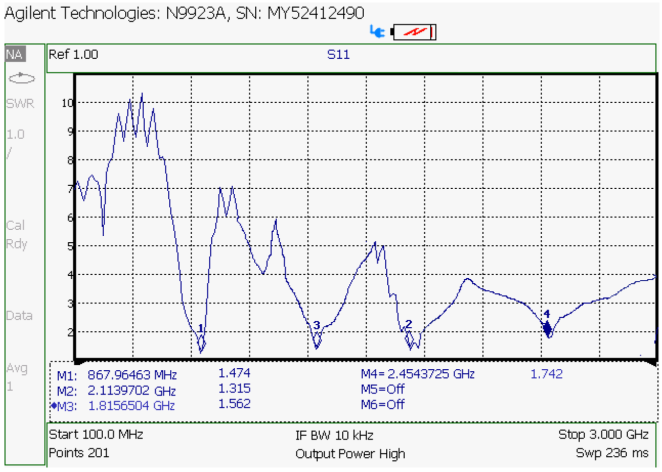


Fig. 10 VSWR of final Antenna

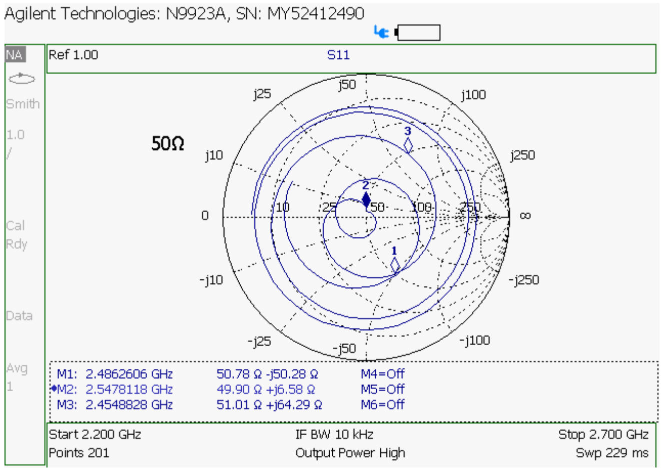


Fig. 11 Smith Chart of final Antenna

VI. CONCLUSION

A planer dipole structure geometry has just been investigated and found to be an easy and effective method to shrink the antenna size as well as excite additional resonance modes. Multiple dipole Structure adds an extra degree of freedom in microwave circuit design and opens the door to a wide range of application.

A compact planer dipole Multiband fractal antenna has investigated in this paper. The simulated results shows that the antenna has a good return loss, and the antenna gain is near 4 dB at the considered frequency and other Multiband frequencies suitable for ISM/LTE/GSM at 2400MHZ/2200MHz/1800MHZ/800MHz. The geometry has implemented by using HFSS electromagnetic tool as simulation software. Further improvement is possible if more L shape is introduced or by further modifying the size used. Since it reveals excellent Multiband characteristics, it has found its application in Mobile wireless application. The proposed microstrip antenna assures compactness, wide bandwidth in design and ease in fabrication

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