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Performance Analysis of Frequency Tuned Micro strip Patch Antenna with DGS

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Abstract:
A simple technique to achieve frequency reconfiguration, dual frequency of operation, wideband operation and compactness in a conventional Microstrip patch antenna has been proposed in this communication. One of the conventional technique to achieve the above said enhanced characteristics is to etch some slots in the ground plane and the ground with slots is called as Defected Ground Structure. A simple rectangular Microstrip patch antenna has been designed which work for the X-band frequency of 10 GHz and various DGS structures are introduced in the antenna ground plane. The basic antenna parameters are been analyzed in terms of frequency of operation, VSWR, gain and Radiation pattern. With the introduction of different types DGS structures we can observe that the operating frequency has shifted to the lower frequencies which lead to compactness. Achieved a compactness of 25% with the introduction of the DGS. Along with compactness Dual frequency of operation and Wideband width of operation can also be observed for different DGS configuration. To validate the proposed technique the same DGS structures has been introduced in another circular patch antenna and observed that the change in antenna performance is same for both the antennas.

Keywords: *Defected Ground, Frequency Reconfiguration, Dual Frequency, Wideband.*

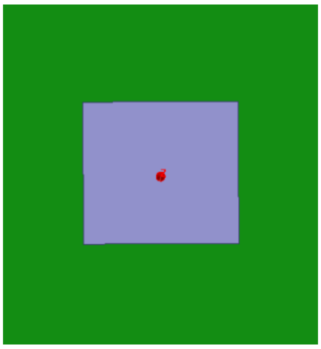
I INTRODUCTION

Microstrip antennas have become the most suitable antennas in the modern communication system due to their unique properties of low profile and flexibility. But the limitation of low band width is still an issue to be addressed and researchers around the world proposed different techniques to enhance the antenna impedance bandwidth[1-2]. With the advent of the modern communication systems requirement of the antennas with enhanced properties has also increased. Antenna with dual frequency of operation and reconfigurable nature has become inevitable to accommodate different applications in a single system[3-4]. Though microstrip antennas are known for their low profile and compact nature still there is requirement for further compactness so as to satisfy the needs of the modern communication systems which is in the era of portable modules for all the applications.

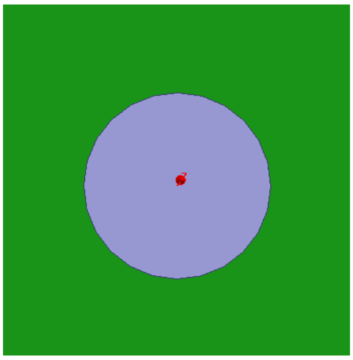
To address all the above issues different techniques were proposed by the antenna design engineers like shorting pin, stacked patch, metamaterials, Electromagnetic band gap structures and defected ground structures[5-7]. Among all the proposed techniques defected ground structures have gained popularity because of their simple structure. In general conventional antennas have continuous ground plane, if we introduce some slots in the ground plane then the ground is called as defected ground[8-9]. The introduced defect may be single or multiple either case we will refer the ground as defected ground structure[10]. To address all the above discussed problems of the microstrip antennas we propose the defected ground structure with different configurations to get different enhancements in the characteristics of conventional antennas.

II PROPOSED DESIGN AND CONFIGURATION

A simple microstrip antenna with coax feedand a overall size of 15mm*15mm with rectangular radiating element is considered and the rectangular radiating element is having the dimensions of 6.1mm*7mm. Easily available low cost Glass Epoxy FR4 substrate with a thickness of 1.6mm has been used as the substrate. The proposed dimensions were calculated based upon the design equations given below such that resonating frequency of the designed antenna will match the X-band frequency of 10GHz. Initially a Coax fed rectangular microstrip patch antenna is considered as shown in Fig.1a. Here ground is a continuous structure. In Fig. 1b we have a circular patch with same physical dimensions for substrate and ground but with circular patch.



(a) Rectangular Patch Antenna

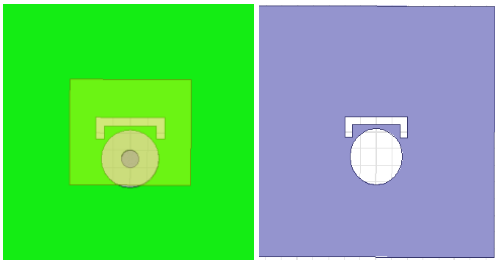


(b) Circular Patch Antenna

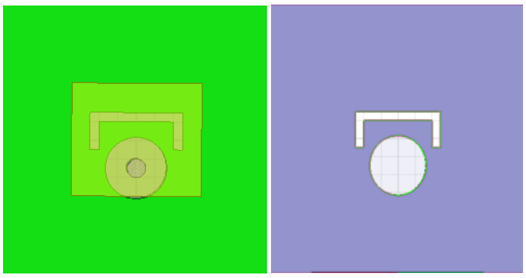
Fig. 1.Top view of the proposed antennas

Here we considered two antennas with different patches so that we can validate the results of the one antenna with another one. Both the antennas have the same dimensions and materials used except that the patch shape is changed. The radius of the circular patch is 3.7mm. Both the antennas operates in one of the six modes at a particular time; Different mode of operation of the defected ground structures are as shown in the figure 2 below.

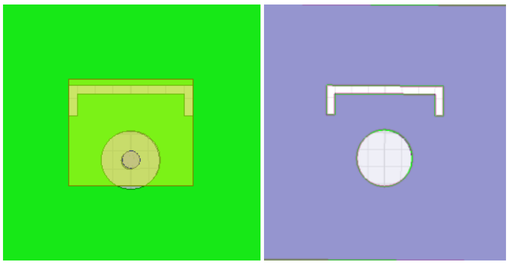
Different DGS shapes are been etched on continuous ground plane structure of the designed rectangular Microstrip antenna and various antenna characteristics like return loss, VSWR, gain and radiation patterns were analyzed for different DGS shapes.



