Coplanar Waveguide-Fed Micro-strip Patched Antenna at 2.4 GHz

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Abstract - *In the past few years, microstrip antennas have much more attention due to their attractive features. The increase in demands of high data transfers through a wireless link, tiny size antennas utilized for various purposes. This paper present the fabricate and simulation of a coplanar waveguide fed (CPW) microstrip patch antenna at resonant frequency 2.4 GHz used for WLAN applications. The patch elements have been placed on the FR-4 epoxy substrate with a relative dielectric constant of 4.4 at the height of 1.6mm. Simulated results are obtained using Ansoft HFSS 11 software, a full-wave electromagnetic field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface. The maximum gain that the proposed patch antenna has achieved is 9.9 dB at a GHz band.*

Key Words: Communication systems, CPW, FR-4 epoxy, gain, HFSS, Microstrip antenna, WLAN application

1.INTRODUCTION

The antenna is a critical component in the RF system for transmitting and receiving signals from and through the air as a medium. The RF system creates a signal that is not transmitted by the system if the antenna is still not properly designed. As a results, there is also no signal somewhere at receiver. Proposed antenna seems to be an active subject in communication design process for the future. Various antennas are used for diverse products. With its cheap material cost and ease of fabrication, the micro strip antenna is perhaps the most creative antenna.

With these rewards, the micro strip patch antenna has certain drawbacks corresponding to surface wave excitation, narrow bandwidth, etc. Different techniques take been assumed to overawed these difficulties, i.e., cutting slots, cumulative the substrate height, $\epsilon r$of substrate etc. The coplanar waveguide, in comparison to a micro strip line, can deliver a compact, low weight, also with the low loss transmission power. The coplanar waveguide initially proposed by C.P. Wen in 1969 [2][3]. Figure 1 demonstrates the design of the CPW micro strip patch antenna.

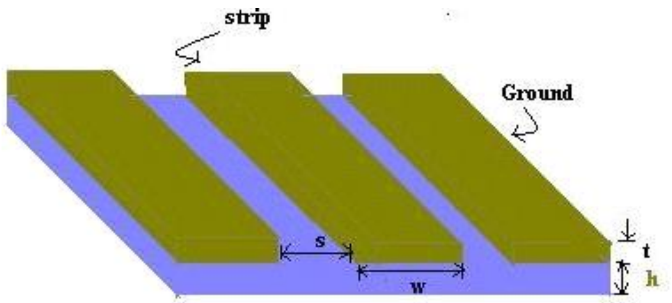

Figure-1 CPW Feed Structure

Microstrip antennas are made up of radiating patches, dielectric substrates, and ground planes. In most cases, patches in micro strip antennas are usually made of gold or copper and having dissimilar shapes. However, the patch is generally circular, triangular, or some other shapes for simplicity, as shown below figure. If the patch is designed in a rectangular shape, then the length L of the patch is chosen between 0.333λo< L < 0.5λo at this place λo represents the free-space wavelength [4][5]. The geometry of our proposed antenna is presented in section II. Section III presents the simulation results. And the last section, IV, presents the conclusion of this paper.

2. ANTENNA DESIGN

We require to consider CPW-feed microstrip patch antenna for the WLAN presentation. There are 3 indispensable constraints aimed at designing of CPW fed antenna as the resonant (fr), the dielectric material of the substrate(ε_r) and substrate thickness (t). In broad sense, the thickness of the substrate also minimises the antenna size footprint but also mitigates available to generate as a surface wave and has a low dielectric constant, allowing the antenna to provide a wider bandwidth, higher efficiency, and lower power loss. For this reason, we should use low-cost FR-4 Epoxy as a substrate with such a height of of h_{sub}=1.6 mm, absolute relative permittivity ε_r=4.4 and tangent loss tanδ=.002. The vital stipulations for the design of the micro strip patch antenna can be planned using the trans mission line method. The width of the feed line is nominated such that its impedance is close to 50Ω. The fallouts of the planned antenna show that the antenna is casing the WLAN frequency band of 2.4 GHz. Simulation setup and methodology is carried out by using HFSS. This is employed to emulate a 3D full-wave electromagnetic field generated by the antenna [7]. HFSS stands for high- frequency simulation software that gives a result like S parameter near / far radiation fields of antenna, *E* - field / *H* - field, etc.

