Circular Patch Antenna with CPW fed and circular slots in ground plane.

Kangan Saxena, USICT, Guru Gobind Singh Indraprastha University, Delhi-75

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***Abstract—** CPW fed antenna with circular patch is designed for dual band frequencies. Inset feed technique results in good impedance matching, size reduction and provides wide bandwidth at the fundamental operating frequency. CPW technology offers ground at the same layer. Antenna is designed for 2.6 GHz. This design emphasizes on introduction of DGS. Defected Ground structure is a method used to improve the performance of the microstrip patch antennas specially the gain and resonating frequency. It is basically a defect or a slot introduced in the ground plane. The ground plane at each side is modified for improving the performance. FR4 is used as substrate which makes it cost effective for usage. The antennas simulated are simple and compact. Design is analyzed using High Frequency Structure simulator.*

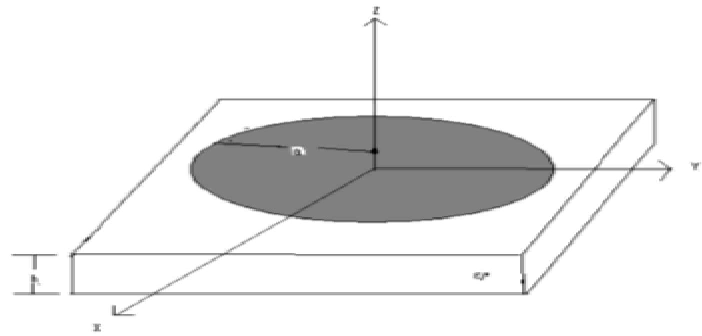
Keywords— *Circular patch, DGS, CPW, Inset feed, impedance matching, Slots*

I- INTRODUCTION

CPW-fed antennas have received good attention because of their attractive characteristics such as ultra-wide frequency band, good radiation properties ,can be easily integrated with MMIC circuits and lower cross polarization obtained from the feed network. Antenna is the transitional structure between free-space and a guiding device. As the process of miniaturization of antennas is growing rapidly, compact designs have to be implemented to cope with the demands of the industry. Feed line is one of the important components of antenna structure Antennas which are cost effective light weight and provide high performance to cover a wide frequency range are required for wireless communication. Introduction of slots in the the radiating patch of the microstrip antenna enhance the multi-band performance and maintain thin profile characteristic of antenna. Due The equivalent circuit for a DGS is a parallel-tuned circuit in series with the transmission line to which it is coupled. Circular slots are incorporated in ground plane and radius is varied to make a good comparison in the results. Operating bandwidth of antenna is between 2.3 and 6.2 GHz.

II- ANTENNA DESIGN

Circular cavity is formed which determines the mode supported by the circular patch antenna. Cavity model is used to analyze the patch antenna . Cylindrical perfect magnetic conductor is around the circular periphery of the cavity and two electric conductors at the top represented by patch and the bottom represented by the ground plane forms the cavity. Vector potential is used to determine the field configuration within the cavity.



The magnetic vector potential Az must satisfy, the homogeneous wave equation..

$$\nabla^2 A_z(\varphi, \emptyset, z) + k^2 A_z(\varphi, \emptyset, z) = 0$$

Whose solution is written as

$$A_X = B_{mnp} J_m\ (kp\, p')[A_2 Cos\ (m\emptyset') + B_2 Sin(\ m\emptyset')] Cos\ (k_z z')$$

With constraint equation of

$$k_p^{\,2} + k_z^{\,2} = k_r^{\,2} = \omega_r^{\,2}\mu\varepsilon$$

Electric and Magnetic fields are related to the vector potential Az

$$E_\rho = -\frac{j}{\omega\mu\varepsilon}(d^2 A_{zz}/ d\rho\, dz)\ ,\ E_\varphi = -\frac{j}{\omega\mu\varepsilon\rho}(d^2 A_z/ d\rho\, dz)$$

$$E_Z = -\frac{j}{\omega\mu\varepsilon}(d^2/dz^2 + k^2)A_Z \quad , \quad H_\rho = (\frac{1}{\mu\rho})(dA_Z/d\varphi)$$

