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DESIGN OF COMPACT L-SLIT MICROSTRIP PATCH ANTENNA FOR WiMAX APPLICATION

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Abstract-.A single feed compact Microstrip antenna is proposed in this paper. L slit introduced at right edge of patch to study the effect of the right edge of patch to study the effect of the slit on radiation behavior with respect to a conventional Microstrip patch.

The resonant frequencies are obtained at 3.44 GHz with corresponding return loss

The antenna has been reduced by 63 % when compared to a conventional rectangular Microstrip patch. The characteristics of the designed structure are investigated by using MoM based electromagnetic solver, IE3D.

I. INTRODUCTION

Wireless communications is rapidly progress due the development of lightweight, low profile, flush-mounted and single-feed antennas. Also, it is highly desirable to integrate several RF modules for different frequencies into one piece of equipment. Hence, multi-band antennas that can be used simultaneously in different standards have been in the focus points of many research projects [1-3]. To reduce the size of the antenna one of the effective technique is cutting slit in proper position on the microstrip patch. The work to be presented in this paper is also a compact microstrip antenna design obtained by cutting an L slit on the right edge of the patch. Our aim is to reduce the size of the antenna as well as increase the operating bandwidth. The proposed antenna (substrate with εr=2.4) has maximum gain of 6.53 dBi and presents a size reduction of 63% when compared to a conventional microstrip [4-7] patch with a maximum bandwidth of 56.13 MHz. The simulation has been carried out by IE3D software which uses the MOM method. Due to the Small size, low cost and low weight this antenna is a good candidate for the application of mobile communication.

II. DESCRIPTION OF ANTENNA STRCTURE AND PRINCIPLES OF DESIGN

A Micro strip patch antenna is a thin square patch on one side of a dielectric substrate and the other side having a plane to the ground. The simplest Micro strip patch antenna configuration would be the rectangular patch antenna. In its most fundamental form, a Micro strip antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on other side as shown in fig. below. The patch is generally made of conducting material such as copper or gold and takes any possible shape. The radiating patch and feed line is usually photo etched on dielectric substrate.

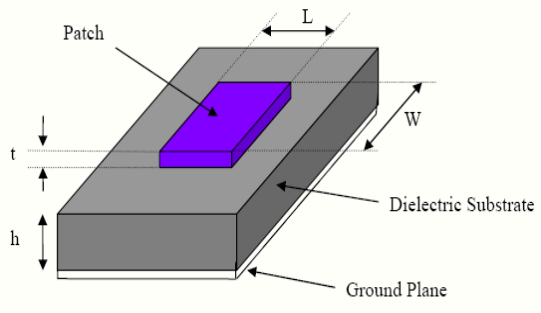

Fig-1 Structure of a Micro strip Patch Antenna

III. ANTENNA DESIGN

The configuration of the proposed antenna is shown in Figure 1. The antenna is a 38.34 mm x 31.53 mm rectangular patch. The dielectric material selected for this design is a Neltec NX 9240 epoxy with dielectric constant (εr) =2.4 and substrate height

IV. Design Specifications

IE3D is an integral full-wave electromagnetic simulation and optimization packages for analysis and design of 3D and planner microwave circuits MMIC, RFIC,RFID, antennas ,digital circuits and high speed printed circuit broads(PCB).since its formal introduce in 1993 IEEE international Microwave Symposium(IEEE IMS 1993),IE3D has been adopted as industrial standard in planner and 3D electromagnetic simulation.[9,11]

The essential parameters for the design of a circularly polarized Microstrip Patch Antenna are:

Frequency of operation (*fo*): The resonant frequency of the antenna must be selected appropriately. The high data rate wireless broadband networking

systems for future wireless communications are WiMAX .Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 3.0 GHz.

Dielectric constant of the substrate (ε_0): The dielectric material selected form design is fabricated on Glass Epoxy which has a dielectric constant of 2.4.

Height of dielectric substrate (h): the height of the dielectric substrate is selected as 1.578mm. Hence, the essential parameters for the design are:

- f_0=3GHz
- $\varepsilon_r = 2.4$
- $h = 1.58$
- c=velocity of light=$3\times 10^8 m/sec$
- characteristics impedance Z_c of Microstrip line feed is 50Ω

1. Calculation of Width (w)

By the formula:

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} = 38.24mm$$

2. Calculation of effective Dielectric constant(ε_{reff}):

By the formula:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{W}]^{\frac{1}{2}} = 2.27mm$$

3. Calculation extension Length(ΔL)

ΔL Is used for calculating resonant frequency of Micostrip antenna

By the formula:

$$\Delta L = 0.412\frac{\left(\frac{W}{h}+0.264\right)(\varepsilon_{reff}+0.3)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} = 0.8149mm$$

4. Calculation of Length (L)

By the formula:

$$L = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} - (2\times\Delta L) = 31.54mm$$