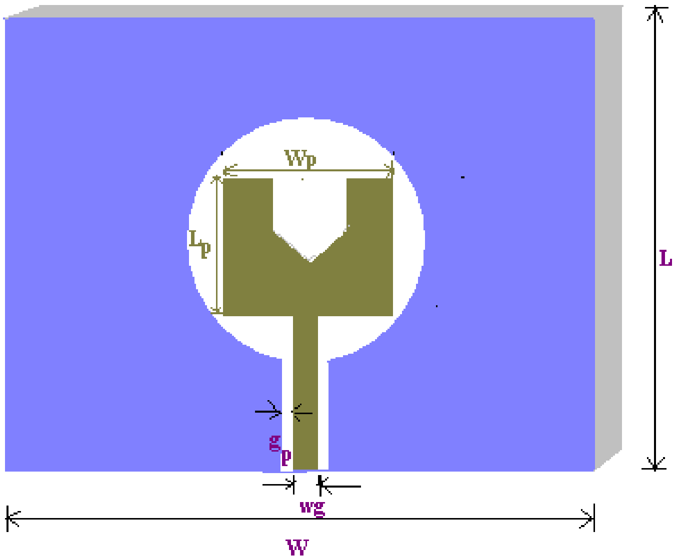

Figure-2 3D Structure of proposed Antenna

2.1 Antenna configuration:

The In this section some of the essential parameters are used for rectangular patch antenna to design accurately are discussing:

- Substrate dielectric constant (r): In this construction of micro strip patch antenna, we use FR-4 Epoxy dielectric material. The chosen material has a dielectric constant of 4.4. When the dielectric constant of the substrate is large, the lengths of the antenna are reduced, which is significant in a communication system.

- When the dielectric constant of the substrate is large, the lengths of the antenna are reduced, which is significant in a communications network.

- Height of dielectric substrate (h): Another crucial element for antenna design is height. The antennas used throughout mobile phones should not be too large. As a result, the thickness or height chosen for our suggested antenna is 1.6 mm. Frequency of procedure or center frequency (f_0): The center frequency of the antenna should be selected properly so that an antenna performs very well when used in any system. Different frequencies are employed in variety of applications for example 2100-5600 MHz frequency ranges are used for Mobile Communication Systems. In the proposed system, the construction of an antenna that is employed in the wireless application with utmost care so we have selected a 2.3 GHz operating frequency for our designs.

For efficient radiation, the width of the patch is given below:
-

(d) Ground plane dimensions

$wg = 6h + w$ (5)

$Lg = 6h + L$ (6)

Where h is the height of the substrate, w is the width of the patch and L is the length of the patch.

Table1: Dimension of patch antenna

Parameter	value
Length of Patch	29mm
Width of patch	38mm
Length of the feed line	34.24mm
Width of the feed line	3.05mm
Dielectric constant	4.4
Operating frequency	2.4GHz
Height of substrate	1.6mm
Radius of circle	26mm

2.2 Simulation and Measurement Results

Here c represents the velocity of light in in medium, with permittivity equal to 1 where as $f0$ represents the operating frequency and ϵr is the absolute relative permittivity.

Comprehensive results are obtain by using Ansoft HFSS software. Thus the Results obtained through the simulation of the proposed designed antenna are discussed in this section. In short, we discuss the important parameters of the proposed antenna such as return loss, bandwidth, VSWR, radiation patterns, gain.

$(\epsilon$ $+ 0.3)($ $\underline{w}$ $+0.264)$
$\Delta L = 0.412$ $\underline{reff}$ $\underline{h}$ (3)
h $(\epsilon reff - 0.258)$

- The actual length L of the patch is

L = L_{eff} - 2ΔL (4)

Where, $Leff =$ c2Lf0√ϵeff

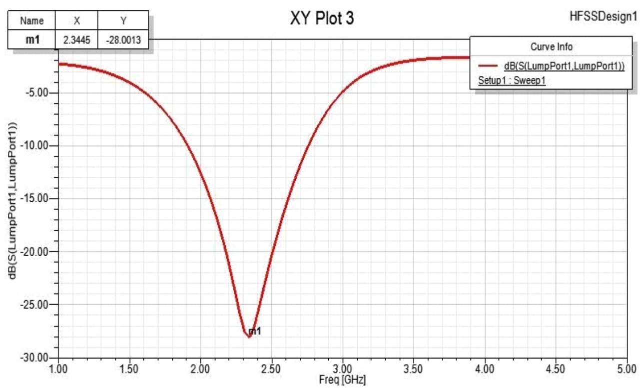

Figure-3 S-Parameter plot of the Microstrip Patch Antenna

I. Return loss

Whenever linking an antenna to a network, return loss is a critical element to consider. It is linked to impedance matching as well as maximum power transfer theory. It may also be used to assess the efficacy of an antenna in delivering supply of electrical to the antenna. The return loss (RL) is obtained by dividing antenna incident power p_{in} to the power reflected P_{ref}back from the receiver. At resonant frequency proposed antenna provides the return loss is-28dB as shown in Fig.3.