$$H_\varphi = (-\frac{1}{\mu})(dA_Z/d\rho_z)\ , \qquad H_z = 0$$

X'mn represents the zeros of the derivative of the Bessel function Jm(x)

$$(f_r)_{mno} = 1/2\pi(\sqrt{\mu\varepsilon})\,(X'_{mn}/a)$$

$$(f_r)_{110} = 1.8412 v_o/2\pi a_e\sqrt{\epsilon_r}$$

Circular Patch radius

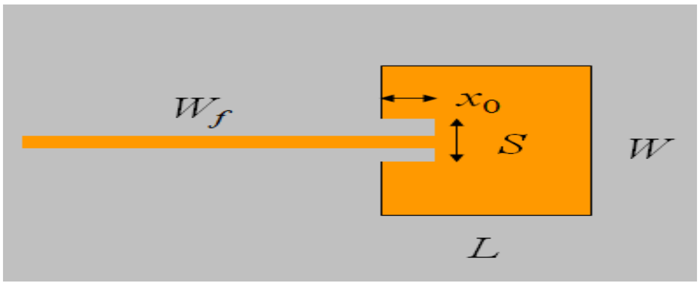
$$a = F/\sqrt{[(1 + \frac{2h}{\pi\epsilon_r F})\{ln\left(\frac{\pi F}{2h}\right) + 1.7726\}]}$$

Effective Radius of Circular Patch

$$a_e = a\sqrt{[\left\{1 + \frac{2h}{\pi\epsilon_r a}\right\}\left\{ln\left(\frac{\pi a}{2h}\right) + 1.7726\right\}]}$$

III- FEEDING TECHNIQUE

Antenna feed line connects the antenna to the transmitter/ receiver electronics. Like the antenna, the feed line is a wire (or wires). However, these wires should neither radiate nor receive RF. Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. There are several feeding technique like coaxial probe fed, microstrip line fed, edge fed, inset fed, CPW fed. The CPW is a feeding in which centre strip carries the signal and side-plane conductor is ground. The advantage of CPW fed slot antenna is its wide band characteristics. Therefore CPW fed slot antenna is most effective and promising antenna for wideband wireless application. Coplanar waveguide transmission line enables us to design a wide range of characteristic impedances and the CPW structures have many attractive features such as wider bandwidths, low radiation losses, less dispersion and easy integration.



IV- DEFECTED GROUND STRUCTURES

The name for this technique simply means that a "defect" has been placed in the ground plane, which is typically considered to be an approximation of an infinite, perfectly-conducting current sink. When DGS is incorporated in the ground plane it provides additional resonance and it slightly shifts the fundamental frequency of the antenna. DGS provide the considerable miniaturization, good impedance matching and wider bandwidth in the design engineering of patch antennas .

Defect in ground planes has been a technique to achieve certain inductance and capacitance values for active circuit design. The DGS elements do not affect the odd mode transmission, but slows the even mode, which must propagate around the edges of the DGS slot. With this change in the phase velocity of the wave, the effective dielectric constant is effectively altered, creating a type of slow-wave structure.

V- CPW DESIGN

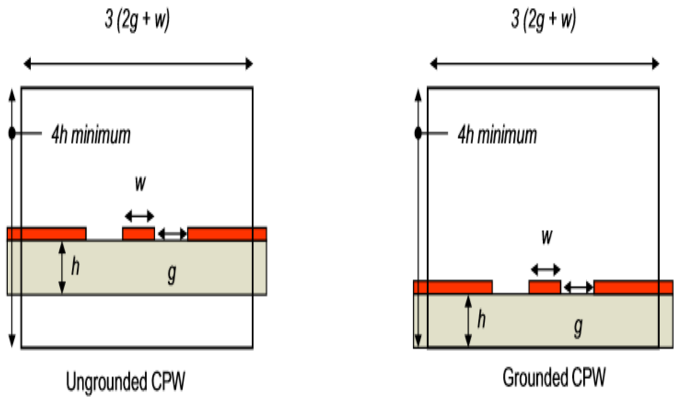
Beside the microstrip line, the CPW is the most frequent use as planar transmission line in RF/microwave integrated circuits. It can be regarded as two coupled slot lines. The conductors formed a center strip separated by a narrow gap from two ground planes on either side. The dimensions of the center strip, the gap, the thickness and permittivity of the dielectric substrate determined the effective dielectric constant, characteristic impedance and the attenuation of the line. Since the number of the electric and magnetic field lines in the air is higher than the number of the same lines in the Microstrip case, the effective dielectric constant εeff of CPW is typically 15% lower than the εeff for Microstrip, so the maximum reachable characteristic impedance values are higher than the Microstrip values.

