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Dual Band Antenna for Wireless Communication

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***Abstract*—A wideband micro strip antenna has been designed for high speed wireless local area network ISM band (2.4GHz).Two slots are incorporated to perturb the surface current path, introducing local inductive effect that is responsible for the excitation of the second resonant mode. This is linearly polarized antenna. The antenna characteristics are analyzed by MOM method. The basic idea is to modify the structure and see the effects. The return loss is below-10db and VSWR<2 are achieved.**

Index Terms **-Directivity, gain, return loss, VSWR.**

I. INTRODUCTION

The micro stip antenna is one of the simplest radiating structures that can be built using printed circuits. Basic micro strip antenna and arrays are widely used in communication system, airborne and automotive application because of their light weight, conformal properties, suitable to integrate with active circuits and low cost. However the main drawback of micro strip antenna is narrow band width. To improve the bandwidth several approaches have been proposed. Among the improvement are; increasing substrate thickness, introducing parasite patches and cutting slots strategically in a metallic patch.The last approach resulted in thin antenna with excellent bandwidth. In this paper we will put emphasis on the analysis and modeling of slots in patch antenna. This antenna can be designed for wireless communication. A comprehensive study has been carried out to understand the effects of dimensional parameters and to optimize the performance of the final design

II. ANTENNA DESIGN METHOD

The geometries and the antenna resonant properties of the proposed antennas were designed and optimized using high electromagnetic field simulation software (IE3D). The length and slot parameters ls, ws, and tilt of slots of patch were adjusted using the simulation software to obtain the desired results to meet the design requirements. First a rectangular patch antenna is designed using the following design equations,

$$W = \frac{c}{2f0\frac{\sqrt{\varepsilon r+1}}{2}} \qquad (1)$$

$$\varepsilon e = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1+\frac{10h}{W}]\wedge(-0.5) \qquad (2)$$

$$fo = \frac{c}{2\sqrt{\varepsilon r}}[\left(\frac{m}{L}\right)\wedge 2+\left(\frac{n}{W}\right)\wedge 2]\wedge 0.5 \qquad (3)$$

$$Le = L + 2\Delta L = \frac{\lambda}{2\sqrt{\varepsilon e}} \qquad (4)$$

The calculation of patch dimensions is based on the transmission line model. A substrate of low dielectric constant is selected to obtain a compact radiating structure that meets the demanding bandwidth specification.

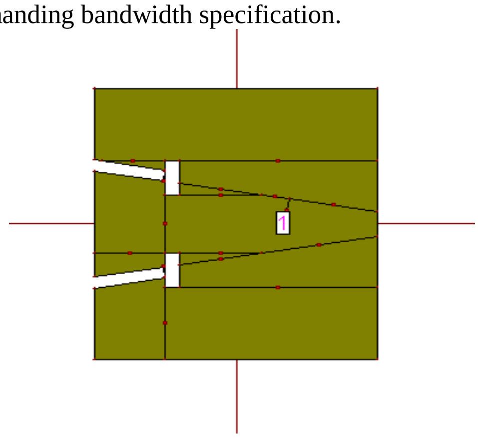

Fig.1Antenna Geometry

III. PARAMETRIC STUDY

A substrate with dielectric permittivity of 2.4 and thickness of 1.58mm is selected to obtain compact radiation structure. The antenna parameters are listed below

Table I: parametric Study

Parameters	Antenna
Length of patch (L)	39.6mm
Width of patch (W)	46.9mm
Substrate height	1.58mm
Dielectric constant (ε_r)	2.4

Table II: Parametric study

	Upper arm slot	Vertical slot	Lower arm slot	Vertical slot
X-coordinate	-19	-9	-19	-9
Y-coordinate	-10	-8	10	8
Z-coordinate	1.58	1.58	1.58	1.58
Length (mm)	18	2	18	2
Width (mm)	2	6	2	6
Rotation	10	0	-10	0

Coupling of power through a probe is one of the basic mechanisms for the transfer of microwave power. The probe can be an inner conductor of a coaxial line in the case of coaxial line feeding .The coaxial cable is attach to the back side of the printed circuit board and coaxial center conductor after passing through the substrate is soldered to the patch metalisation.The location of the feed is determined for the given mode so that the best impedance match is achieved.

