T Shape Eccentric Slot Stacked Microstrip Antenna for UMTS

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ABSTRACT
T shape eccentric microstrip antenna with circular polarization radiation for UMTS(universal mobile telecommunication system). The antenna have a thick air substrate of 5mm and stacked microstrip radiating patch, Where the return loss is less than -10 db. The results show that the dual band antenna, is able to achieve VSWR less than 2 and the return loss above the -10db.

Keyword –Microstrip antenna, stacked , dual band

I INTRODUCTION

Antennas are a very important component of communication systems. by definition, an antenna is a device used to transform an RF signal, traveling on a conductor, in to an electromagnetic wave in free space the broadband circularly polarized microstrip antennas play a vital role in wireless communication due to its low-profile, small-size and light weight. Inspite of numerous advantages, microstrip antenna, suffers from disadvantages like low gain and narrow impedance bandwidth [1 2]. Substrate with low dielectric constants, multilayer structures and utilizing air gaps between the dielectric layers can enhance the impedance [2], through coupling cross-slot to excite the radiating patch [3],
The distance between the radiating patch and the ground plane is (1.6+.0012 mm).

II ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed broadband microstrip antenna, The radiating T shape patch , printed on a substrate of thickness 8.2 mm and relative permittivity ε_r, has the dielectric material thickness is 1.6mm the length of both side, L=29 mm ,and W = 29 mm and the ground plate consist of Lg = 38.6 and Wg =38.6 mm is excited by the distance of feed point is (19.5, 30.2)mm.

Rectangular patch antennas can be designed by using a cavity model [5] suitable for moderate bandwidth antennas. The lowest-order mode, TM_{10}, resonates when the effective length across the patch is a half-wavelength. "Fig.1", demonstrates the patch fed below from a coaxial along the resonant length. Radiation occurs due to the fringing fields. These fields extend the effective open circuit (magnetic wall) beyond the edge.

III ANALYSIS

(a) **Resonance frequency of antenna:-** The resonance frequency f_{mn} depends on the patch size, cavity dimension, and the filling dielectric constant, as follows:

$$f_{mn} = \frac{k_{mn} c}{2\pi \sqrt{\varepsilon_r}} \qquad (1)$$

where m = 0, 1, 2, and n = 0, 1, 2…,

k_{mn} = wave number at m, n mode, **c** is the velocity of light, ε_r is the dielectric constant of substrate, and

$$k_{mn} = \sqrt{\left(\frac{m\pi}{W}\right)^2 + \left(\frac{n\pi}{L}\right)^2} \qquad (2)$$

For TM_{01} mode, the length of non-radiating rectangular patch's edge at a certain resonance frequency and dielectric constant according to equation (1) becomes

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_r}} \qquad (3)$$

$$W = \frac{c}{f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (4)$$

Where f_r = resonance frequency at which the rectangular microstrip antennas are to be designed. The radiating edge W, patch width, is usually chosen such that it lies within the range L<W>2L, for efficient radiation. The ratio W/L = 1.5 gives good performance according to the side lobe appearances.

In practice the fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than L. Therefore, the actual value of the resonant frequency is slightly less than f_r. Taking into account the effect of fringing field, the effective dielectric constant for TM_{01} mode is derived using [6,7]

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_{eff}}} - 2\Delta l \qquad (5)$$

Where ε_{eff} = effective dielectric constant and Δl = line extension which is given as:

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r + 1)}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (6)$$

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

(7)

(b) **Cavity Field of Antenna:**- From the cavity model explained above, the electric field is assumed to act entirely in the z-direction and to be a function only of the x and y coordinates i.e.

$$\vec{E} = \hat{Z}E_Z(x, y)$$

(8)

The z-component of the electric field E_z satisfies the two-dimensional wave equation

$$\frac{\partial^2 E_Z}{\partial x^2} + \frac{\partial^2 E_Z}{\partial y^2} + k^2 E_Z = 0$$

(9)

The outward current flowing on the perimeter of the patch must be zero (since the patch boundary is an open-circuit). So

$$\frac{\partial E_Z}{\partial n} = 0$$

(10)

