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Department of ECE, Aarupadai Veedu Institute of Technology, Vinayaka Missions University,

Paiyanoor-603 104, Tamil Nadu, India

Design of Microstrip Patch Antenna for WLAN Applications

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ABSTRACT: Microstrip patch antennas being popular because of light weight, low volume, thin profile configuration which can be made conformal. Wireless communication systems applications circular polarization antenna is placing vital role. In this study we introduce a new technique to produce circular polarization.Hybrid coupler is directly connected to microstrip antenna to get circular polarization. The dual fed circular polarized microstrip antenna is etched on a FR4 with dielectric substrate of 4.6 with the height of 1.6mm.Simulation is done by ADS software. Simulation results show that the designed antenna characteristic is suitable for Wi-Fi applications.

Index Terms— Circular Patch, Dual Feed, Hybrid Coupler, Microstrip antenna, Polarization, WLAN.

I. INTRODUCTION

Wireless LAN can be used either to replace wired LAN or as an extension of the wired LAN infrastructure which uses microwave or miilimeter band [1]. Microstrip antenna can be implemented using Yagi Uda antenna techniques [2]. There are in general two antennas for WLAN applications, one is fixed WLAN base stations or access points, and the other one is for mobile communication terminals [3]. For base station applications, impedance matching for WLAN bandwidth should be better than 1.5:1 VSWR or about 14 dB return loss, similar to the cellular system base station. Antenna that capable to excite circular polarization is very attractive because it can overcome the multipath fading problem, thus enhance the system performance, especially indoor WLAN operation [4,5]. Currently, the most commonly used WLAN system is the IEEE 802.11b System. A key requirement of WLAN system is that it should be low profile, where it is almost invisible to the user [6]. Depends upon the feeding techniques good impedance matching is achieved [7]. RSA Raja Abdullah, D Yoharaaj has implemented Identical Dual-Patch Microstrip Antenna with Air-Gap (IDMA) to enhance Bandwidth [8]. To obtain the circular polarization most of the techniques used PIN diode or varactor diode [9, 10]. Using diode discrete commutation is possible but in modern communication tuning is necessary.

In this paper the microstrip antenna with hybrid coupler is designed and this enumerates a high degree of isolation. The proposed antenna is having circular patch with cross slot at the centre. Hybrid coupled microstrip antenna is fabricated and measured using agilent E5062A network analyser.

II. MICROSTRIP PATCH ANTENNA

A Microstrip Patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side [11, 12]. The patch is generally 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 dielectric substrate. Based on the desired material characteristic dielectric material is chosen over specific frequency range. Values for dielectric constants range from 2.2 = ε_r = 12 for operation at frequencies ranging from 1 to 100 GHz

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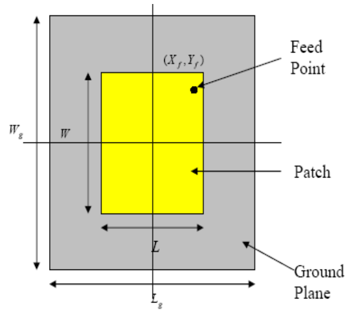

Fig.1 Geometry of Microstrip Antenna

All wireless communication requires some level of isolation in their own transmitter and receivers at the base station. Connecting Hybrid Coupler with microstrip antenna does not makes any difference which port is the input because the relationship at the outputs remains the same as these devices are electrically and mechanically symmetrical. This configuration ensures a high degree of isolation between the two output ports and the two input ports without unwanted interaction between them [13].