$$Z_0 \;= 30/\sqrt{\epsilon_{eff}}[K(ko')/K(ko)]$$

$$E_{eff} \;= 1 + \frac{(E_r - 1)}{2}\left[\frac{K(ko')K(k1)}{K(ko)K(k1')}\right]$$

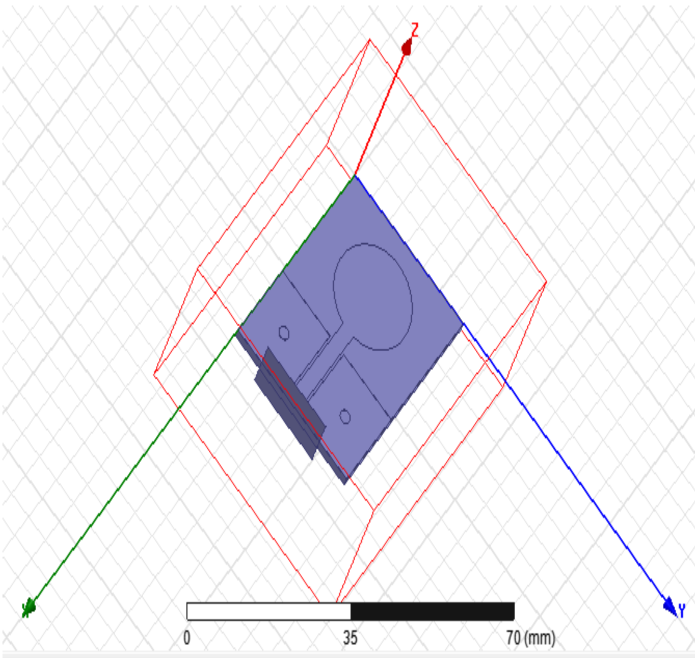
$$G = 2s + W \qquad K_0 = W/G \qquad ko' = \sqrt{1-k_0^{\,2}} \qquad k_1' = \sqrt{1-k_1^{\,2}}$$

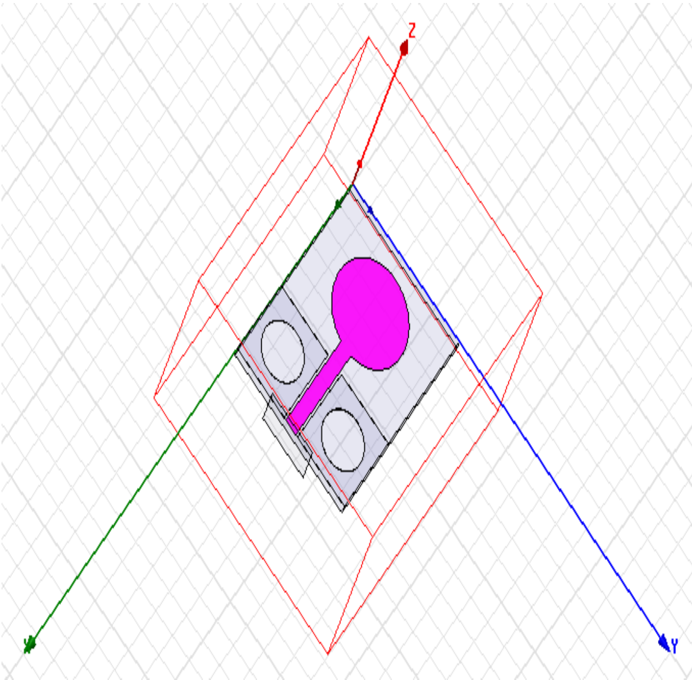
K(k_0), K(k_1), K (ko'), K(k1') are the first complete elliptic integral function and its complement function respectively. h, ε_r, ε_{eff}, w, s were the thickness of the dielectric substrate, the substrate relative permittivity, the effective dielectric constant substrate, the width of CPW-fed wire, the gap between CPW-fed wire and the ground.