Where n is the outward normal vector at the perimeter of the patch by using the separation of variables, the electric field of the m and n mode numbers [9] is

$$E_Z = E_0 Cos\left(\frac{m\pi x}{W}\right)\left(\frac{n\pi y}{L}\right)$$

(11)

(c) **Far field of antenna:**- For calculate the far field, the aperture model is used. The resonator surface is considered to be a set of four slots of width [8]. By using Green's function the following general form of the far field for any (m, n) mode

$$E(r) = \frac{jke^{-jkr}}{2\pi r}\left\{\bar{i}_\theta\left[E_x\cos\phi + E_y\sin\phi\right] + \bar{i}_\phi\left[-E_x\sin\phi\cos\theta + E_y\cos\phi\cos\theta\right]\right\}$$

(12)

Where

$$hE_Z\frac{L}{2}\sin c(\zeta a)j^n\left[\sin c\left(\eta\frac{L}{2} + \frac{n\pi}{2}\right) + (-1)^n\sin c\left(\eta\frac{L}{2} - \frac{n\pi}{2}\right)\right]$$

(13) and

$$E_y = \left[\left(-1-(-1)^n\right)j\sin\left(\eta\frac{L}{2}\right) + \left(1-(-1)^n\right)\cos\left(\eta\frac{L}{2}\right)\right]$$

$$hE_0\frac{W}{2}\sin c(\eta a)j^m\left[\sin c\left(\zeta\frac{W}{2} + \frac{m\pi}{2}\right) + (-1)^m\sin c\left(\zeta\frac{W}{2} - \frac{m\pi}{2}\right)\right]$$

(14)

Then the far field components are

$$E_\theta = \frac{jke^{-jkr}}{2\pi r}\left(E_x\cos\phi + E_y\sin\phi\right) \qquad (15)$$

$$E_\phi = \frac{jke^{-jkr}}{2\pi r}\left(-E_x\sin\phi\cos\theta + E_y\cos\phi\cos\theta\right) \quad (16)$$

Where $\zeta = k\sin\phi\cos\theta$, $\eta = k\sin\theta\sin\phi$, $k = \frac{2\pi}{\lambda_0}$, and λ_0 = wavelength in free space.

Equation (12) enables one to plot the radiation pattern for every mode of the rectangular microstrip patch antenna.

Graph shows the return loss of the antenna in fig 2, fig 3 indicate the vswr vs frequency,fig 4 represent the smith chart of the antenna ,fig 5 indicate the 3D view of proposed geometery ,fig 6 represent the 3D radiation pattern, fig 7 is directivity of antenna ,fig 8 indicate the gain of antenna, fig 9 shows the efficiencies of antenna and radiation ,fig 10 represent the axial ratio of antenna, fig 11,12,13 are shows the 2D radiation of antenna .

