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CPW-Fed Microstrip Patch Antenna for WLAN Application at Resonant Frequency 2.3 GHz

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Abstract:
In recent years, microstrip antennas have much more attention due to their attractive features. The increase in demands of high data rate transfer through wireless link, small size antennas used in various purposes. This paper presents, the design and simulation of a coplanar waveguide fed (CPW) microstrip patch antenna at resonant frequency 2.3 GHz that's used for WLAN applications. The patch elements have been placed on the FR-4 epoxy substrate with relative dielectric constant 4.4 at the height of 1.6mm. Simulated results are obtained by using Ansoft HFSS 11 software, which is 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 have been achieved by the proposed patch antenna is 9.9 dB at 2.3 GHz band.

***Keywords**: Communication systems, CPW, FR-4 epoxy, gain, HFSS, Microstrip antenna, WLAN application*

1. Introduction

Antennas play an important role in wireless communication system. Every wireless device uses an antenna to send and receive information. In Wireless applications designing of a small size antenna for efficient wide band are a major challenge [6]. Microstrip patch antennas are versatile in terms of their geometrical shapes and implementations. These antennas are most suitable in wireless application due to their low profile, low weight, and low power handling capacity, simple and inexpensive to manufacture using modern printed–circuit technology [1]. Therefore microstrip antennas are suitable for various applications like; aircraft, spacecraft, satellite, missile application due to their attractive characteristic.

With these advantages microstrip patch antenna have some disadvantages also like surface wave excitation, narrow bandwidth etc. Various methods have been adopted to overcome these problems i.e. cutting slot, increasing the substrate height, decreasing ϵ_r of substrate etc. The coplanar waveguide, as compared with the microstrip line, can provide a compact low weight and low loss transmission. The coplanar waveguide was introduced by C.P. Wen in 1969 [2][3]. Figure (1) shows the geometry of CPW microstrip patch antenna.

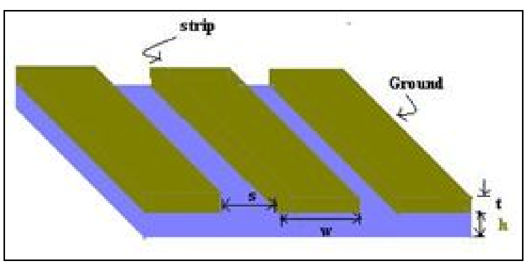

Figure 1: CPW Feed Structure

As shows in the above figure that all conductors are placed on the same plane, which neglects the need of via holes that makes the structure easy to connect shunt or series lumped elements. So, that this technique is less costly than other. The line impedance and phase velocity of the coplanar waveguide are less dependent on the substrate height than on the aspect ratios that are slot width / center conductor width [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 conclusions of this paper.

2. Antenna Design

We have designed CPW-feed microstrip patch antenna for WLAN application There are three essential parameters for designing of CPW fed antenna such as the resonant frequency ( ), the dielectric material of the substrate( ) and substrate thickness (t) . In general, the thickness of the substrate not only reduces the size of antenna, but also minimize the spurious radiation as surface wave, and low dielectric constant, so that the antenna can have greater bandwidth, better efficiency, and low power loss, for that reason we are using low-cost FR-4 Epoxy as a substrate with the height of =1.6 mm, dielectrics . constant =4.. and tangent loss tanδ=.002. The essential parameters for the design of microstrip patch antenna can be calculated using the transmission line method. The width of the feed line is selected such that their impedance is near to 50Ω. The results of the designed antenna show that antenna is covering the WLAN frequency band of 2.3 GHz.

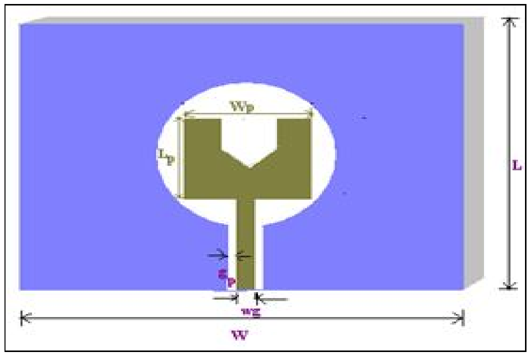

Figure 2: 3D Structure of proposed Antenna

2.1. Antenna Configuration

The antenna parameters of microstrip patch antenna can be calculated by the transmission line method is given by the following equations:-

(a) Width of patch

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

$$w = \frac{c}{2 f_0 \frac{\sqrt{\epsilon_r + 1}}{2}} \quad \text{.......................................} \ (1)$$

Here c is the speed of light in free space where as f_0 represent to Operating frequency and ϵ_r is dielectric constant.