III. DIRECTIONAL COUPLER

A 3 dB, 90° hybrid coupler is a four-port device, that is used either to equally split an input signal with a resultant 90° phase shift between output signals or to combine two signals while maintaining high isolation between them. However, in a practical device the amplitude balance is frequency dependent and departs from the ideal 0dB difference. All 90° Power Dividers/Combiners, also known as quadrature hybrids or simply quad hybrids, are reciprocal four port networks [14, 15]. Figure 2 is a functional block diagram of a 3 dB quad hybrid coupler. The hybrid coupler, or 3 dB directional coupler, in which the two outputs are of equal amplitude, takes many forms. It is beginning when quadrature (90 degree) 3 dB coupler coupling with outputs 90 degrees out of phased. Now any matched 4-port with isolated arms and equal power division is called a hybrid or hybrid coupler. Now a days the characterizing feature is the phase difference of the outputs. In an ideal hybrid circuit, the difference should be 0 dB.

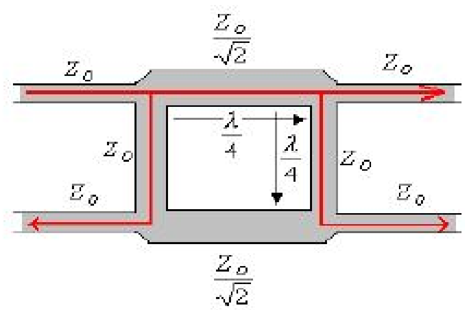

Fig.2 3dB Hybrid coupler

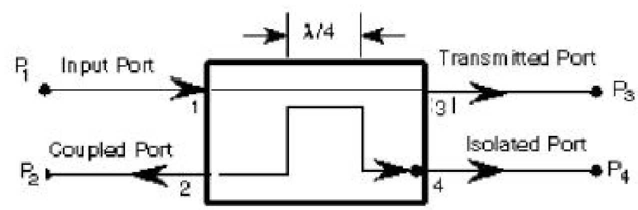

Fig. 3 Internal diagram of 3dB quad hybrid coupler

Referring to Figure 3, a signal applied to port 1 splits equally between ports 2 and 3 with one of the outputs exhibiting a relative 90° phase shift. If ports 2 and 3 are properly terminated into matching impedances, nearly all the signal applied to port 1 is transmitted to the loads connected to ports 2 and 3. In this circumstance, port 4 receives negligible power and is termed as isolated. However, if there is an impedance mismatch at port 2, for example, then signal power reflected back from port 2 were divided proportionally between ports 1 and 4 and power is not fed to port 3.

IV. MICROSTRIP ANTENNA POLARIZATION

Polarization of an antenna is defined as the polarization of the wave transmitted (radiated) by the antenna, whereas polarization of radiated wave is defined as property of an electromagnetic wave describing the time varying direction and relative magnitude of the electric field vector; specifically, the figure traced as a function of time by the extremity of the vector at fixed location in the space, and the sense in which it is traced, as observed along the direction of propagation.

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Polarization may be classified as linear, circular and elliptical [16, 17].

If the vector that describes the electrical field at a point in space as a function of time is always directed along a line, the field is said to be linearly polarized. The polarization can also be determined by the propagating antenna. Linear polarized electromagnetic (EM) wave can be horizontal. A circular polarized wave radiates energy in both the horizontal and vertical planes and all planes in between. Circular polarization occurs when two signals of equal amplitude but have 90° phase shifted. Circular polarization can result in Left Hand circularly polarized (LHCP).Where the wave is rotating anticlockwise, or Right Hand circularly polarized (RHCP) which denotes a clockwise rotation. Non linear polarized wave forms are said to be elliptically polarized.Here the proposed antenna is circularly polarized and it can be used in terrestrial communications the link margins are much better than space borne signal mainly due to the distances involved.

V. Method of Analysis

The ideal methods for analysis microstrip antenna are Transmission line model, cavity model and Methods of moment techniques.

A. Transmission line model

In this model microstrip antenna is represented by two slots of width W and height h, separated by a low impedance transmission line of length L. Some electric field lines are travelling outside the substrate resulting fringing effect that is changing effective dielectric constant. It is a function of the dimensions of the patch and the height of the substrate. Transmission line model is easy to design but it is having less accurate.