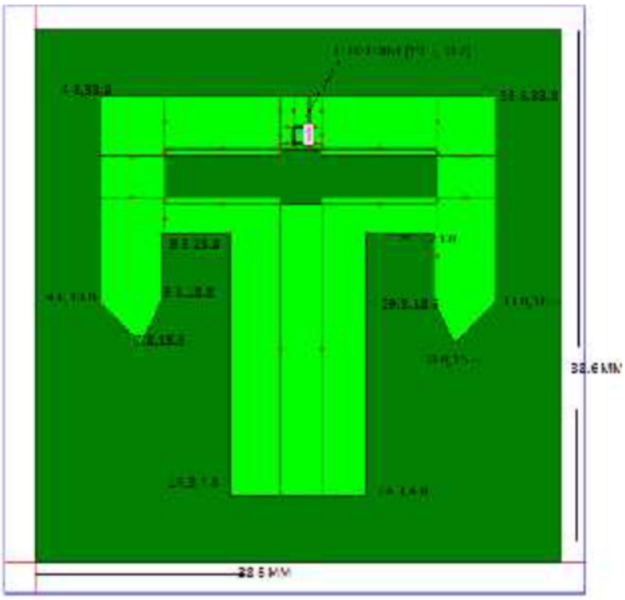

Fig. 1: Geometry of Proposed antenna on IE3-D

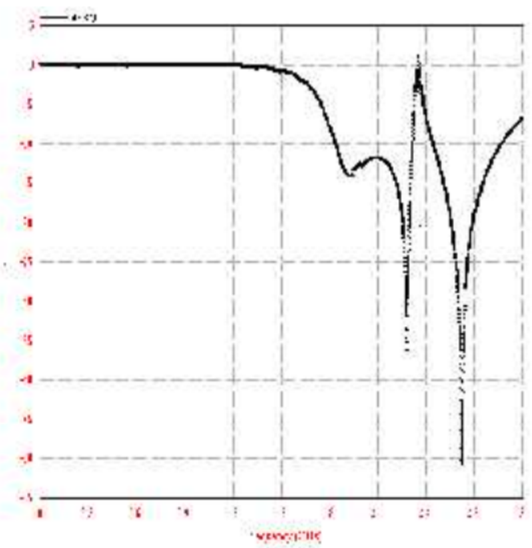

Fig. 2 : return loss Vs frequency.