(b) Length of patch

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left(1 + 12\frac{w}{h}\right)^{-\frac{1}{2}} \text{......} \ (2)$$

Where ϵ_{reff} effective dielectric constant, ϵ_r is dielectric constant, h is height of substrate and w is the width of patch.

$$\frac{\Delta L}{h} = 0.412 \frac{(\epsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_{reff} - 0.258)} \text{..........} \ (3)$$

(c) Actual length L of patch is

$$L = L_{eff} - 2\Delta L \quad \text{.....................} \ (4)$$

Where, $L_{eff} = \frac{c}{2Lf_0\sqrt{\epsilon_{eff}}}$

(d) Ground plane dimensions

$$w_g = 6h + w \quad \text{.........................} \ (5)$$

$$L_g = 6h + L \quad \text{.........................} \ (6)$$

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

Parameter	Value
Length of Patch	29mm
Width of patch	38mm
Length of feed line	34.24mm
Width of feed line	3.05mm
Dielectric constant	4.4
Operating frequency	2.3GHz
Height of substrate	1.6mm
Radius of circle	26mm

Table 1: Dimension of patch antenna

Table 1 show the dimension of proposed antenna which is used in their designing. In general, we are using the ground plane is located on substrate with dimension 40 mm x. 48.74 mm and patch of dimension 38 mm×29mm is designed on FR4 substrate of height 1.6mm. The structure of CPW-fed consists of a strip width of about 3.05 mm along with gap of 1 mm between the strip and the coplanar ground plane.

3. Simulation And Measurement Results

Simulated results are obtained by using Ansoft HFSS 11 software. Thus the Results achieved after the simulation of proposed antenna are discussed in this section. In short we discuss the important parameters of proposed antenna such as return loss, bandwidth, VSWR, radiation patterns, gain.

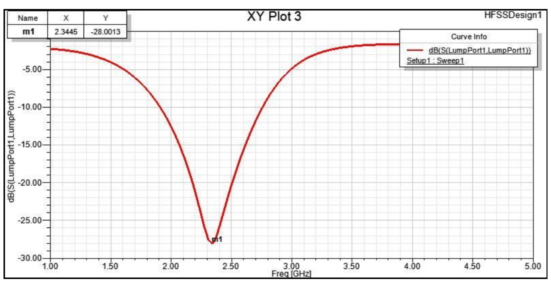

Figure 3: S-Parameter plot of the Microstrip Patch Antenna

3.1. Return Loss

Necessary condition required for an antenna so that it radiates effectively, the return loss should be less than−10 dB. Figure 3 shows the S-Parameter plot or return loss plot of the of design antenna. At resonant frequency proposed antenna provides the return loss is- 28dB.

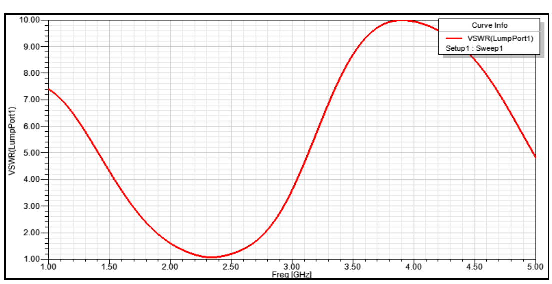

Figure 4: VSWR vs. Frequency plot

3.2. VSWR

Figure 4 shows the VSWR versus frequency plot for our designed antenna. VSWR is important parameter for antenna designing. As we know that value of VSWR should be lies between 1 and 2 for efficiently performance of an antenna or considered to be perfectly matched. Plot shows that value of VSWR is 1.08 at 2.3 GHz. In fact 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 design antenna is perfectly matched.