5. Calculation of inset depth

By the formula:

$$G_{12} = \frac{1}{120\pi^2}\int_0^{\pi}\left[\frac{\sin\left(\frac{K_0\omega}{2}\cos\theta\right)}{\cos\theta}\right]^2 J_0(K_0L\sin\theta)Sin^3\theta = 5.2093e-004$$

6. Input resistance for the inset-feed is given approximately by:

$$R_{in}(y=y_0) = \frac{1}{2(G_1+G_2)}cos^2\left(\frac{\pi}{L}y_0\right) = 44.32\Omega$$

$$= R_{in}(y_0=0)cos^2\left(\frac{\pi}{L}y_0\right)$$

$$= 107.669\ \Omega$$

7. Calculation of $Return\ loss$

By the formula:

$$\text{Returnloss} = -10\times log_{10}\left(1-I^2\right) = -18.3672db$$

V. EXPERIMENAL RESULT USING MATLAB

From fig2, conclude that resonance frequency is at 3 GHz and give return loss of nearly -18db.

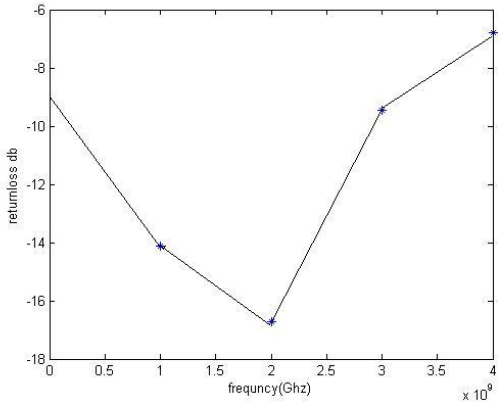

Fig 2 Return loss vs. Impedance match as a function of frequency plot (MATLAB)

From fig3 frequency vs. V.S.W.R plot, VSWR is 1.054db at frequency range 3 GHz. Thus V.S.W.R plot for antenna 1.4:1.this considers a good value of level of mismatched is not very high. High level of mismatch means port not properly matched.

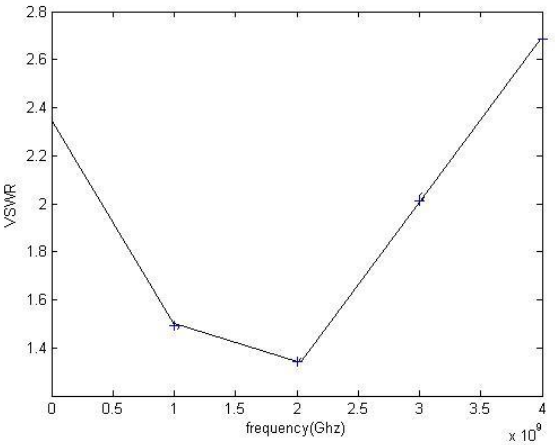

Figure 3 shows the impedance match as a function of frequency vs. VSWR

From Fig. 4 radiation pattern Microstrip antenna radiates toward its patch surface, Phi should start at 0 deg and stop at 90 deg with a 90 deg step size.

