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Design and Analysis of a Wideband CPW fed Circular Patch Antenna for Wireless Communication Applications

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ABSTRACT: In this paper a novel design approach of a Co Planar Waveguide (CPW) fed printed antenna is proposed.The designed antenna consists of a slotted circular patch and a stripline of width 1.9 mm The proposed antenna resonated at 4.5 GHz(C band) and 9.8 GHz(X Band) with a bandwidth of 16.66 % and 20.4 % respectively which makes it a wideband circular printed antenna.The matching of the resonator is also found very good at those two frequencies , the S[1 1] parameters are reported as -27 dB at 4.5 GHz and -40 dB at 9.8 GHz. The proposed antenna is designed using FR4_epoxy(dielectric constant = 4.4). Also a comparative study is been reported in the paper between the two substrates FR_4 epoxy in design 1 and Duroid (dielectric constant = 2.2)indesign 2 by designing the same antenna with same parameters but two different dielectric substrates. The second design with Duroid gives resonant frequency at 6.2 GHz (C Band) and 13.7 GHz (Ku Band)

KEYWORDS: Co planar waveguide (CPW) , C band, X Band, Ku Band,Wireless communication applications,satellite communication application ,Circular Patch antenna

I. INTRODUCTION

Microstrip or printed antennas are small size, light weight, easy to install and conformal in shape so they are widely used in wireless and mobile communications, as well as satellite communication applications. Narrow Bandwidth is one of the drawbacks of Microstrip antennas. Various researchers have reported many techniques that can be used to overcome this drawback. Introducing the Microstrip antenna to a co planar waveguide(CPW) is one of the techniques. Here in the CPW technique there is a stripline in between two conducting plates in the same plane.These two conductor plates behave as the ground plane and the centre stripline carries the feed signal to the antenna.Hence the radiating patch and the ground plane along with the feed line all are in same plane. It has been reported in many research papers that CPW feeding gives enhanced bandwidth.

II. RELATED WORK

E. A. Soliman, S. Brebels, P. Delmotte, G. A. E. Vandenbosch, and E. Beyne, has reported the bow tie slot antenna and has shown a wide bandwidth approaching 40% [1]. In [2] A coplanar wave guide (CPW) fed patch antenna is presented for dual band operation which generates two frequency bands one is 1.65-2.08GHz and other is 3.29-3.60GHz with impedance bandwidth of 430MHz and 310MHz respectively. S. T. Rowe ; R. B. Waterhouse has reported a bandwidth of 40% on a high dielectric constant feed substrate [3].In [4] A detailed discussion was made on the effect of defected ground plane in a CPW fed antenna. In [5] ,[6],[7] we find a brief idea about the parameter calculations of the antenna.

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III. PROPOSED ANTENNAE

A. *Design Considerations:*

The design of the proposed antenna with substrate FR_4 epoxy(er = 4.4) is given in fig 1. The second design with another substrate duroid (er = 2.2) is given in fig 2. Both the antennas are kept parameter wise identical just to see the performance variance.

The resonant frequency of excitation can be given as [5]

$$f_r = \frac{x'_{nm} \times c}{2\pi a \sqrt{\varepsilon_r}} \quad \text{eq.(1)}$$

For a physical radius = *a*, wherec is the velocity of light ,andε_r is the effective dielectric constant. After considering the fringing extension modified resonance frequency becomes

$$f_{rTMmno} = \frac{x'_{nm} \times c}{2\pi a_{eff} \sqrt{\varepsilon_r}} \quad \text{eq.(2)}$$

where m=0,1,2,3,………number of half cycle variation along , and n=1,2,3,…… number of half cycle variation along ϕ. ρ Here the fringing effect is taken into account by using an effective radius [5]

$$a_{eff} = a\left[1 + \frac{2h}{\pi a \varepsilon_r}\left\{\ln\left(\frac{\pi a}{2h}\right) + 1.7726\right\}\right] \quad \text{eq.(3)}$$

Where h is the height of the substrate.

Here in the proposed antenna(Design 1) the circular patch radius is 19 mm. FR_4 epoxy is the dielectric material used here with dielectric constant ε_r= 4.4. and the substrate height (h) is 1.6 mm .Below in the Fig 1 the proposed antenna Design 1 is described.