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Excitation of the patch is achieved through the coupling of the feed current J_z to the E_z field of the patch mode .The coupling constant can be obtained as:

$$\text{Coupling} = \iiint E_z J_z dv \qquad (5)$$

$$= \cos(\Pi x_o / L) \qquad (6)$$

Where L = resonant length of the patch

X_o= offset of the feed point from the patch edge.

The above expression shows that coupling is maximum for a feed located at a radiating edge of the patch (X_o=0 or L). After selecting the patch dimensions L and W for a given substrate, the next task is to determine the feed location (x_o, yo) so as to obtain a good impedance match between the generator impedance and the input impedance of the patch element. It is observed that the change in feed location gives change in impedance hence provides a simple method for impedance matching. We see that if the feed is located $x_o = x_f$ and $0 \leq x_f \leq W$, the input resistance at resonance for the dominant mode TM_{10} mode can be expressed as

$$R_{in} = R_r \cos^2(\Pi xf/L) \qquad R_r \geq R_{in} \qquad (7)$$

Where xf is the inset feed distance form the radiating edge, and Rr is the radiation resistance at resonance when the patch is fed at a radiating edge .The radiation resistance Rr with an estimated accuracy of 10% average for h $\leq 0.03\lambda o$ and εr $\leq$ 10 are given as

$$R_r = V_o^2 / 2P_R \qquad (8)$$

$$= \varepsilon_{re} \quad \underline{Z_{o/}}\ 120I_2 \qquad (9)$$

Where Zo is the characteristic impedance of which the patch is a segment. The inset distance is selected such that Rin is equal to the feed line impedance, usually taken to be 50Ω. Although the feed point can be selected anywhere along the patch with , it is better to choose yf = W/2 if W$\geq L$ so that TM0n (n odd) modes are not excited along with the TM10 mode. Determination of exact feed point requires an iterative solution for impedance to match .The above equation provides a useful solution for the purpose. Kara has suggested an expression for xf that does not need calculation of radiation resistance .It is approximately given as

$$Xf = L/2\sqrt{\varepsilon re(L)} \qquad (10)$$

Where $\varepsilon re(L)$ is defined

$$\varepsilon re(L) = \underline{\varepsilon_r+1} + \underline{\varepsilon_r-1} \quad F(L/h) \qquad (11)$$

IV. SIMULATION RESULTS

The results of the simulated antenna are tabulated below

Table III: Antenna characteristics

Parameters	Freq2.27GHz	Freq2.5GHz
Return loss (db)	-11db	-12db
VSWR	1.98	1.96
Polarization	Linear	Linear
Gain	6.2dbi	4.2dbi
Directivity (db)	7.2dbi	8dbi
Radiation Efficiency	80%	70%

Polarization: The polarization of a rectangular patch antenna is linear and directed along the resonating dimensions, when operated in the dominant mode. Large bandwidth patch antennas may operate in the higher mode also. The radiation pattern and polarization for these modes can be different from the dominant mode. Another source for cross polarization is the fringing field along the non radiating edges .These fields are oriented 90^0 with respect to the field at the radiating edges. Their contribution to the radiation fields in the E and H planes is zero. However, in the intercardinal planes, even the ideal, single-mode patch will radiate cross polarized fields. The cross polarization level increases with substrate thickness. Circular polarization can be obtained from a nearly square patch by suitably locating the feed point [3].Polarization of the antenna can be changed mechanically or electronically. For electronic tuning, PIN diodes or varactor diodes can be used. For the dominant (1, 0) mode excitation and linear polarization, the mode (0, 2) contributes maximum to the cross polarization. The cross component of a rectangular patch can be minimized by a suitable choice of patch width W. Radiation Efficiency ε_r : The radiation efficiency is defined as the ratio of radiated power P_r to the input power P_i that is