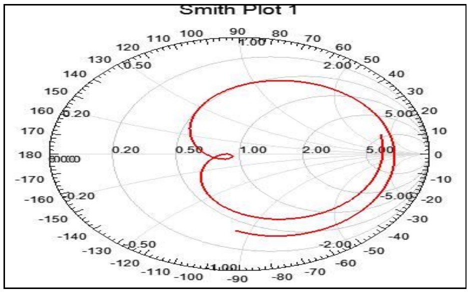

Figure 5: Smith chart

3.3. Bandwidth

With the help of S-parameter plot of the proposed microstrip patch antenna as shows in figure 1, we can easily calculate the impedance bandwidth. The proposed antenna provides impedance bandwidth of 35.84% at the resonant frequency of 2.3 GHz using the formula which is defined as:

$$IBW = \frac{f_h - f_l}{f_r} * 100\%$$ .... (7).

Where

- f_h : Upper frequency point at 10dB
- f_l: Lower frequency point at 10dB
- f_r: Resonant frequency of antenna

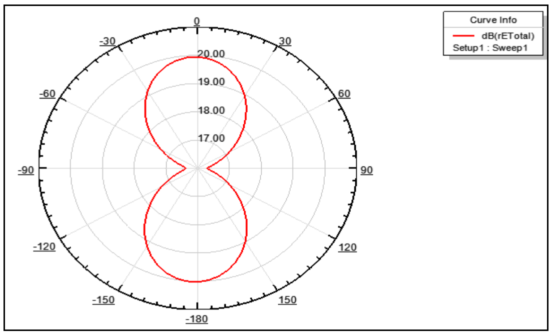

Figure 6: Radiation Pattern plot of proposed antenna

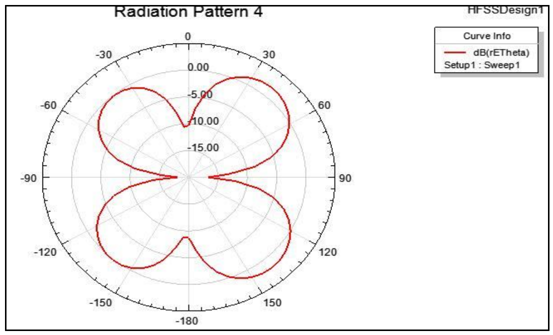

Figure 7: Radiation Pattern plot of proposed antenna

3.4. Radiation Patterns

The antenna radiation pattern is a measurement of its power or radiation distribution with respect to a particular type of coordinates. The total radiation patterns for the proposed antenna at resonant frequency of 2.3 GHz for Phi= 0 degree is shown in figure 6 and Figure 7.

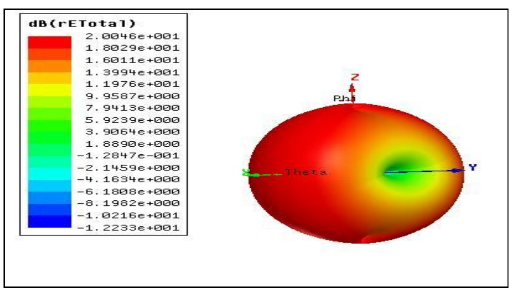

Figure 8: Gain

3.5. Gain

Figure 3 shows the polar plot of Gain. Gain is the important parameter of an antenna that shows how much power is transmitted in the direction of maximum radiation to that of an isotropic source. Moreover, the gain should not be less than 0dBi. The maximum gain of the proposed antenna is 9.9 dB at 2.3 GHz. In fact its value for the proposed antenna varies from 3.9 dB to 9.9 dB.

4. Conclusion

Thus the simulation & design of wide band microstrip patch antenna on substrate of dielectric constant ( ) 4.4 at resonant frequency ( ) 2.3 GHz have been successfully done using Ansoft HFSS. This design of microstrip patch antenna with CPW-fed is proposed for the WLAN application to operate in the frequency range of 2.3 GHz. And also the return loss characteristics and radiation patterns shows that the antenna can be effectively used for WLAN communication.

5. References

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