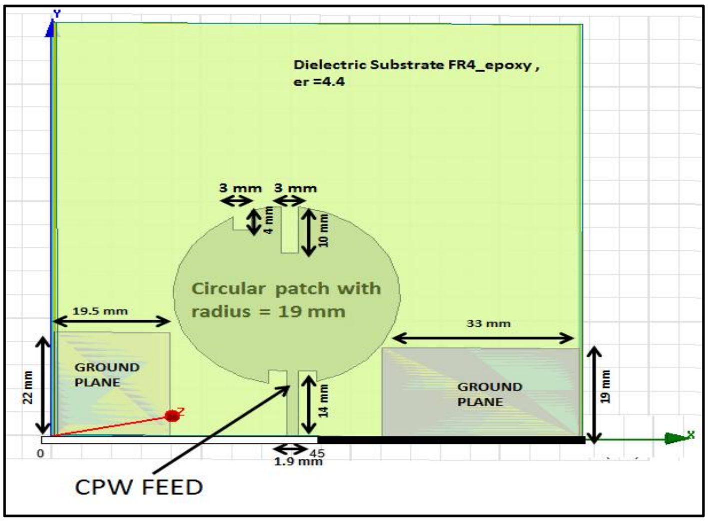

Fig 1: **Design 1**:the proposed antenna with FR_4 epoxy

The CPW feed is a stripline of width 1.9 mm and length 14 mm. The circular patch is off radius 19 mm where 2 slots of dimension 3mmX4mm and 3mm X 10 mm is been cut respectively. On the both side of the signal carrying stripline the two conducting plates are present which are the ground plane of this structure.As we can see from the structure the ground planes are made asymmetric to achieve better result. The ground plane dimension on left is 19.5mm X 22mm and the dimension of the ground plane on the right side of the feed line is 33 mm X 19 mm .

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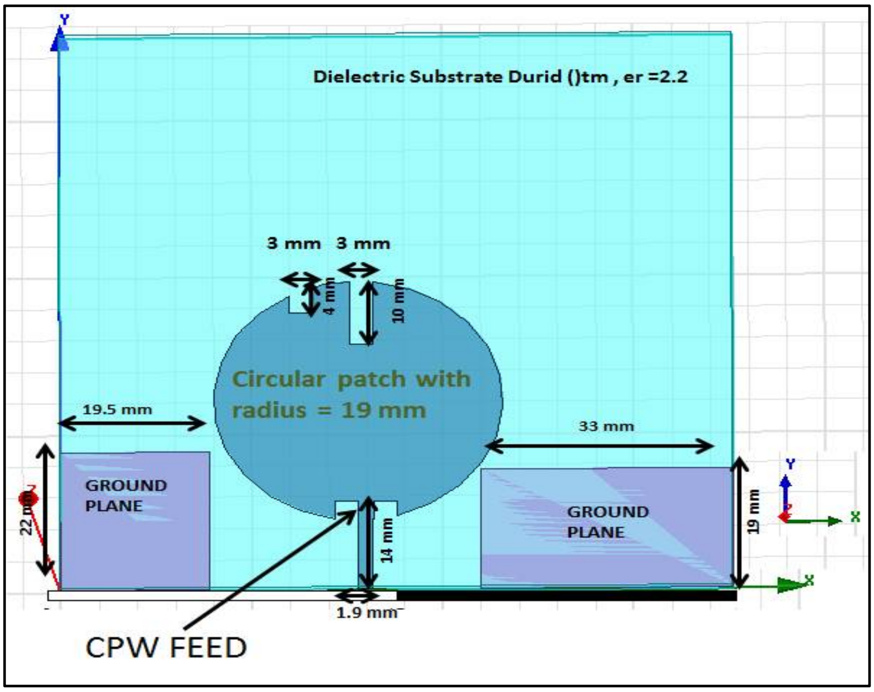

Fig 2 :Design 2: another antenna with identical design parameters but different dielectric substrate (Duroid , er =2.2)

Another design is made keeping all antenna parameters same so that only the effect of change in Dielectric substrate can be seen. Here in Fig 2 the designed antenna is identical with Design 1 with respect to design parameters the only difference is the use of Duroid as dielectric substrate material in Design 2.

