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Design of a Rectangular Fractal Patch Geometry for Modern Communication Systems

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Abstract: ***In modern wireless communication systems, compact multiband antennas with wider bandwidth and low profile configuration are in great demand. This has initiated antenna research in many directions. One of such antennas is a fractal shaped antenna element. The fractal structures may be designed by stacking of numerous small units together in such a way that the final geometry has the same shape as that of the unit structure. In addition to their larger bandwidths, fractal antennas are compact in size relative to the conventional antennas because of their efficient volume filling nature. In the present paper, design of new compact fractal multiband antenna geometry is presented. This antenna is targeted for application in Wi-MAX communication systems which operates in three bands namely lower band (2.3 to 2.9 GHz), medium band (3.4 to 3.96 GHz) and upper band (5.25 to 5.85 GHz). Two iterations of the rectangular fractal multiband antenna, with probe feeding in 2-6 GHz band are examined. The proposed antenna resonates at three frequencies namely 2.8 GHz, 3.95 GHz and 5.8 GHz after 2nd iteration. These three frequencies lie in the three considered bands. From the return loss variations with frequency; it is realized that proposed antenna may also be used for Wi-Fi (5.1-5.825 GHz) applications. Finally this antenna is fabricated and its return loss, VSWR and input impedance variations with frequency are tested.***

Antenna Configuration -

The design paramters of proposed antenna are as folllows:

(i) The base antenna geometry is a rectangle with width length '*a*'= 20.2mm and width '*b*' = 19.8mm.

(i) The antenna structure is simulated on glass epoxy FR4 dielectric substrate having dielectric constant (ε_r) and loss tangent (tanδ)of the substrate equal to 4.4 and 0.025 respectively. The thickness of substrate is h = 1.59mm and the patch thickness is 0.0035mm.

(ii) The antenna is fed through a 50Ω coaxial probe of diameter 1.24mm.

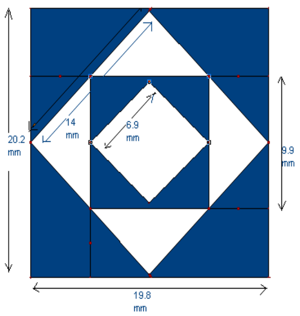

Fig. 1: Design of considered patch geometry

The geometry of final patch geometry is given in figure 1. This geometry is obtained after several optimizations in each step of iteration. The variations of reflection coefficient and input impedance of antenna suggests that antenna is resonating at three frequencies namely 2.8 GHz, 3.95GHz and 5.8GHz. These three frequencies lie in the three frequency bands allocated for modern days Wi-Max communication systems. Corresponding to these frequencies, the impedance bandwidths are 7.3%, 30% and 11.1% respectively. These bandwidths are much higher than those obtained for a conventional tectangulat patch antenna with same patch size. The three simulated input impedances are (55.59-3.38j)Ω at frequency 2.8GHz, (55.59-3.38j)Ω at frequency 3.95GHz and (55.59-3.38j) Ω at frequency 5.8GHz, which are close to 50 Ω impedance of coaxial probe.

Simulation and Measured Results-

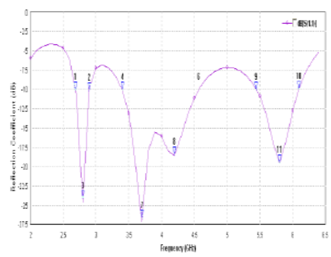

Fig. 2(a): Simulated variation in reflection coefficient of antenna with frequency

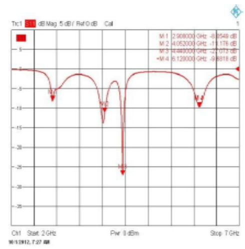

Fig. 2(b): measured variation in reflection coefficient of antenna with frequency