$$\mathcal{E}_r = P_{r/}P_i \qquad (12)$$

The input power gets distributed in the form of radiated power, surface wave power, and dissipation in the conductors and dielectric. It has been observed that radiation efficiency depends on the substrate thickness and permittivity, and is not effected very much either by the patch shape or feed [4].Numerical values indicate that radiation efficiency is almost independent of aspect ratio W/L of the rectangular patch [5].

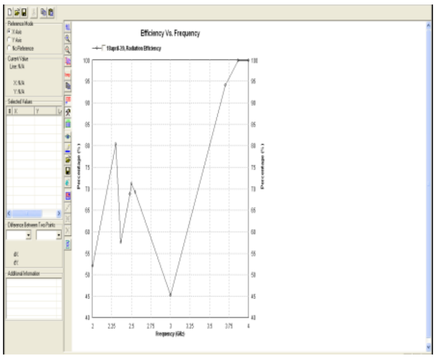

Fig.2 Radiation Efficiency

BANDWIDTH: If the antenna input impedance can be matched to its feeding structure across a certain frequency range, that frequency range will define the antenna bandwidth (BW). The bandwidth can be specified in terms of the return loss or the voltage standing ratio (VSWR). The typical values

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for micro strip antennas are VSWR<2 or return loss (S11 in db) < -10db. Furthermore, the BW is inversely proportional to the quality factor (Q) and given by

$$BW = \frac{VSWR - 1}{Q\sqrt{VSWR}} \quad (13)$$

The minimum quality factor is give by

$$Q_{min} = \frac{1 + 3(koR)^{\wedge}2}{(koR)^{\wedge}3 * [1 + (koR)^{\wedge}2]} \quad (14)$$

Where R is the minimum sphere radius which completely encloses the antenna. The technique to increase the bandwidth and to decrease the antenna dimensions generally employs, in combined way or not, high dielectric constant substrates, modification of patch shapes of the antennas.Also to reduce the area of the E antenna a technique of shorted pin between the patch and the ground plane may be applied in position where the higher frequency has major reduction in is value. As the bandwidth for wideband operation is due to interaction between close resonant frequencies, the first step is to verify that how the frequency response is modified when feed is applied to various positions.