B. Cavity model

Transmission line model ignores field variations along the radiating edges. This model provides a better way to model the radiation patterns and is closer in the physical interpretation of the antenna characteristics. The normalized fields within the dielectric can be found more accurately by treating the region as a cavity bounded by electric conductors (above and below) and by magnetic walls along the perimeter of the patch. The disadvantage of this method is complex in nature.

C. Method of Moment

In this method, the surface currents are used to model the microstrip patch and the volume polarization currents are used to model the fields in the dielectric slab. The basic form of the equation to be solved by the Method of Moment is

$$F(g) = h$$

where F is a known linear operator, g is an unknown function, and h is the source or excitation function. The aim here is to find g, when F and h are known.

Here we used ADS software for analysing proposed antenna. ADS is used to compute S, Y, Z parameters of general planar circuits. Microstrip topology is analysed quickly and accurately with momentum using ADS. The simulator is based on the Method of Moments (MoM) technology that is particularly efficient for analysing planar conductor and resistor geometries.

VI. Design of Microstrip Patch and Hybrid Coupler

The implemented antenna is having FR4 substrate with dielectric constant 4.6 and input impedance 50 Ohm. Thickness of the Substrate is taken as 1.6 mm. Operating frequency has chosen as 2.4Ghz. A radius of circular patch antenna can be calculated by using the following equations

Radius of the Patch (a):

$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[l_n \frac{\pi F}{2h} + 1.7726\right]\right\}^{\frac{-1}{2}} \tag{1}$$

Where

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}} \tag{2}$$

Using above equations the radius is found to be a =30 mm at resonant frequency f_r =2.4 GHz. The Impedance choice of Hybrid coupler Z_o is calculated as follows

$$\frac{w}{d} = \frac{8e^A}{e^{2A}-2} \qquad \text{for } \frac{w}{d} < 2 \tag{3}$$

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$$\frac{w}{d} = \frac{2}{\pi}\left[\frac{B-1-\ln(2B-1)}{+\frac{\varepsilon_r-1}{2\varepsilon_r}\left\{\ln(B-1)+0.39-\frac{0.61}{\varepsilon_r}\right\}}\right] \quad \frac{w}{d} > 2 \tag{4}$$

Consider $\frac{w}{d} > 2$

$$B = \frac{377\pi}{2z_0\sqrt{\varepsilon_r}} \tag{5}$$

$Given \quad z_0 = 50\Omega \quad \varepsilon_r = 4.6 \; h \; or \; d = 1.6mm$

$$B = \frac{377\pi}{2\times 50\times\sqrt{4.6}} = \frac{1183.78}{214.476}$$

$$\mathbf{B = 5.52}$$

$$\frac{w}{d} = \frac{2}{\pi}\left[B-1-\ln(2B-1)+\frac{\varepsilon_r-1}{2\varepsilon_r}\left\{\ln(B-1)+0.39-\frac{0.61}{\varepsilon_r}\right\}\right] \tag{6}$$

$$= \frac{2}{3.14}\left[5.519-1-\ln(2\times 5.519-1)+\frac{4.6-1}{2\times 4.6}\left\{\ln(5.519-1)+0.39-\frac{0.61}{4.6}\right\}\right]$$

$$= \frac{2}{3.14}[2.213+0.6905]$$

$$\frac{w}{d} = 1.8492$$

$$\mathbf{w = 2.95mm}$$

Length of the hybrid (l):

$$l = \frac{90^0(\pi\times 180^0)}{\sqrt{\varepsilon_e}\times k_0} \tag{7}$$

$$k_0 = \frac{2\pi f}{c} = \frac{2\pi\times 2.4\times 10^9}{3\times 10^8}$$

$$\mathbf{k_0 = 50.24}$$

$$l = \frac{90^0(\pi\times 180^0)}{\sqrt{3.457}\times 50.24}$$

$$\mathbf{l = 16.81mm}$$

Effective Dielectric constant (ε_e):