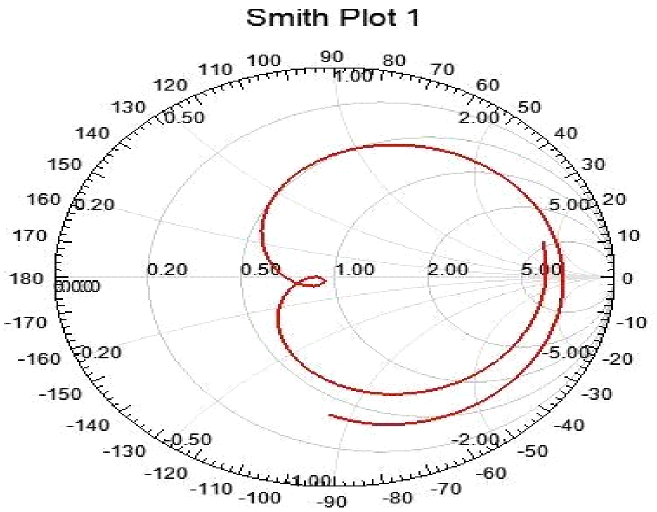

Figure-5 Smith chart

II. Bandwidth

The impedance bandwidth may be expressed mathematically using the S-parameter plot of the proposed microstrip patch antenna, as illustrated in figure 4.2. Bandwidth is an important antenna characteristic. The antenna operates on a specific frequency range, and that switching frequency is quite well recognised as an antenna's bandwidth, while in other words, it describes the resonant frequency over which the antenna variables including as input impedance, radiation pattern, polarisation, side-lobe level, and gain, are inside an acceptable norms of the centre frequency. The proposed antenna provides impedance bandwidth of 35.84% at the resonant frequency of 2.4GHz using the formula which is defined as:

$$IBW = \frac{h - fl}{fr} * 100\% \qquad (8)$$

Where

f_h: Upper-frequency point at 10dB

f_l: Lower frequency point at 10dB

: Resonant frequency of the antenna

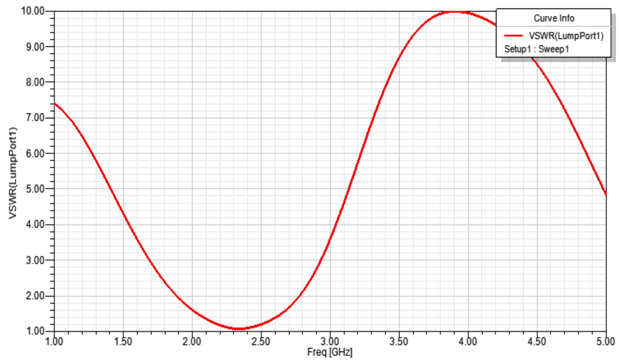

Figure-4 VSWR vs. Frequency plot

III. VSWR

The VSWR versus frequency plot for our constructed antenna is shown in Figure 4. VSWR is a critical characteristic in antenna design. VSWR is an abbreviation for Voltage Standing Wave Ratio. Maximum and lowest voltages have emerged at the feed line throughout operation, and the ratio of such voltages is called as the antenna's VSWR. As we all know, the value of VSWR should be among 1 and 2 for an antenna's good functioning or to be regarded ideally matched. When the antenna's power generation is not ideal, a standing wave emerges in the device. For the antenna to work well and be deemed to be ideally matched, the VSWR value should be 1:1. The plot s illustrate that the value of VSWR is 1.08 at 2.4 GHz. The value of VSWR is between 1 and 2 in the frequency range from 1.8 GHz to 2.7 GHz. Therefore we can say that the designed antenna is perfectly matched

