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229 – 233

Development of Dual Band Dual Polarized Patch Antenna System for Indoor Application

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Abstract—Wireless communication systems have received increased interests in recent years , also increases demand of indoor wireless networks. Many buildings and malls have been installed with indoor wireless networks consisting of numerous indoor base station antennas. This paper presents dual band dual polarized patch antenna system for indoor application The substrate material FR4 is selected for microstrip patch antenna design. An analysis of the return loss, gain, axial ratio of the proposed antenna is carried out using ADS (Advanced Design System) software. The result shows that return loss ,gain and axial ratio at 2.4 GHz frequency respectively -28 dB ,3.662dBi,2.821 dB achieved and at 2.6 GHz frequency -10dB ,2.295,dBi,3.358 dB is achieved.

Keywords*-Microstrip patch antenna, indoor application , feeding techniques, ADS software, axial ratio*

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I. Introduction

In recent years, the demand for wireless communication system which provides high data rates, high quality of service and flexible interfaces is increasing. Especially, cellular phone systems or wireless local area networks (WLANs) have increased due to the increase in the number of people using their services .In recent years, also increased the demand of indoor wireless networks in the home, office, restaurant etc to connect internet to mobile, computer, laptop etc purpose. Many buildings and mall have been installed with indoor wireless networks consisting of numerous indoor base station antennas mounted on the ceiling. In fact, monopole antennas are widely used because vertically polarized radiation patterns are required. However, due to limited space available for the installation of the antenna and the wide bandwidth requirement, research has focused on the development of a compact wide-band, dual band patch antenna with monopole-like radiation patterns In indoor environment, integrated networks serving all operators are commonly installed. For this implementation, wideband or multiband antennas are needed[1]. Dual-wideband antenna for LTE indoor base stations.This antenna contains three separate radiating elements: a top rectangular patch with two U-shaped slots and two long rectangular slots for covering the higher frequency band of 1700–2700 MHz and two lower folded inverted-L-shaped elements for covering the lower frequency band of 800–960 MHz. It is expected that the presented antenna may find its immediate applications in all mobile and wireless systems, including 2G, 3G, 4G LTE, and WiFi.[1].Dual band antenna design using a circular patch with two capacitive feeding disks and arc-shaped slots. The CP was achieved by the use of the dual 90° phase shift disc feed method[2].Evolution process of dual polarized wideband MIMO antenna system with common elements suitable for wireless AP application at operating frequency band from 2.3-2.9 GHz is investigated. The proposed system comprises of two orthogonally modes wideband microstrip fed monopole antenna with common radiated element and L corner ground plane . Due to mutual coupling a new parasitic element is introduced in order to increase the isolation between the ports . The expected frequency band covers the WiFi and LTE applications[3].Two-port, pattern diversity antenna for 3G and 4G indoor application has been designed, fabricated, and measured. The antenna is a unique combination of a low-profile monocone antenna and a coupled-fed microstrip antenna. By reusing part of the antenna structure, the two antennas are integrated with little disruption for each other[4]Dual-band dual-polarized antenna which is applied in WiMax and WLAN bands has been demonstrated. The CP and LP radiation patterns have been obtained by using asymmetrical and symmetrical U-slots.[5].Wide-band dual-polarized antenna structure with a special feed con¯guration is proposed. The structure is able to operate within the frequency bandwidth 1900- 2700 MHz, which covers WLAN, UMTS and extends UMTS bands. The structure is initially designed and optimized; afterwards a prototype of the design is manufactured.[6].A compact wide-band monopolar patch antenna is designed and developed. It has a wide impedance

 ISSN: 2321-8169
229 – 233

bandwidth of 27.1%from 0.772 to 1.014 GHz. Also, it has nearly omnidirectional radiation pattern in the azimuth plane, which only has a maximum ripple level of 1.751 dB. Moreover, conical radiation patterns are obtained in the elevation planes is suitable to be used as the indoor base station antenna, which is mounted on the ceiling, for both CDMA800 and GSM900 mobile communication systems.[7]

Microstrip patch antennas are popular in wireless applications due to their low profile structure. Therefore they are highly compatible for embedded antennas in handheld wireless devices such as pagers, cellular phones etc. The telemetry and communication antennas on missiles are often in theform of Microstrip patch antennas. Now a days they have been used in Satellite communication [8,9].