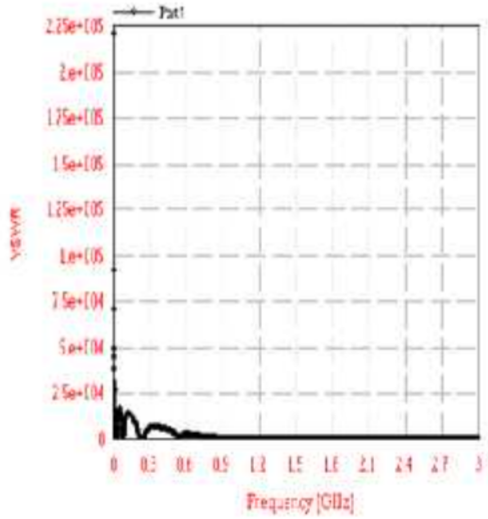

Fig. 3 VSWR versus frequency

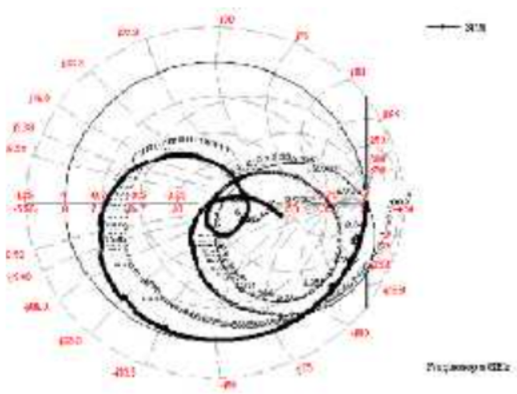

Fig. 4: smith chart of impedance

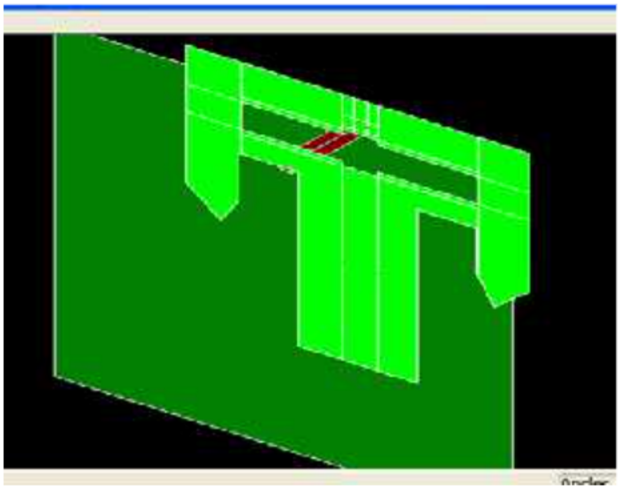

Fig. 5: 3D View of T shape Geometry

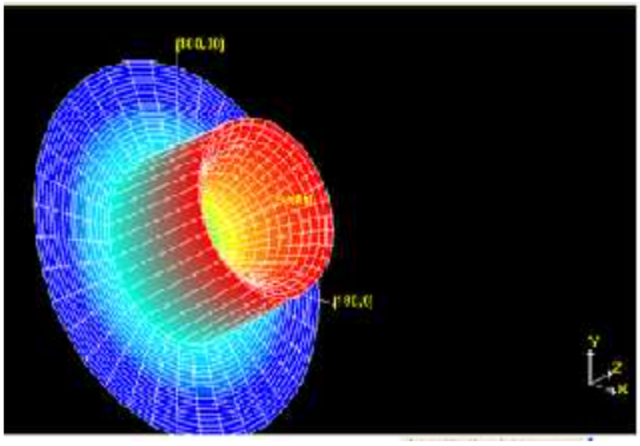

Fig.6 : Direction of maximum radiation pattern 3D

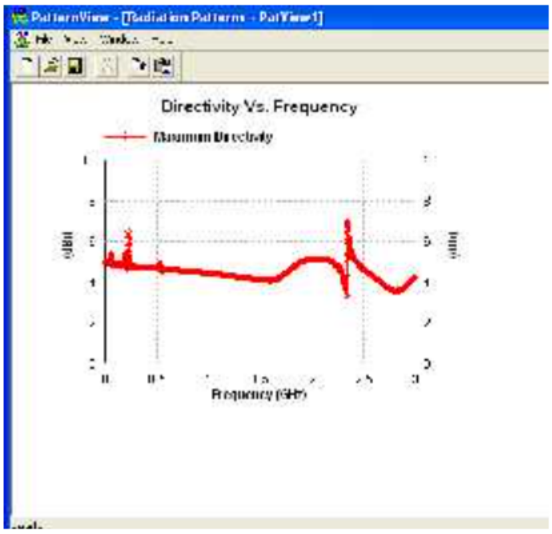

Fig. 7: Directivity of antenna in dB

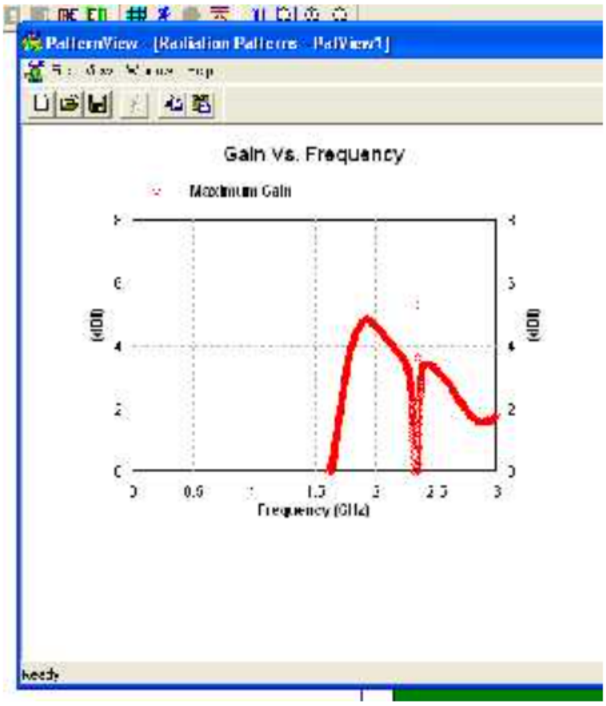