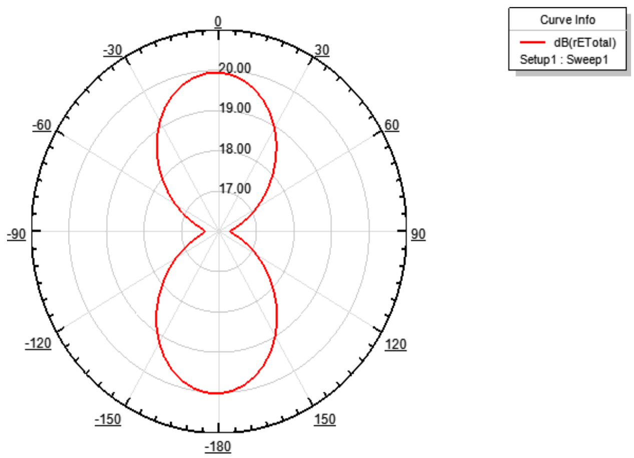

Figure-6 Radiation Pattern plot of the proposed antenna

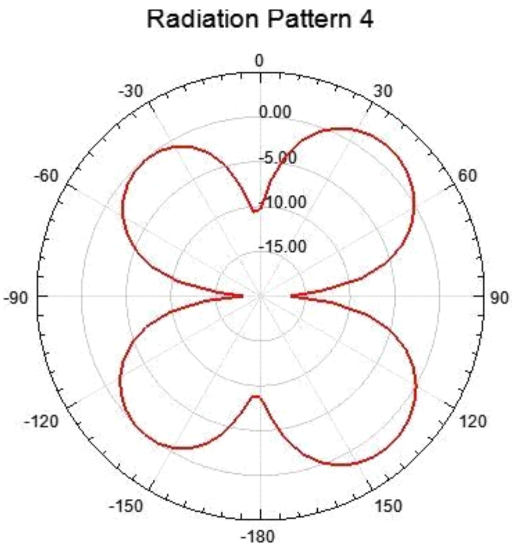

Figure-7 Radiation Pattern plot of the proposed antenna

- *Radiation Patterns*

The antenna radiation shape can be used for quantification of antenna's radiation dispersion or strength in certain directions. The radiation pattern can be expressed in the form of mathematical empirical realtion or as a graphical depiction of any antenna's radiation qualities in spatial coordinates. Radiation intensity, directivity, phase, polarisation, field strength, and power flux density are all the same as the radiation features of the antenna. Furthermore, the far-field zone is the crucial region for determining radiation patterns and representing them as a directional coordinates function. It establishes an order that may be used to characterize how an antenna focuses the energy that it emits. Polar plots are used to display information from different sources or the receiver. The total radiation patterns for the planned antenna at the resonant frequency of 2.3 GHz for Phi= 0 degrees are shown in Figures 6 and 7.

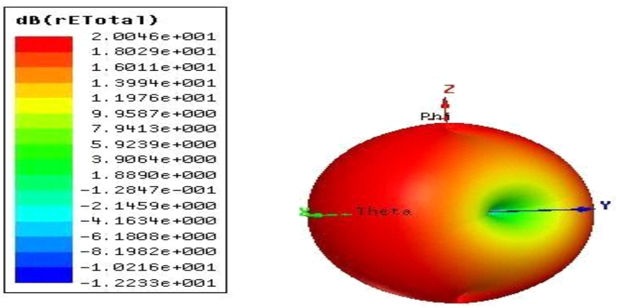

Figure-8: Gain

- *Gain*

Figure 8 depicts The Gain polar plot. Gain is a vital antenna characteristic that indicates the amount of power that is to be transferred in the direction of the greatest radiation with that of an isotropic source. Furthermore, the Gain must be less than 0dBi. Antenna gain is a critical characteristic for describing the antenna's directivity and efficiency. Gain is calculated for any antenna by dividing the radiation intensity by the broad peak. Antenna gain is often expressed in decibels (dB). Moreover, the Gain should not be less than 0*dBi*. Directivity and Gain have the same value when the antenna shows 100% efficiency. 3 shows the polar plot of Gain. Gain is the important parameter of an antenna that shows how much power is transmitted in the track guidance of maximum radiation to that of an isotropic source. Moreover, the gain should not be less than 0dBi. There is no increment in power generated during the operation if antenna gain is high or Gain has a high value. The highest Gain of the proposed antenna is 2 dB at 2.4 GHz.

3. CONCLUSION

We report the simulation & design of wide band micro strip patch antenna on a substrate with relative permittivity (ϵr) 4.4 with a resonant frequency 2.4 GHz employing Ansoft HFSS. This design of a micro strip patch antenna with CPW-fed is planned for the WLAN claim to purpose in the frequency below of 2.4 GHz. Comprehensive results for the targeted applications have been achieved.

REFERENCES

[1] C. A. Balanis, Antenna Theory: Analysis & Design, John Willey & Sons, Inc., 1997.

[2] Leena Varshney, Vibha Rani Gupta, Harish Kumar, Priyadarshi Suraj CPW-Fed Broadband Microstrip Patch Antenna,

[3] International Journal of Advanced Engineering & Application, Jan 2011 Issue-1

[4] AK Gupta, RK Prasad, DDK Srivastava "Design and analysis of Quad-Band rectangular micro strip patch antenna", Journal of Electronics and Communication Engineering, July-Aug 2012 Issue- 6

[5] John Wiley & Sons "Compact and Broadband Microstrip Antennas". Kin-Lu Wong, Inc., 2002.

[6] Raj Kumar, P. Malathi "On the Design of CPW- Fed Ultra Wideband Triangular Wheel Shape Fractal Antenna", International Journal of microwave and optical technology, Vol.5 NO. 2 March 2010.

[7] D. Parkash, R. Khanna "Design and development of CPW-fed micro strip antenna for WLAM/WiMAX applications",

[8] Progress In Electromagnetics Research C, Vol. 17, 17-27, 2010

[9] Ansoft High-Frequency Structure Simulator v11 User's Guide. Pittsburgh, PA: Ansoft Corp., 2005. Computer Software.