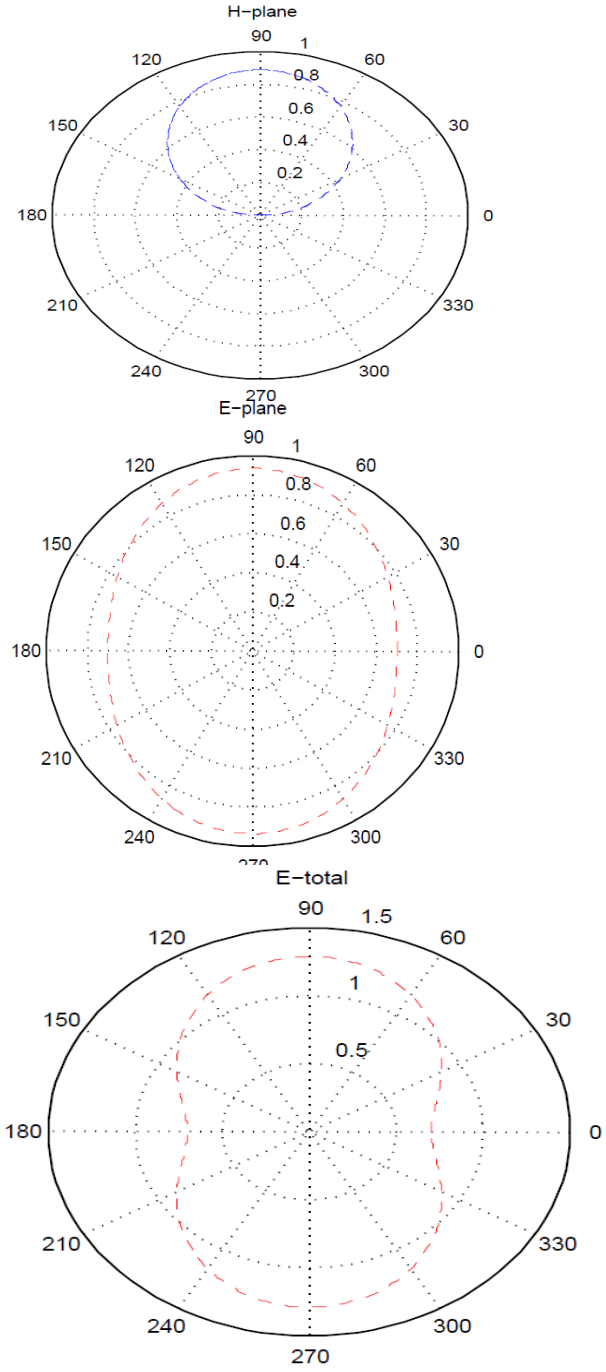

Figure 4: Radiation patterns at (a) E-plane and (b) H-plane (c) E-total

VI. SIMULATED RESULT USING IE3D

Given specifications were,

1. Dielectric constant (ε_r) = 2.4
2. Frequency (f_r) = 3.0 GHz.
3. Height (h) =1.58 mm.
4. Velocity of light (c) = 3×108 ms-1.
5. Practical width (W) = 38.24 mm.
6. Loss Tangent (tan δ) = 0.002
7. Practical Length (L) L = 31.54 mm

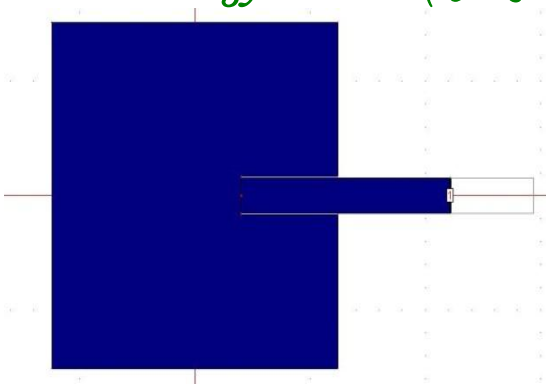

Fig. 5 Structural view of patch

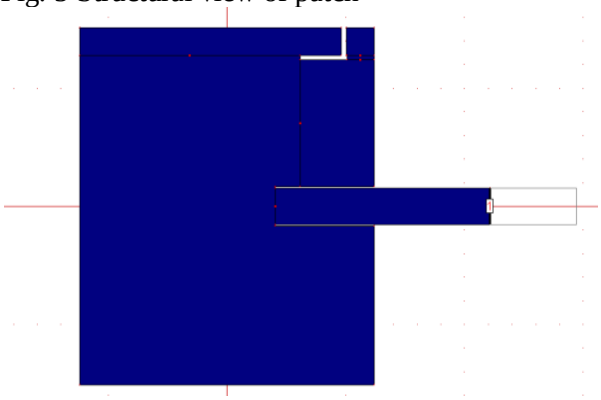

Fig 6 Structural view of L-slit patch

From Fig.7 conclude that resonance frequency is not exactly at 3 GHz, It is resonating at about 2.89 GHz and give return loss of nearly -12.5db.Return loss of antenna which should be -10db for good performance.-10db return loss means 90% of power is radiated.