IV. SIMULATION RESULTS

The design simulations are done using Ansoft HFSS 13.0 . Now let us discuss the results of the two designs

A. *S Parameter Vs Frequency*

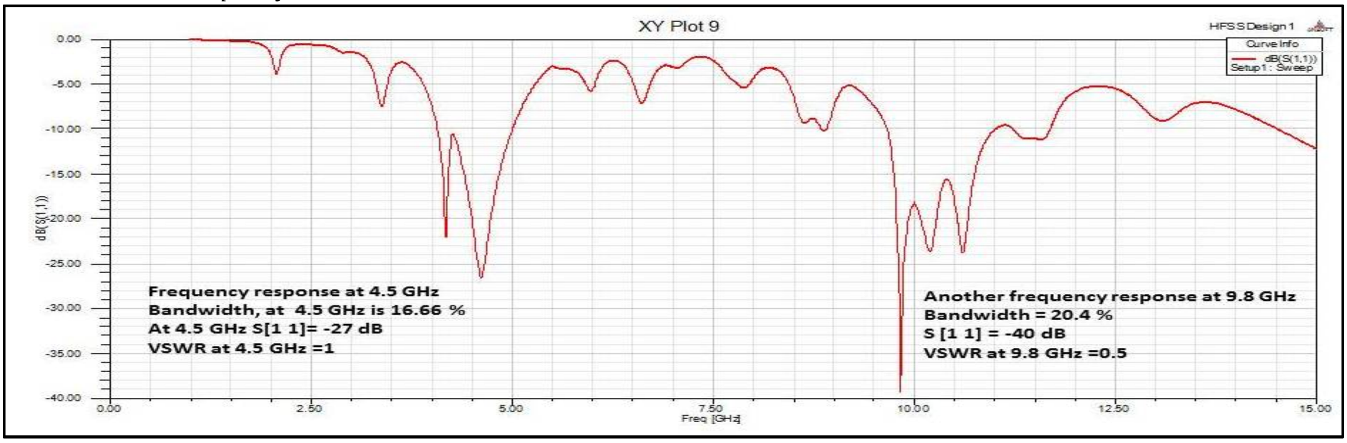

Fig 3 : the S [1 1] vs Frequency response for Design 1 with FR4_ epoxy(er=4.4)

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In Fig 3 we see the variation of S[1 1] with respect to frequency for Design1 Antenna with FR4_epoxy as dielectric substrate. Here two resonant frequencies can be seen the first one is at 4.5 GHz which is a C band frequency and can be used for wireless communication applications. The bandwidth of the first frequency response is 16.66 % and the S[1 1] measured as -27 dB which indicates a good impedance matching. The next frequency response is seen at 9.8 GHz with a bandwidth of 20.4 % and a S[1 1] value of -40 dB which means another good impedance matching is seen at this frequency.

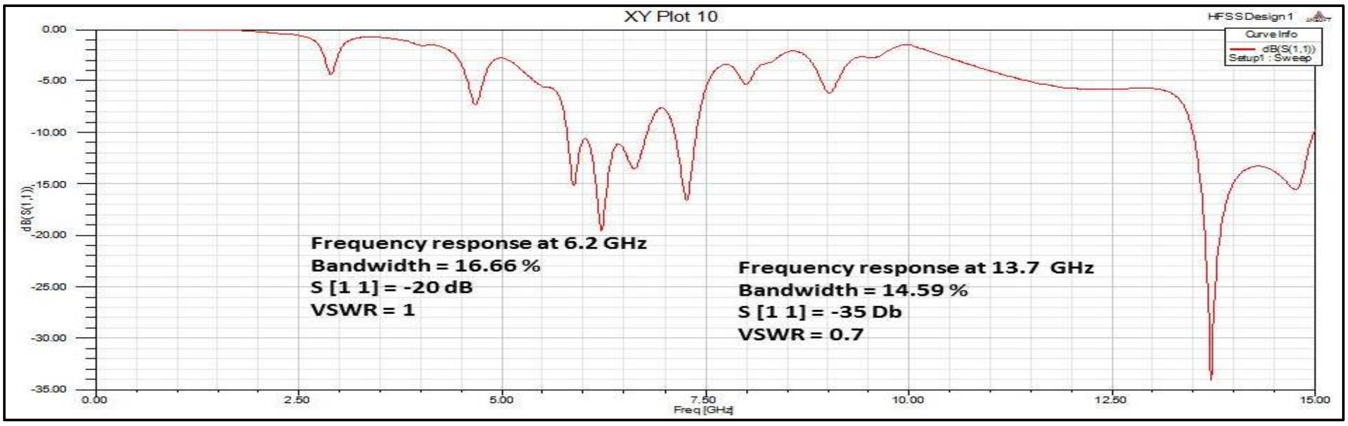

Fig 4 : the S [1 1] vs Frequency response for Design 2 with Duroid (er=2.2)