So in this paper design system which covers dual band Wi-Fi and LTE isproposed. The two systems operate at different frequency bands with opposite polarization ,so they do not interfere each other

II. Introduction Of Patch Antenna And Feeding Techniques

Fig 1.shows the basic structure of patch antenna a radiating patch on the top and a ground plane on the bottom side. The patch is mainly made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the Substrate. For simplicity of analysis, the patch is mainly square, rectangular, circular, triangular, and elliptical or some other usual shape. For a rectangular patch, the length L of the patch is mainly in the range of 0.3333λ0 <L< 0.5λ0, where λ0 is the free space wavelength.

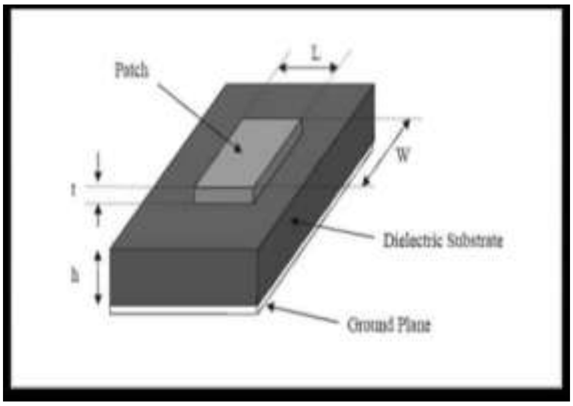

Fig 1. Structure of patch antenna[1]

There are different techniques available to feed or transmit electromagnetic energy to a Microstrip antenna. The MSA can be excited directly either by coaxial prob or microstrip line or it can be excited indirectly using electromagnetic coupling and coplanner waveguide feed . In which case there is no direct metallic contact between the feed line and the patch .Feeding technique influence the input impedance and characteristics of the antenna and is an important design parameter.

Microstrip line and the coaxial feeds are relatively easier to fabricate. Coaxial probe feed is used because it is easy to use and the input impedance of the coaxial cable in general is 50 ohm. There are several points on the patch which have 50 ohm impedance. We have to find out those points and match them with the input impedance. These points are find out through a mathematical model. Shows the diagram of coaxial feed at fig 2.

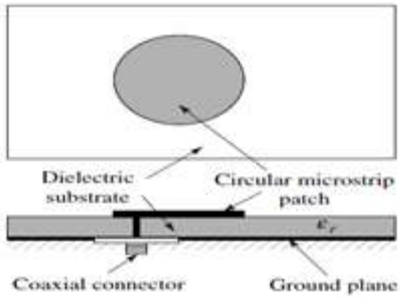

Figure 2. Rectangular Microstrip antenna coaxial feed [1]

In microstrip type of feeding technique, a conducting strip is connected directly to the edge of the Microstrip patch antenna .The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure .The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the position of inset . Hence this is an easy feeding scheme, since this technique provides ease of fabrication and simplicity in modelling as well as impedance matching. Shows the geometry of microstrip line feed is shown in fig 3

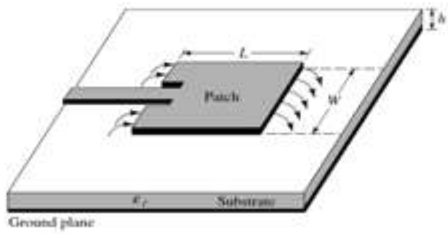

Figure 3.Rectangular Microstrip antenna Microstrip Line feeding [1].

III. PARAMETRIC STUDY OF MSA AND DESIGN EQUATION [2]

Effect of dielectric substrate (Ɛr): The first important parameter of good antenna design is dielectric substrate (Ɛr). A thick dielectric substrate having low dielectric constant is desirable. This provides better efficiency, larger bandwidth

ISSN: 2321-8169
229 – 233

and better radiation. The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power lower quality factor Q. FR-4 Epoxy which has a dielectric constant of 4.4 and loss tangent equal to 0.02 can be used for antenna design

Effect of feed point location : With change value of feed point from center of the patch to right side of the edge input impedance shift from clockwise direction with increase in frequency means that input impedance increases.

Effect of width: The resonant frequency decreases due to increase in $\Delta L$and $\in r$.The input impedance decreases because the radiation from radiating edge increases .Also BW of the antenna increases.