Fig. 8: Gain of antenna in dBi

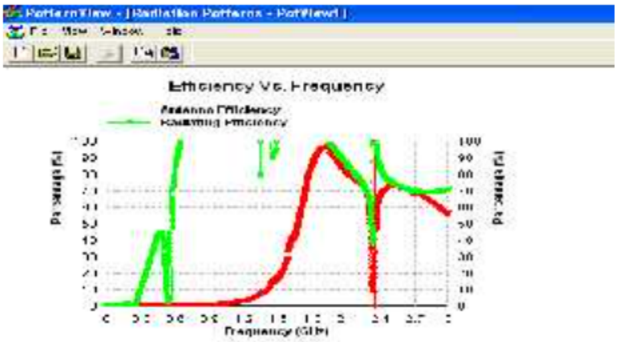

Fig. 9: Antenna efficiency and radiation efficiency

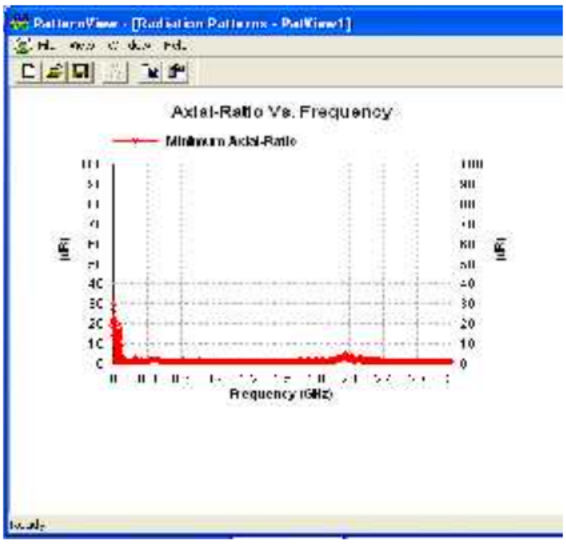

Fig. 10: Axial ratio of antenna <1, or = 1

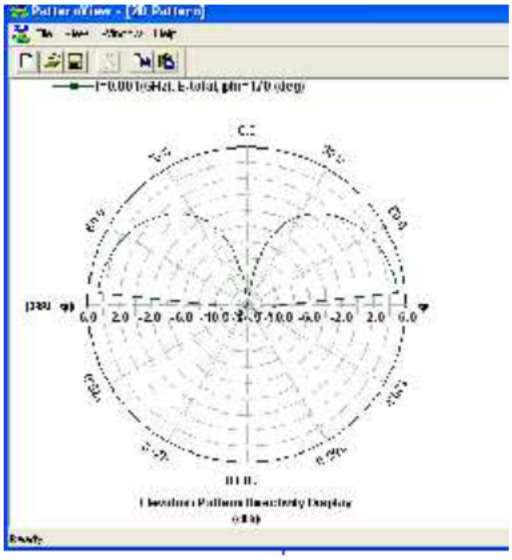

Fig. 11: 2D radiation pattern (polar plot)

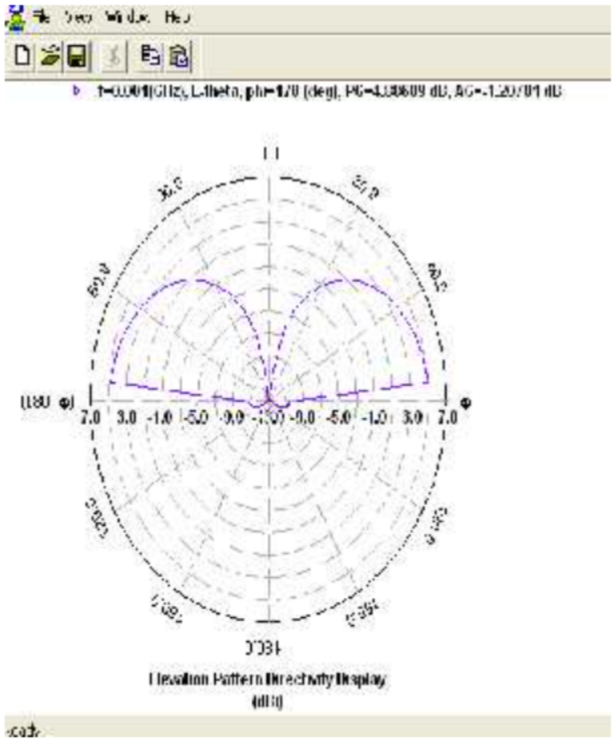

Fig. 12: 2-D radiation pattern

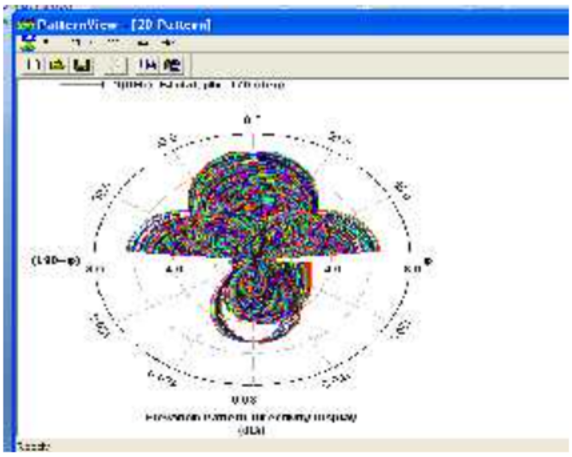

Fig. 13: 2-D radiation pattern (max. point)

