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Comparison of Rectangular, Circular and Triangular Patch Antenna with CPW Fed and DGS

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Abstract
This paper presents design of antenna for dual band frequencies. (2.3 GHz and 5.2 GHz). Comparative analysis is presented on the basis of geometry of patch of antenna. Rectangular, Circular and Triangular Patch is used to compare the results. Inset feed is used due to which proposed CPW antenna achieves size reduction, compactness, good impedance matching and wide bandwidth at the fundamental operating frequency. Vias can be eliminated in case of CPW technology because it offers ground at the same layer. Antenna is designed for 2.6 GHz. For enhancing the bandwidth and performance DGS is introduced. Defected Ground Structure (DGS) can be used as an unique approach to improve the performance of the microstrip patch antennas specially the resonating frequency. High Frequency Structure simulator is used to analyse the design.

Keywords
CPW, Inset Feed, Impedance Matching, Circular Patch, DGS, Triangular Patch

I. Introduction

Communication had a great role to play in the worldwide society now days. Communication system is rapidly switching from "wired to wireless". Wireless technology provides less expensive alternative and a flexible way for communication. Antenna is one of the crucial element of the wireless communications system .The main areas of research in the world of communication systems today is wireless technology and without understanding the operation and fabrication of antennas study of communication systems is incomplete. Due tos less weight, cost-effectiveness and ease in designing planar antennas are mostly used. CPW feed antennas is the most popular and useful planar antennas.

CPW antennas have many interesting features like single metallic layer, can be easily integrated with MMIC circuits, Omni-directional radiation coverage, connection between passive and active lumped element and lower cross polarization obtained from the feed network. In multilayer fabrication it is necessary to connect the top layer to the bottom layer. Vias are used to connect the ground plane which is at the bottom to the top layer. Due to inset feed technique it is easy to achieve impedance matching and inductance cancellation at the port. The designed antenna is applicable for 2.3 and 5.2 GHz. DGS can be formed by making simple slot in the ground of the antenna which effects the distribution of the current in the ground plane leading a controlled propagation of Electromagnetic (EM) waves through the dielectric layer. DGS leads to bandwidth enhancement reduction in size i.e miniaturization, provides good impedance matching thus giving better output results. The antenna also covers Wi-MAX frequencies.

II. Antenna Design

A. Rectangular Patch Antenna

Microstrip patch antenna or radiating patch consists of a small rectangular sheet of metal. It is present on one side of dielectric substrate, whose other side has larger sheet of metal ground plane. Patch is conducting in nature and it consists of material such as copper or gold is used to make the patch. Some of electric field lines are in air and are not limited to dielectric substrate, it results in extended electric field called the "fringing fields". Therefore electrical length of the antenna increases but resonant length of antenna decreases. A resonant cavity is formed by the metallic where the edges of patch form the sides of cavity and ground plane is at the bottom and patch is on top of the cavity. Perfect electric conductor is on the top and bottom surfaces and sides of resonant cavity have perfect magnetic conductor. Open-circuit boundary condition is represented approximately by edges of patch. Antenna is designed at 2.6 Ghz using standard design equations. Electric field for (m, n) cavity mode is given as

$$Ez(x,y) = AmnCos\left(\frac{m\pi x}{L}\right) Cos\left(\frac{n\pi y}{W}\right)$$

The surface current on the bottom of the metal patch is x directed, and is given by

$$Jsx(x) = A10\left[\frac{\frac{\pi}{L}}{jwUoUr}\right]$$

B. Circular Patch Antenna

By treating the patch, ground plane and material between them as a circular cavity, we can determine the mode supported by circular patch antenna. Two electric conductors are at the top and the bottom of the cavity which represent the patch and the ground plane respectively. Around the circular periphery of the cavity there is cylindrical perfect magnetic conductor. ae is effective radius of patch