VI- PROPOSED ANTENNA

The size of the antenna is 42mm x 32mm with FR4 substrate of thickness 1.6mm and the copper thickness is 0.07mm. The gap between the feed and ground plane is 0.5mm. The same value is used for inset gap.The inset feed length is 3.1mm. Here I have used circular shaped DGS structure. For circular patch radius is 11mm.



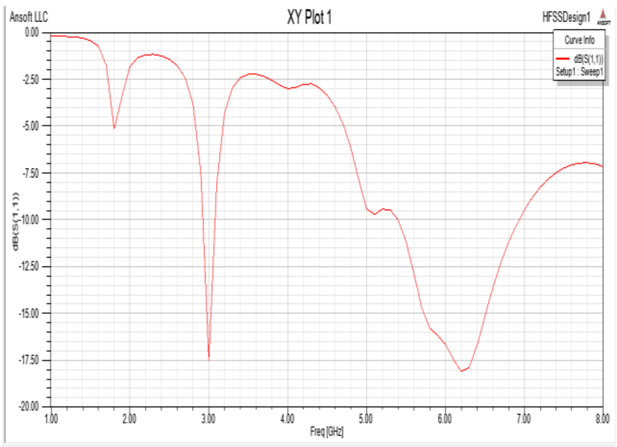


VII- RESULTS

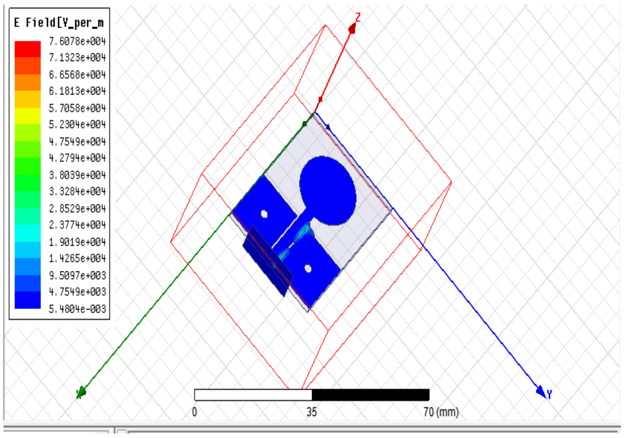
1) CPW fed antenna with DGS of radius

R= 1.15 mm in ground at 2.6 GHz.

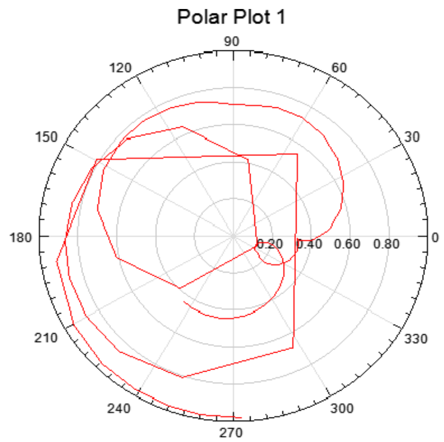
a) "Return loss vs Frequency"



b) "E-field distribution"