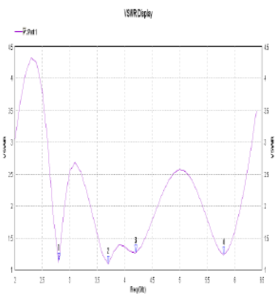

Fig 3(a)simulated variations in VSWR with frequency

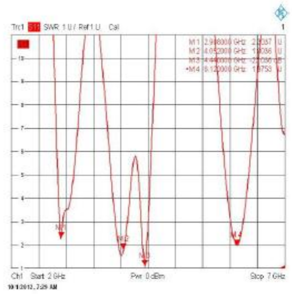

Fig3(b) Measured Variations in VSWR with frequency

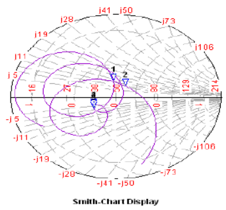

Fig. 4(a): Simulated variation in smith chart of antenna with frequency

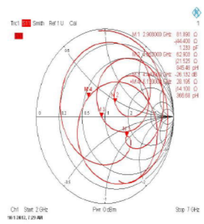

Fig.4(b) measured Variation in smith chart of antenna with frequency

The two dimensional simulated E and H plane radiation patterns of the antenna are shown in figs. 5(a) - 5(d) respectively. These patterns are obtained for all the three frequencies bands achieved through simulation analysis and representative patterns are reported here in lower band and median band.

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In the first frequency band where resonance frequency is 2.8 GHz, both E and H planes, patterns are symmetric in nature and the direction of maximum radiations is normal to patch geometry. In the second frequency band from 3.41 GHz to 4.63GHz where resonance frequency is 3.95 GHz, again both E and H planes, patterns are symmetric in nature and the direction of maximum radiations is normal to patch geometry. At resonance frequency 3.4GHz; the E plane patterns are little more directive than H plane patterns. In the third frequency band from 5.4 GHz to 6.09GHz where resonance frequency is 5.8 GHz, both E and H planes, patterns are no more symmetric in nature and the direction of maximum radiations is inclined at an angle $\theta = 60^o$.

In the third frequency band in both simulated and measured input impedance variations, a very small loop is realized. This suggests a possibility, of circular polarization. It is verified through simulation of axial ratio. If the axial ratio is less than 3dB; presence of circular polarization is confirmed. Through simulation analysis we realized that the axial ratio 2.6dB which confirms the circular polarization though it is not very pure in nature.

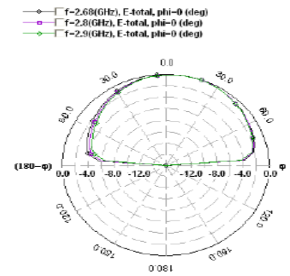

Fig. 5(a): Elevation pattern gain display of final patch antenna in lower frequency band

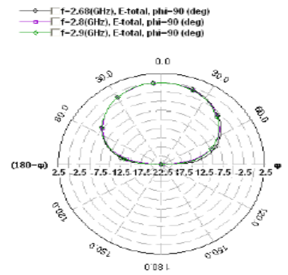

Fig. 5(b): Elevation pattern gain display of final patch antenna in lower frequency band

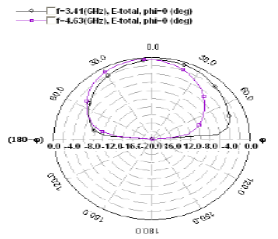

Fig. 5(c): Elevation pattern gain display of final patch antenna median frequency band

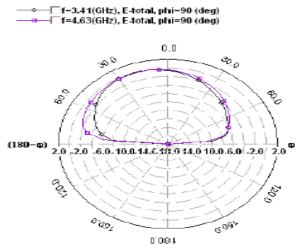

Fig. 5(d): Elevation pattern gain display of final patch antenna in median frequency band

CONCLUSIONS

Based upon the outcomes, it can be realised that proposed compact fractal geometry describes a multi-band behavior with improved impedance bandwidths. The simulated results indicate that the antenna exhibits good reflection coefficients at respective resonance frequencies and is suitable for Wi MAX & Wi-Fi (5.1-5.825 GHz) applications. Experimental Verifications are done by fabricating and measuring the antenna. The simulated and measured results are in good agreement.

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