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

C. Triangular Patch Antenna

Triangular geometry of the microstrip patch antennas can be used in circuit elements and in wireless applications. Due to its physical smaller size TPA can be a good substitute for rectangular patch, In recent years, the TPA has been used used as broadband radiators ,circularly polarized antennas, designing arrays and dual frequency and multiband antennas. a is the side of TPA given as follows

$$a = 2c/3f\sqrt{\epsilon_r}$$

D. CPW Feed

There are various feeding techniques like edge fed, inset fed, aperture coupled, proximity coupled ,coaxial probe fed, microstrip line fed, CPW fed. In CPW feeding there is a center strip which carries the signal and side-plane conductor is ground. It provides ground at the same plane so vias can be eliminated. Wide band characteristics are the main feature of CPW fed slot antenna. Therefore for wideband wireless application. CPW fed slot antenna is most effective and promising antenna. Wide range of characteristic impedances can be designed by coplanar waveguide transmission line. CPW structures usually provide wider bandwidths, easy integration, better impedance matching, low radiation losses and less dispersion.

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

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

In above equations w, s are the width of CPW strip, the gap between strip and the ground, h, εr, εeff represents thickness of the dielectric substrate, the substrate relative permittivity, the effective dielectric constant substrate, K(k0), K(k1), K (ko'), K(k1') are the first complete elliptic integral function and its complement function respectively. A Lumped Port excitation will be used for the CPW. Position and dimension of port can also influence the results, return loss and resonating performance of antenna.

E. Defected Ground Structures

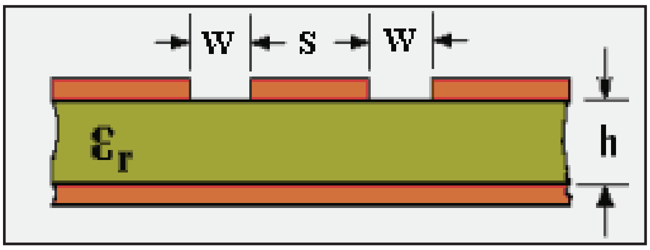
Defect in ground planes has been a successful technique to achieve certain inductance and capacitance values for active circuit design. The transmission line properties are disturbed due to the removal of ground plane, these defects are used to alter the values of distributed components. Boundary conditions of transmission line gets altered due to defect. Introduction of DGS in the ground plane provides additional resonance at 5.2GHz and it slightly shifts the fundamental frequency of the antenna.

$$f_r \;=c/4\sqrt{\epsilon_r}\,L1$$

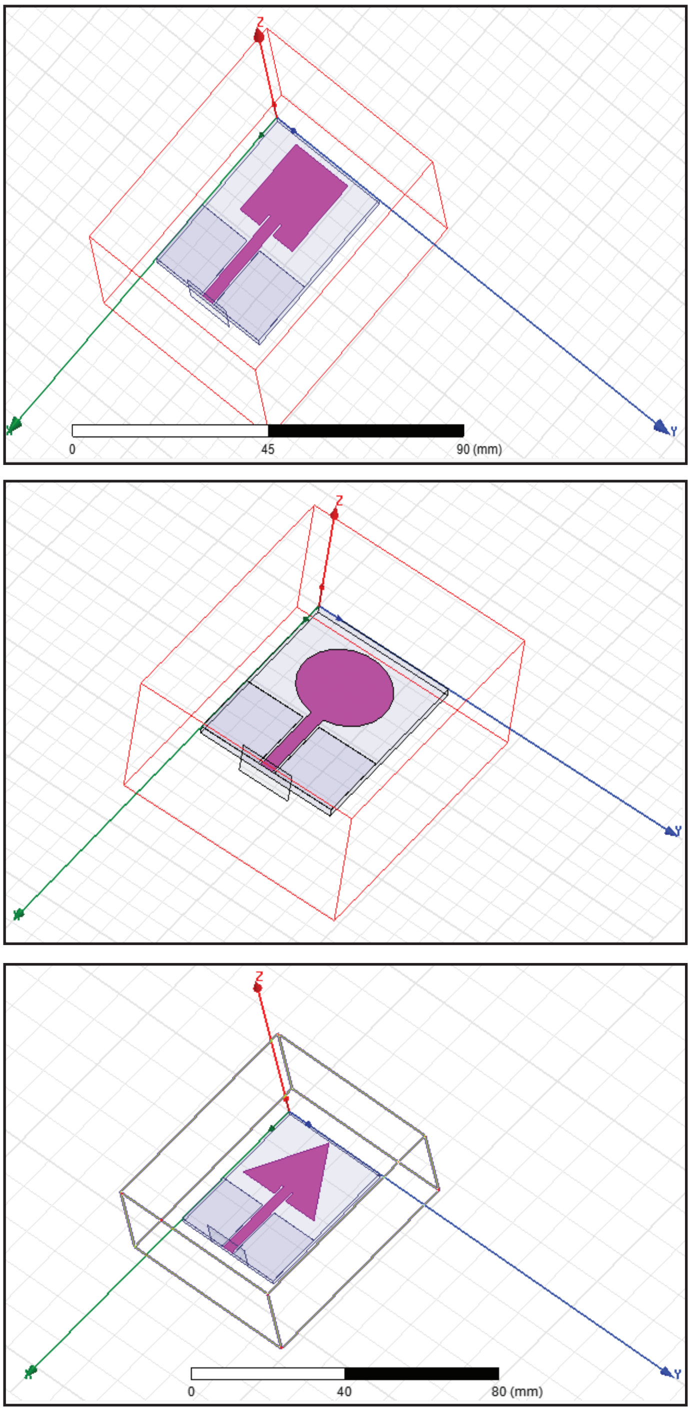
Where L1 is the length of DGS structure.