Effect of height: With increase in h , the fringing field from the edge increases which increases the the extension in height ΔL and hence the effective length , thereby decreasing frequency. The input impedance increases due to the increase in the probe inductance of the coaxial feed. The BW of the antenna increases .Efficiency decreases due to increase in cross polar level.

Effect of ground plane : For practical considerations, it is essential to have a finite ground plane if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery.

Feed Location Design: Coaxial probe feed is used because it is easy to use and the input impedance of the coaxial cable in general is 50 ohm. There are several points on the patch which have 50 ohm impedance. We have to find out those points and match them with the input impedance. Feed point is choosen so that where at the point of radiating patch maximum area of patch is covered. By changing feeding points antenna is radiate at different radiating frequency.

Effect of tangent loss : With increase in tanΩ the loss in the dielectric material increases and hence Zin decreases .The increase in loss tangent also decreases the impedance variation and increases the loss in the patch leading to increase in BW and a decrease in efficiency

Design equation :
The antenna parameters antenna can be calculated by the transmission line method [1]

1) Calculation of width:

$$W = \frac{1}{2\,f_r\sqrt{\mu_0\varepsilon_0}} \times \sqrt{\frac{2}{\varepsilon_r+1}} \quad \text{......................Equation 5.1}$$

2) Calculation of Effective dielectric constant:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\,\frac{h}{W}\right]^{-1/2} \text{........Equation 5.2}$$

3) Calculation of effective length:

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{eff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L \quad \text{..........Equation 5.3}$$

4) Calculation of the length extension:

$$\Delta L = 0.41h * \frac{\varepsilon_{eff}+0.3}{\varepsilon_{eff}-0.258} \times \frac{\frac{w}{h}+0.264}{\frac{w}{h}+0.8} \text{...Equation 5.4}$$

IV. DESIGN OF PATCH USING ADS SOFTWARE

Table 1 patch dimension of proposed geometry

Sr No	Parameter	2.4GHz	2.6 GHz
1	Width	28.5mm	34.8
2	Length	28.4 mm	34.9
3	Loss tangent	0.01	0.01
4	Dielectric constant of the substrate (εr)	4.6	4.6
5	Height of dielectric substrate (h)	1.6	1.6

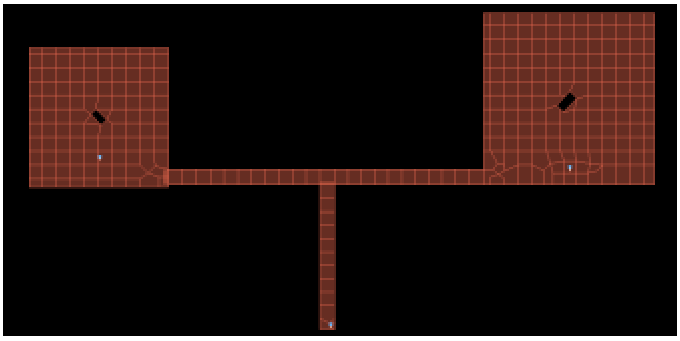

Fig 4 Geometry of proposed antenna

Shown in fig 4 geometry of proposed antenna in which at 2.4 GHz frequency slot width 3.041 mm and slot length 1.57 mm and slot at -45 degree and at 2.6 GHZ frequency patch slot width 3.960mm and length 1.980mm and slot at +45 degree
Shown in fig 5 which describe return loss at 2.4 GHz -28dB and at 2.6 GHz -10 dB achieved also shown fig 6and 7 gain and axial ratio at 2.4 GHz and fig 8,9 shown gain and axial ratio at 2.6 GHz axial ratio obtain atboth frequency approximately 3dB so provide circular polarization

ISSN: 2321-8169
229 – 233

Simulation result

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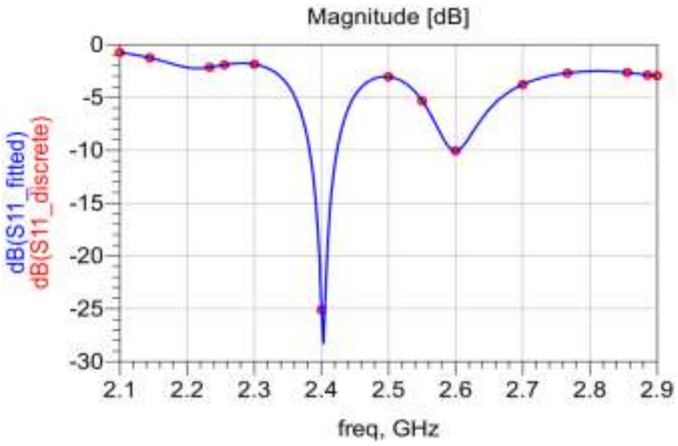