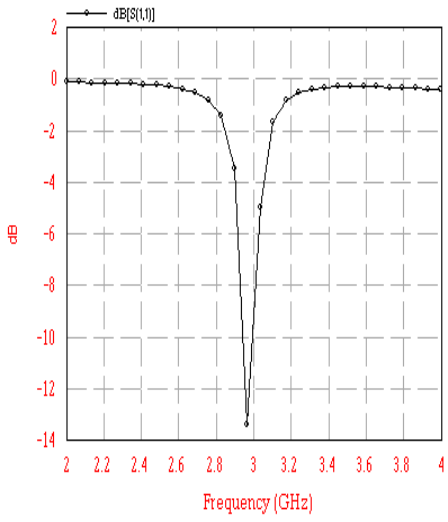

Fig 7 Frequency vs. return loss patch

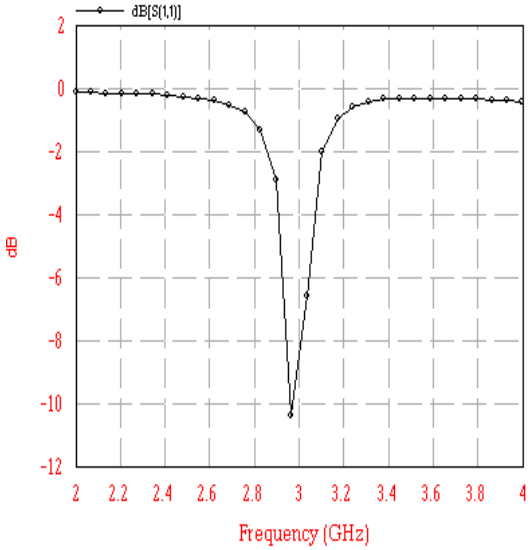

Fig 8 Frequency vs. return loss patch of L-slit antenna

From Fig.8 conclude that resonance frequency is not exactly at 3 GHz, It is resonating at about 2.89 GHz and give return loss of nearly -10.5db.Return loss of antenna which should be -10db for good performance.-10db return loss means 90% of power is Frequency vs. return loss patch

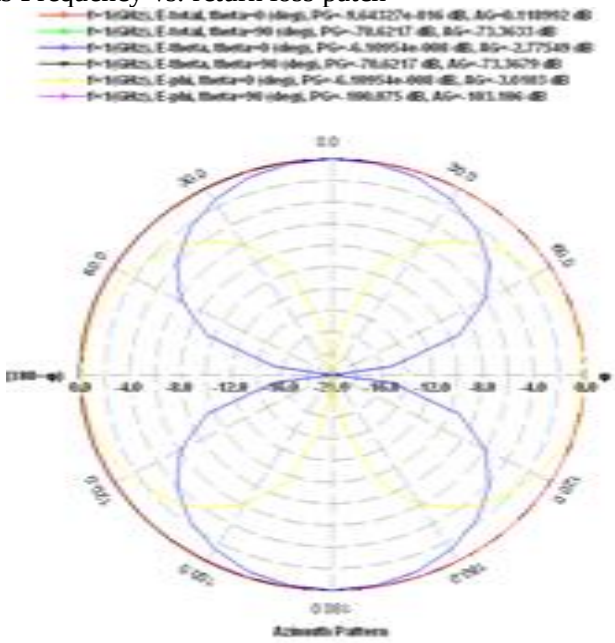

Fig 9 radiation pattern of E-plane, H-plane, E-total of L-slit antenna

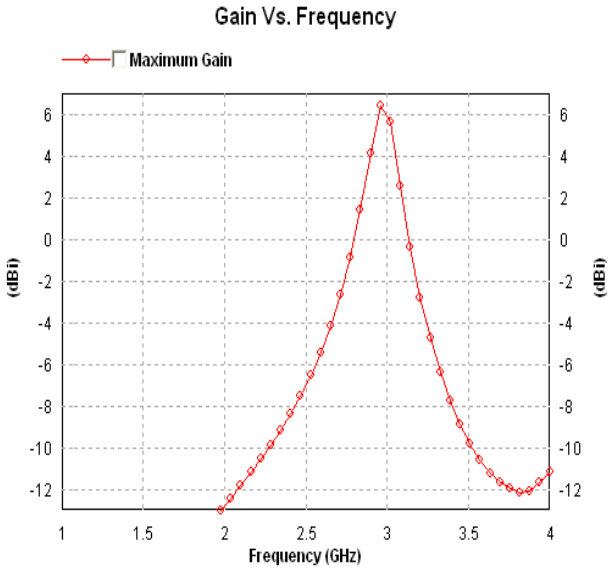

Fig 10 Gain vs Frequency plot
From fig 10 we find that maximum gain occur at 2.58Ghz frequency

Conclusion

A single feed single layer L slit microstrip antenna has been proposed in this paper. It is shown that the proposed antenna can operate in four frequency bands. The slit reduced the size of the antenna by 65 % and increase the bandwidth up to 53.13 MHz with a return loss of -14.25 dB, absolute gain about 6.53 dBi .Efficiency of antenna has been achieved 82 % for the higher band of operation. An optimization between size reduction and bandwidth enhancement is maintained in this work.
The theoretical results are compared with the simulated data obtained from IE3D.From MATLAB program, value of w, h, L, ε_{reff} insert depth(G_{12}), Return loss ,directivity, Beam widths of E-plane and H-plane of Microstrip antenna are calculated. Then Return loss vs. Frequency plot, V.S.W.R vs. Frequency, E-Plane polar-Plane polar plot and E-total polar plot are drawn. By using w, h, L, the simulated result using IE3D software are verified by measurement. For L slit Microstrip antenna design fabricates on Neltec NX 9240 substrate based, Microstrip board with dielectric constant 2.36 and the substrate height is 1.58 mm and loss tangent is 0.002. The properties of antenna such as bandwidth, S-Parameter has been investigated and compared between different optimization scheme and theoretical results.

Results shows that proposed of Microstrip patch antenna has very small size, wide bandwidth,

moderate gain and very good axial ratio bandwidth, required for communication using WiMAX.

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