$$\varepsilon_e = \frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\sqrt{\frac{1}{1+\frac{12d}{w}}} \tag{8}$$

$$= \frac{4.6+1}{2}+\frac{4.6+1}{2}\frac{1}{\sqrt{1+\frac{12\times 1.6\times 10^{-3}}{2.958\times 10^{-3}}}}$$

$$= 2.8 + 1.8(0.3653)$$

$$\boldsymbol{\varepsilon_e = 3.45}$$

VII. RESULTS AND DISCUSSION

The simulation of circular microstrip antenna is done on ADS software and we get simulation results of return loss, Gain, 3D E- fields. Figure 7 depicts the resonating frequency of proposed patch antenna is 2.4 GHz and the return loss is -31.905dB. This low value of return loss yields higher efficiency in WLAN applications. Figure 5,6 shows the layout and photograph of a patch antenna on FR4 PCB . Figure 7 and 8 shows the return loss characteristic of simulated and fabricated antenna, both are in a good agreement. The antenna is having best impedance matching at 2.45 GHz, is calculated from the smith chart shown figure 9. Radiation pattern in figure 10 represents the directional properties of microstrip antenna. Antenna gain and Directivity for frequencies within the bandwidth is presented in figure 11, maximum gain is

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approximately 6.368dB and directivity is 9.016 dB which meets the requirements of wireless communication. The simulated and measured results satisfy the requirements of wireless communication.

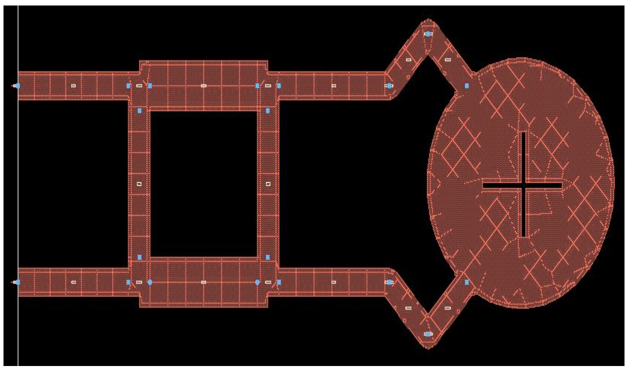


Fig.5 Proposed Antenna Layout design in ADS

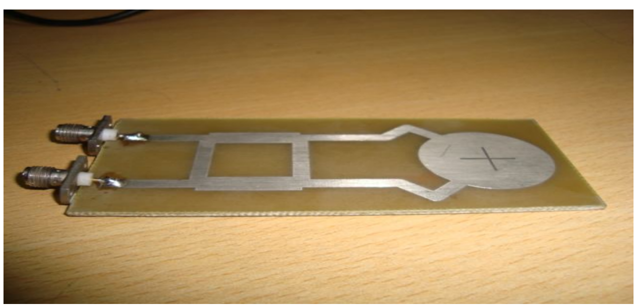


Fig.6 Photograph of a Patch Antenna on FR4PCB

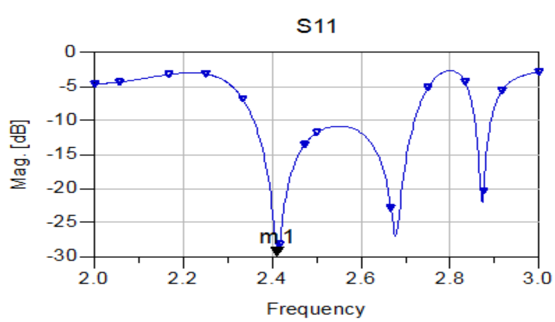
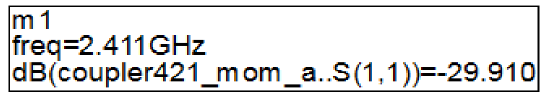