Next in Fig 4 the relation between S[1 1] and frequency is observed for Design2 antenna with Duroid as dielectric substrate. Here also two resonant frequencies are detected one at 6.2 GHz (a C Band frequency) and another at 13.7 GHz (a Ku Band frequency) . So the antennae can be used in both wireless communication and Satellite communication purpose. The first resonating frequency is reported to have 16.66 % bandwidth with a S[1 1] value of -20 dB .The second one is with a bandwidth of 14.59 % and a S[1 1] value of -35 dB. Both indicates a good impedance matching and a wide bandwidth.

B. *Radiation Pattern*

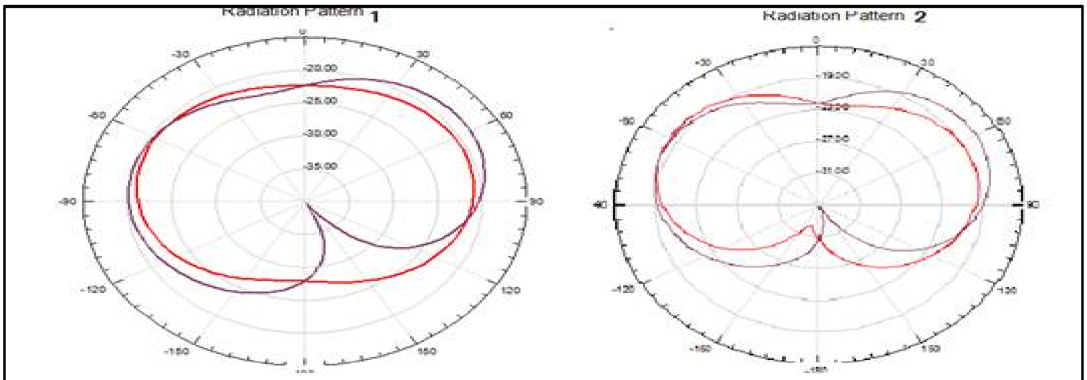

Fig 5 : Radiation Pattern for both the antenna
Radiation Pattern 1 is for the antenna designed with FR4_ epoxy
Radiation Pattern 2 is for the antenna designed with Duroid

As we look at the radiation pattern of both the antennae in Fig5. It is seen that the radiation pattern of the antenna 2 i.e the antenna with Duroid is more symmetric than the antenna designed with FR_4 epoxy . Though the change is very nominal and may be ignored.

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Table 1 : comparative study between design 1 (CPW fed antenna with FR4_epoxy as dielectric substrate)and design 2 (CPW fed antenna with Duroid as dielectric substrate)

Item	Dielectric substrate/dielectric constant value	Resonant frequency response(frequency Band)	Bandwidth in % (in MHz)	S[1 1] in dB	VSWR(abs.)
Antenna 1	FR4_epoxy / 4.4	Fr1 = 4.5 GHz (C Band) Fr2 = 9.8 GHz (X Band)	16.66% (749 MHz) 20.4 % (1999 MHz ~ 1.9 GHz)	-27 dB -40 dB	1 0.5
Antenna 2	Duroid / 2.2	Fr1 = 6.2 GHz (C Band) Fr2 = 13.7 GHz (Ku Band)	16.66 %(384 MHz) 14.5% (1986 MHz ~ 1.9 GHz)	-20 dB -35 dB	1 0.7

In Table 1 a comparative study between the two antenna is reported. As we can observe the Bandwidth and impedance matching both are better for the antenna designed with FR_4 epoxy than the Duroid substrate antenna.

V. Conclusion and Future Work

Two identical antenna with CPW feed is designed in this paper using two different dielectric substrate to study the effect of the substrate on a CPW fed antenna if all other design parameters are kept constant. Here we observed a huge right side shift in frequency almost by 2 GHz when we change the dielectric substrate from FR4 _ epoxy to Duroid.Also there was an effect on bandwidth and matching of the antenna which was evident from the comparative discussion made in Table 1.Both of them gave high bandwidth and good matching. From the comparative study of both the designs it can be concluded that the antennae can be well efficiently used for wireless communication applications. The antennae can be used for standard C band applications also Ku band applications which includes wireless communication application also satellite communication applications..The future work is to design the hardware and get the testing result and tally that with the HFSS simulation results.

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11.

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