III. Proposed Antenna Design

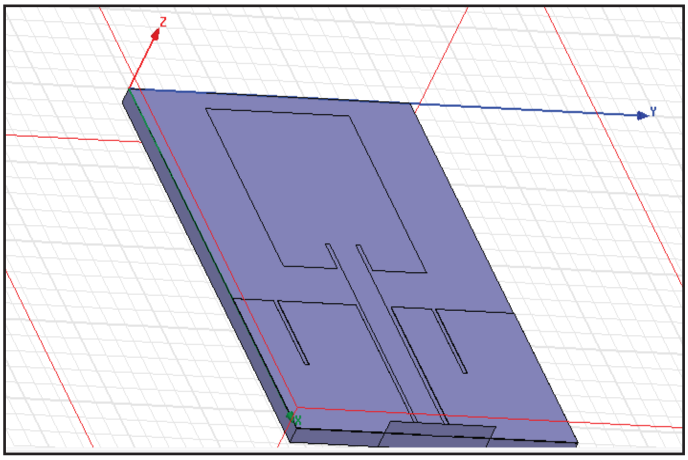
Antenna is designed for the size 42mm x 32mm with FR4 substrate. Thickness of the substrate is 1.6mm and the copper thickness is 0.07mm. Inset gap and DGS width is 0.5 mm. Same value is used for gap between the feed and ground plane. The inset feed length is 3.1mm. For size reduction and better resonating performance DGS is widely used in many applications. Different shapes of DGS structures can be used. In this design two rectangular slots are inserted in ground plane. Position and shape of DGS position produces different effects on antenna results such as band stop and provide wide bandwidth. Ground plane edges have more current concentration in CPW. If the DGS is in the edge it provides additional resonant frequency. The rectangular patch is of dimension 16.34 mm and 19.44 mm. For circular patch radius is 11mm.