Fig 5 Frequencyvs Return loss plot of geometry

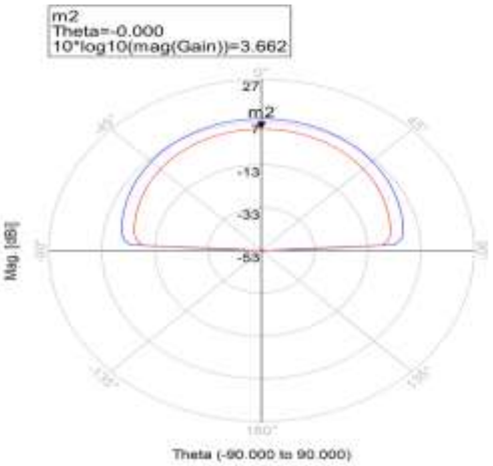

Fig 6 Gain plot of geometry at 2.4 GHz

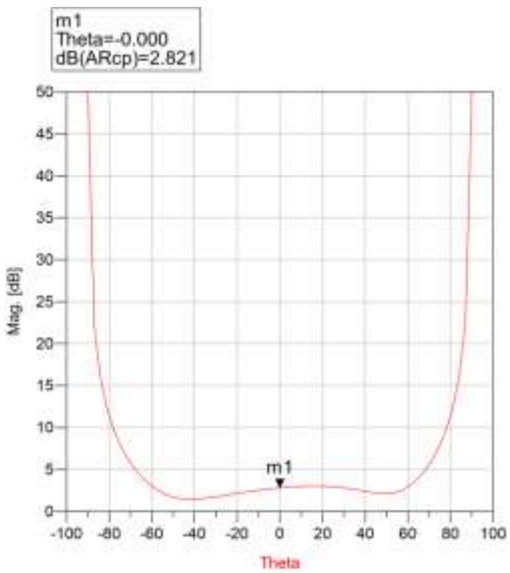

Fig 7 axial ratio of geometry at 2.4 GHz

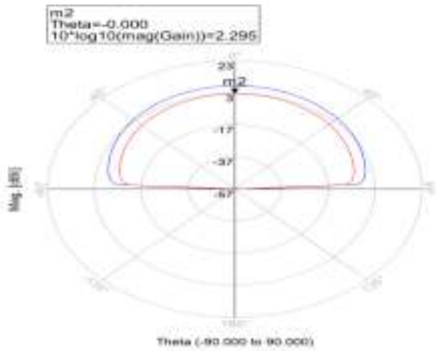

Fig 8 Gain plot of geometry at 2.6 GHz

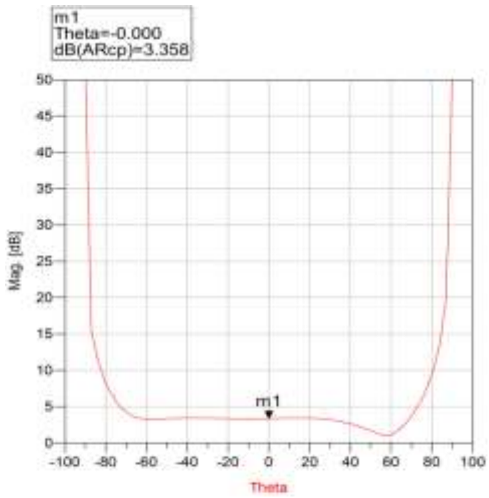

Fig 9 axial ratio of geometry at 2.6 GHz

Table 2 result of geometry

Sr No	Parameter	2.4GHz	2.6 GHz
1	Return loss	-28 dB	-10 dB
2	Gain	3.662	2.295
3	Axial ratio	2.821	3.358

V. CONCLUSION

In this paper describe the simulation of dual frequency dual polarized patch antennaa in ADS software at 2.4 GHz and 2.6 GHz frequency and result obtain at both frequency gain below 4 dB and at both frquency obtain axial ratio nearly 3dB which is good candidate for requirement of circular polarization and capable system in indoor environment

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