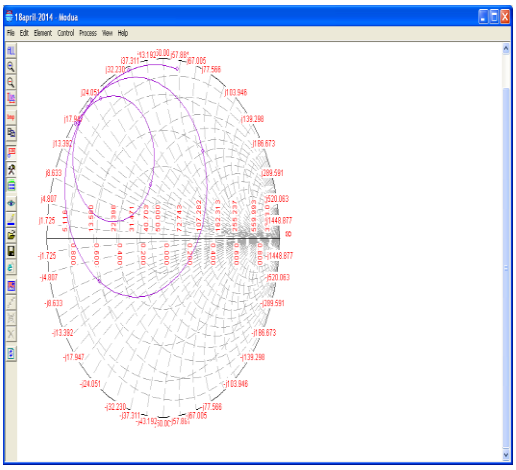

Fig.3 Smith Chart

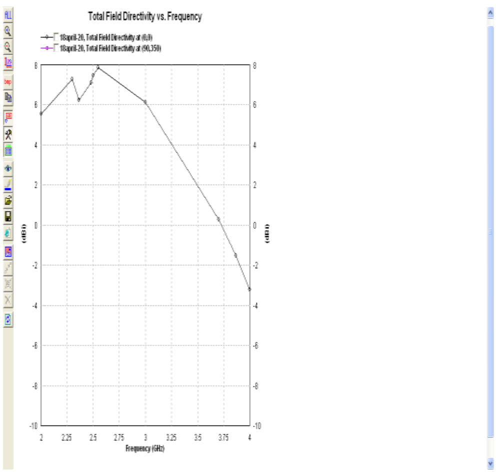

Fig. 4 Directivity

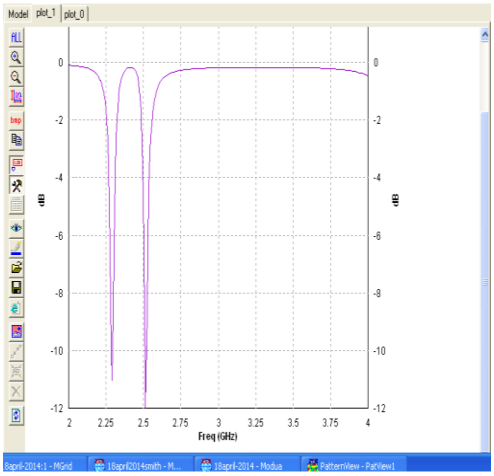

Fig.5 Return Loss

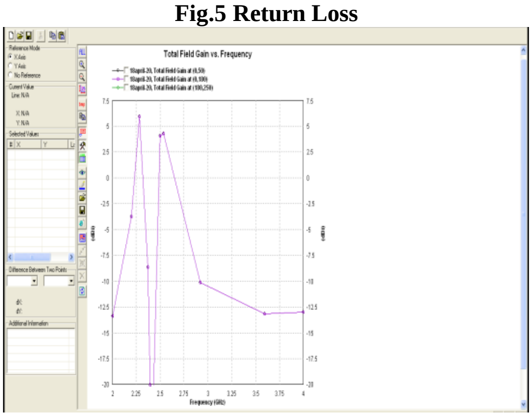

Fig.6 Gain

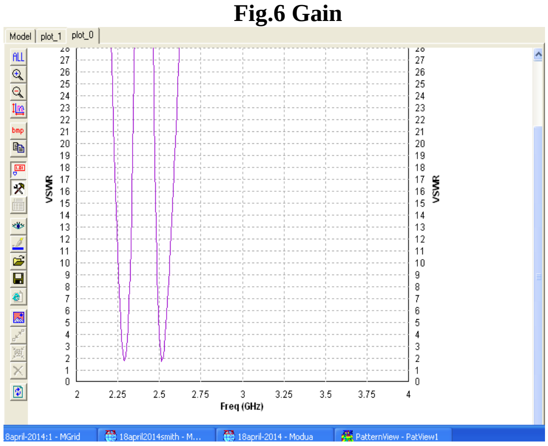

Fig.7 VSWR

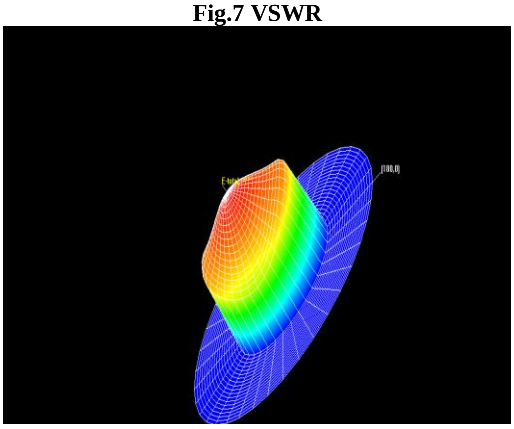

Fig.8 3D Radiation Pattern

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V. APPLICATION

For many applications, the advantages of micro strip antennas far outweigh their limitations. Initially, micro strip antennas found widespread applications in military systems such as missiles, rockets and satellites. Currently, these antennas are increasingly used in commercial sectors, due to reduced cost of substrate material and mature fabrication technology. With continued research and development and increased usage, micro strip antennas are ultimately accepted to replace conventional antennas for most applications. The present design has efficiency of 80% and can be used in wireless routers.

Fig.9 Wireless Router

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