Since the feed point connected with the coaxial connector, have good equal amplitude and 90° phase shift, dual band CP radiation can be achieved [5]. Furthermore, by using the thick air substrate, much wider CP bandwidth can thus be obtained. The impedance matching of the antenna can be achieved by fine adjusting the feed position, the distance between the radiating patch and the ground plane (1.6+.006mm).

In this paper, we have designed dual and stacked microstrip antenna with 2.5 ghz . The antenna has an output by using IE3D. A thick air substrate of 5 mm is used in the present proposed design, and impedance matching is obtained through the square radiating patch. The results show that the proposed antenna is able to achieve VSWR less than 2 and the return loss above the -10.db.

IV CONCLUSION

Characteristics of a design of broadband C P square microstrip antenna has been analysed. The proposed antenna is most suitable for universal mobile telecommunication systems (UMTS) which has the transmitter frequency of 1920-1980 Mhz ,and receiver frequency between 2110-2170 Mhz.

REFERENCES

[1] Milligan, T. A. (2005). *Modern antenna design*. Hoboken, New Jersey: John Wiley and sons.

[2] Kumar, G., & Ray, K. P. (2003). *Broadband microstrip antenna*. USA: Artech House.

[3] Khodai, G. F., Nourinia, J., & Ghobadi, C. (2008). A practical miniaturized U-slot patch antenna with enhanced bandwidth. *Progress in Electromagnetic Research B, 3*, 47–62.

[4] Ansari, J. A., Singh, P., & Yadav, N. P. (2009). Analysis of shorting pin loaded half disk patch antenna for wideband operation. *Progress in Electromagnetic Research C, 6*, 179–192.

[5] Ansari, J. A., Singh, P., & Yadav, N. P. (2009). Analysis of wideband multilayer patch antenna with two parasitic elements. *Microwave and Optical Technology Letters, 51*, 1397–1401.

[6] Sharma, A., & Singh, G. (2008). Design of single pin shorted three-dielectric layered substrates rectangular patch microstrip antenna for communication system. *Progress in Electromagnetic Research Letters, 2*, 157–165.

[7] Ansari, J. A., Ram, R. B., & Singh, P. (2008). Analysis of a gap-coupled stacked annular ring microstrip antenna. *Progress in Electromagnetic Research B, 4*, 147–158.

[8] Wong, K. L. (2005). *Compact and broadband microstrip antenna*. New York: John Wiley and sons.

[9] Sabban, A. (1983). A new broadband stacked two layer microstrip antenna. *IEEE AP-S International Symposium Digest* (pp. 63–66).

[10 Waterhouse, R. B. (1999). Broadband stacked shorted patch. *Electronics Letters, 35*, 98–100.

[11] P. C. Sharma, Kuldip. C. Gupta. Analysis and optimized design of signal feed circularly polarized microstrip antennas. IEEE Trans on Antennas andPropagat, Vol.AP-31, No.6, 1983

[12] Kin-Lu Wong and Jian-Yi Wu. Single-feed small circularly polarized square microstrip antenna. Electron. Lett, Vol.33 No.22, 1997

[13] C-Y Huang, J-Y Wu and K-L Wong.Cross-slot-coupled microstrip antenna and dielectric resonator antenna for circular polarization. IEEE Trans on Antennas and Propagat, 1999,47(4)

[14] S Matsuzawa and K Ito. Circularly polarized printed antenna fed by coplanar waveguide. Electron. Lett, Vol.32 No.22, 1996

[15] S. D. Targonski and D. M. Pozar. Design of wide-band circularly polarized aperture coupled microstrip antenna. IEEE Trans on Antennas and Propagat, vol. 41, pp. 214-220, 1993.