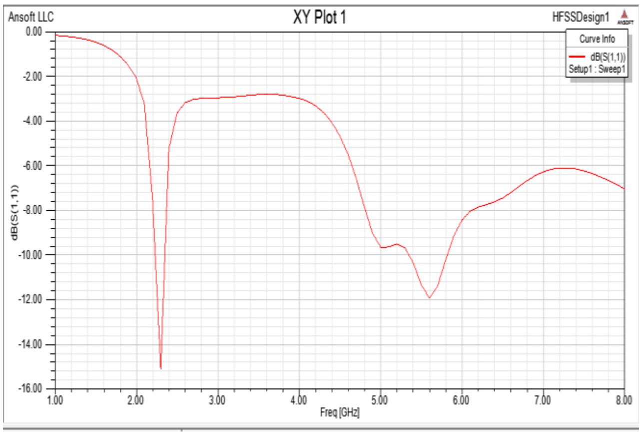
c) Polar Plot



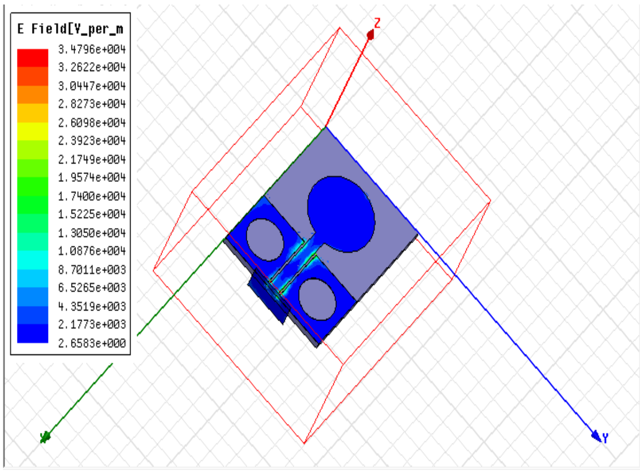
2) CPW fed antenna with DGS of radius

R= 5 mm in ground at 2.6 GHz.

a) "Return loss vs Frequency"



b) "E-field distribution"



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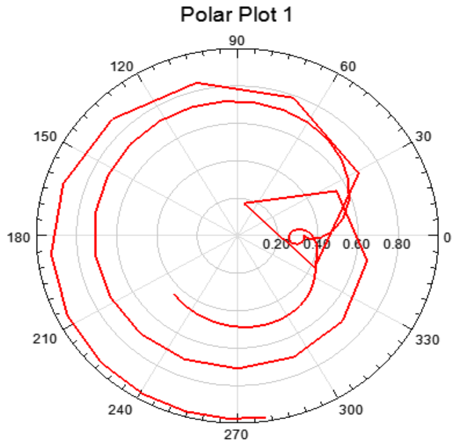

VIII- CONCLUSION AND FUTURE WORK

The design and simulation of CPW feed circular patch antenna was successfully designed and analyzed using Ansoft HFSS. Comparative analysis was made by changing the radius of DGS structure . More focus is on methods which results in enhancing the bandwidth and efficiency. In CPW the characteristic impedance is determined by the ratio of the centre strip width W to the gap width s, so size reduction is possible without limit, the only penalty here is higher losses. The design can be modified further by changing antenna dimensions on some different substrate and introducing different shapes as defective ground structure in ground plane. Below is the summary of the simulated results:

S.No	Patch	DGS in the ground	Resonating frequency
1.	Circular	Yes, Circular of radius = 1.15 mm.	3 and 6.2 GHz.
2.	Circular	Yes, Circular of radius = 5mm.	2.35 and 5.6 GHz.

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XI- BIOGRAPHY

Kangan Saxena received her B.Tech degree in electronics and communication from Amity School of Engineering and Technology at Amity University, Noida (India) in 2012 and the M.Tech degree from USICT, Guru Gobind Singh Indraprastha University Dwarka, New Delhi. She is working with HCL Technologies Noida since 4.5 years as a Lead Engineer. She works on DSC and DSLR cameras in consumer electronics domain. She is also teaching in USICT on weekends. She is focusing on optimization and various applications of microstrip and CPW antennas. She is currently doing simulations on HFSS and is planning to do Ph.D in near future. Her research interest includes Advanced Digital Communications, Wireless Communications, Smart Antennas and Optical Communications.