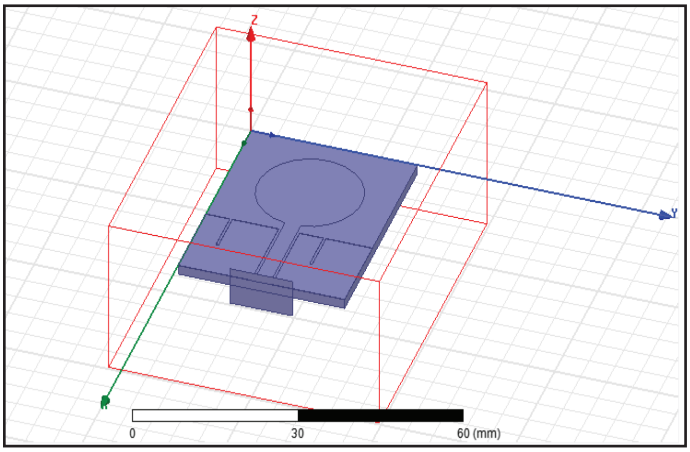


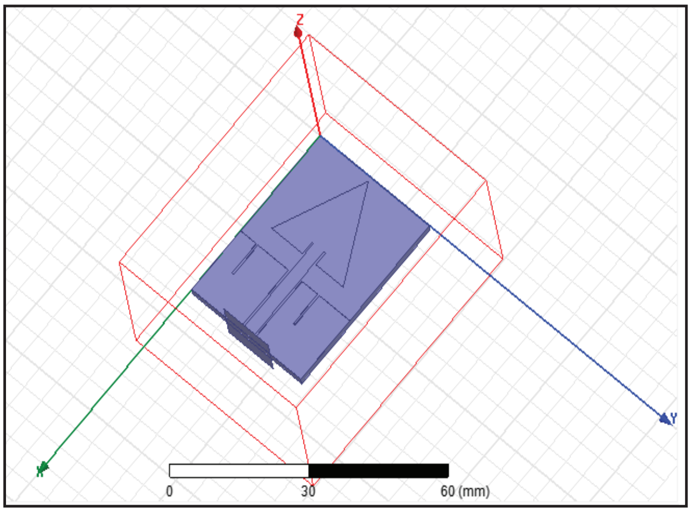
Without DGS



With DGS

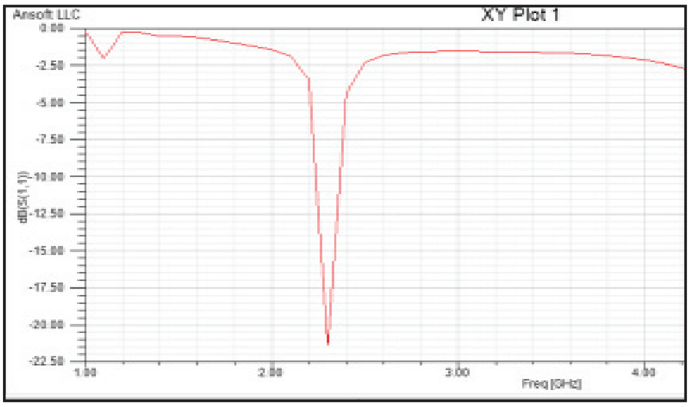




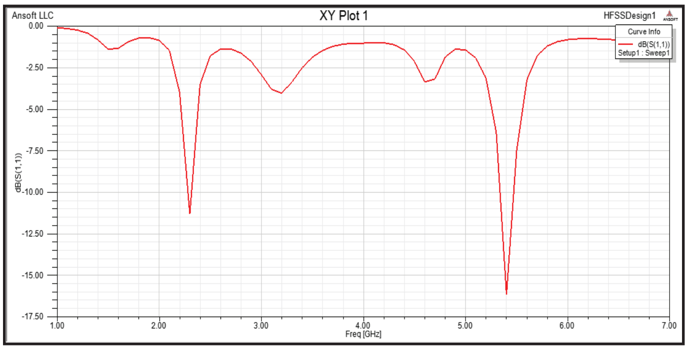


IV. Results

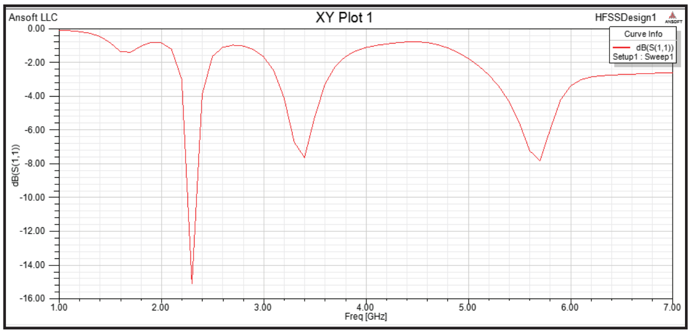
1. Return loss vs Frequency for Rectangular Patch Without DGS