Fig.7 Simulated result of Return loss Characteristic



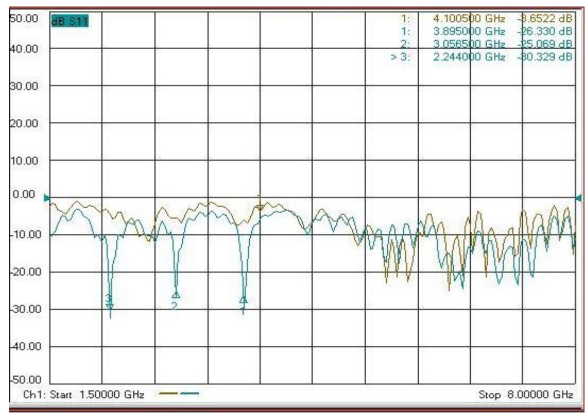


Fig 8 Measured results of return Characteristic

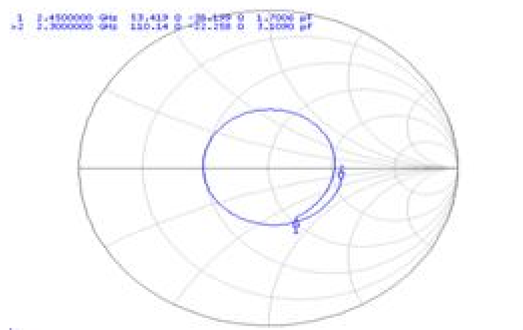


Fig 9 . Impedance matching of fabricated antenna

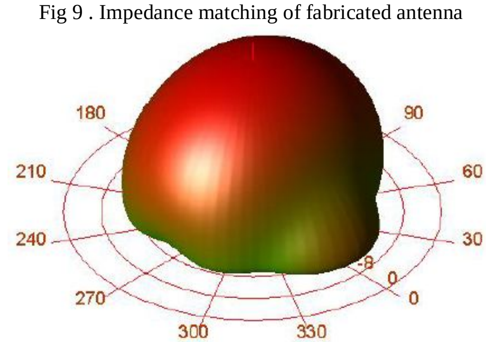


Fig.10. 3D Radiation Pattern of Patch Antenna

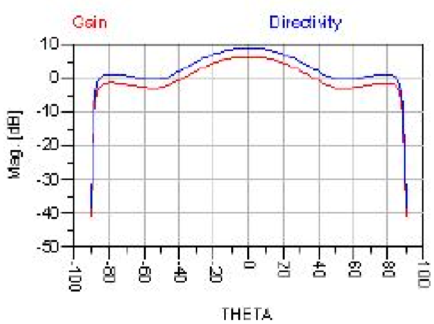


Fig.11 Gain and Directivity of Proposed Microstrip antenna

TABLE I
CIRCULAR POLARIZED MICROSTRIP PATCH ANTENNA RESULTS

Specifications	Observation
Frequency(GHz)	2.404
Return Loss (dB)	-30
Power radiated(W)	$2.1x10^4$
Effective angle	1.57615
Gain	6.36836
Directivity	9.01612
Efficiency	55%
Maximum intensity	$1.26896x10^4$
HPBW(dB)	85.1496

VII. CONCLUSION

In this paper, dual fed circular polarization microstrip antenna was chosen. The microstrip antenna is designed to operate at 2.404 GHz frequency. The dual fed circular polarization microstrip antenna is successfully implemented and fabricated. The performance of the simulated and fabricated antenna agreed well. The proposed antenna gives better value because only 0.47 % power is reflected and 99.53 % power is transmitted. The VSWR of the microstrip antenna is 1.2:1, which shows that the level of mismatched for the microstrip antenna is not very high. The bandwidth of this microstrip antenna is better, which is 17.04 % and the maximum radiation occurs at -40° with gain of 6.36dB which can be applicable in wireless communication system.

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