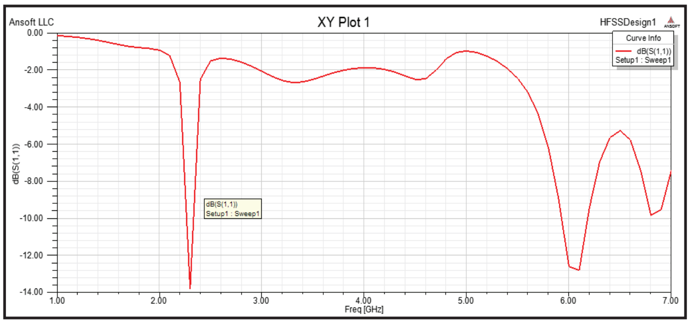
2. Return Loss vs Frequency for Rectangular Patch with DGS



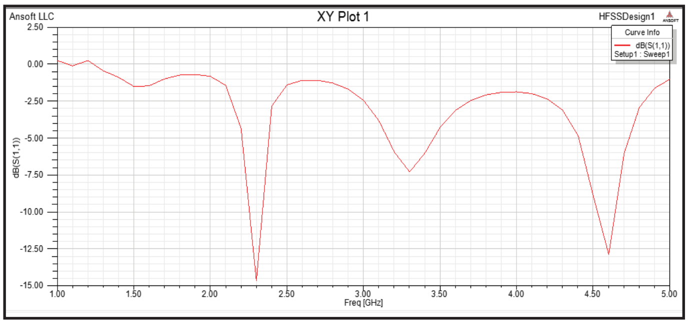
3. Return Loss vs Frequency for Circular Patch Without DGS



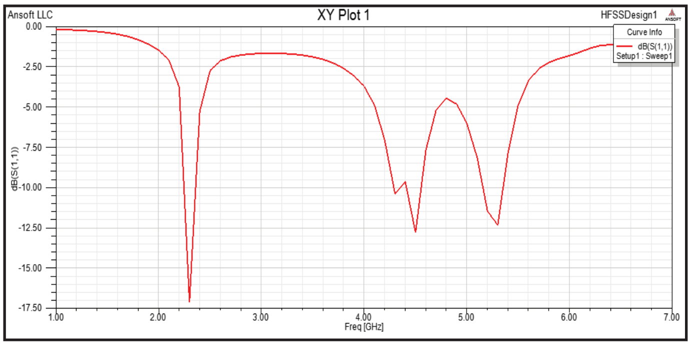
4. Return loss vs Frequency for Circular Patch with DGS



5. Return Loss Vs Frequency for Triangular Patch Without DGS.



6. Return loss vs Frequency for Triangular Patch With DGS



V. Conclusion

The design and simulation of CPW feed antenna was successfully designed and analysed using Ansoft HFSS. Comparative analysis was made by changing the shape of patch. The antenna is optimized to obtain dual frequency with good return loss and gain. The proposed antenna resonates at two different frequencies covering WLAN (2.4Ghz/5.2Ghz), WiMAX(2.5) applications. Variation in length of DGS length was also given and satisfactory results were obtained. For calculating this length, effective dielectric constant (εeff) is calculated for corresponding resonant frequency

(5.15 GHz) using standard microstrip line formula. Below is the summary of the simulated results:

Table 1:

S.No	Patch	Resonating frequency
1.	Rectangular Without DGS	2.35Ghz
2.	Rectangular With DGS	2.3 Ghz and 5.4 Ghz.
3.	Circular Without DGS	2.35 GHz.
4.	Circular With DGS	2.3 GHz and 6 GHz
5.	Triangular Without DGS	2.3 GHz
6.	Triangular With DGS	2.3 GHz and 5.35 GHz

VI. Future Work

Position and dimension of port also affects the performance of antenna. Optimization of the results can be done by giving more variation in DGS length and changing shape of DGS structure. Resonating performance of antenna can be improved by introducing slots in the patch, it increases mean current path in the patch and thus increasing the dimension of patch. Horizontals slots and vertical slots can be placed. Horizontal slots can be used to divide the patch into subsections which act as switches. Since the number of the electric and magnetic field lines in the air is higher than 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. 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 being higher losses. Extensively and exclusively focusing on the area of different design methods especially in enhancing the impedance bandwidth and the efficiency.

VII. Acknowledgment

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