(a) Mode A



(b) Mode B



(c) Mode C

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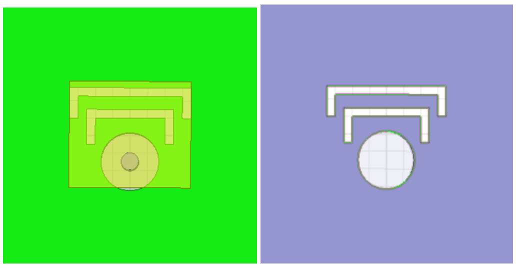
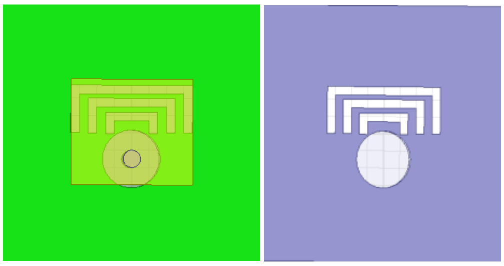
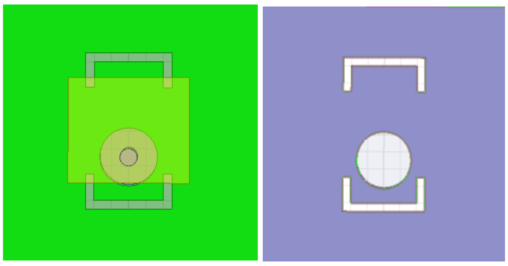


(d) Mode D



(e) Mode E



(f) Mode F

Fig. 2.Geometry of the proposed DGS modes

Each mode is having a different DGS structure incorporated in the ground and the performance of the antennas are been analysed for all the six modes. The slot width of all the DGS's is 0.5mm.

The design equations for calculating the circular patch radius are given below.

$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{-1/2} \quad (1)$$

where

$$F = \frac{8.791\times 10^9}{f_r\sqrt{\varepsilon_r}} \quad (2)$$

$$a_e = a\left\{1 + \frac{2h}{\pi a \varepsilon_r}\left[ln\left(\frac{\pi a}{2h}\right) + 1.7726\right]\right\}^{1/2} \quad (3)$$

The design equations for calculating the rectangular patch are given below.

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (4)$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (5)$$

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (6)$$

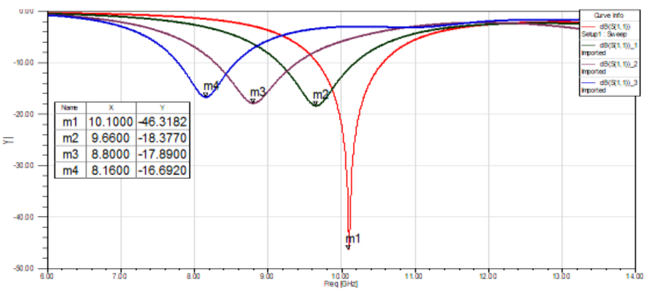
$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (7)$$

$$L = L_{eff} - 2\Delta L \quad (8)$$

III RESULTS

The Coax fed patch antennas with defected ground plane provides enhanced radiation and impedance matching characteristics. Different modes of operation is having different impedance characteristics like compactness, dual band operation and wide impedance bandwidth.

In mode A, B and C operations it is observed that by incorporating the DGS compactness is observed which are shown below in the figure 3. Figures 3(a) depicts the impedance matching plots for three different DGS modes of A,B and C when etched in the ground plane of the considered rectangular microstrip patch antenna and in figure 3(b) we can see the impedance matching plots for three different DGS modes of A,B and C when etched in the ground plane of the considered circular microstrip patch antenna . A compactness of 25% is observed with respect to the 10GHz frequency.



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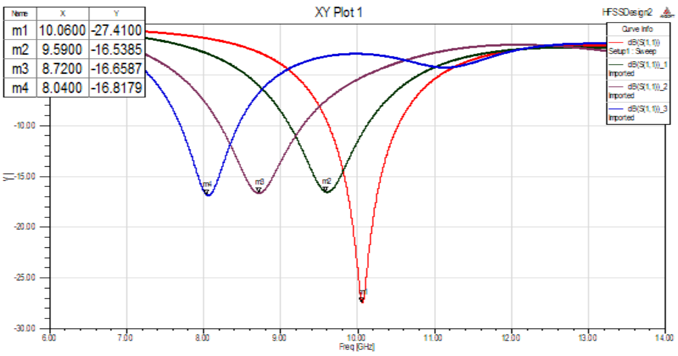
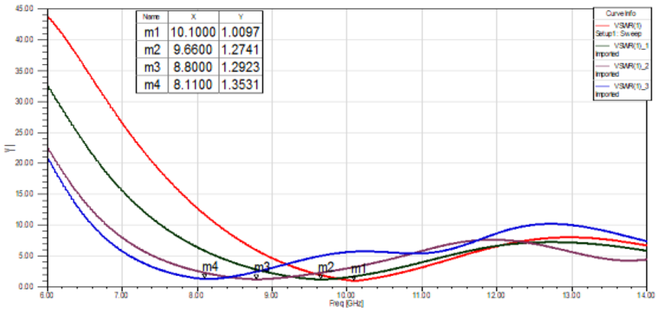
(a) Rectangular Patch

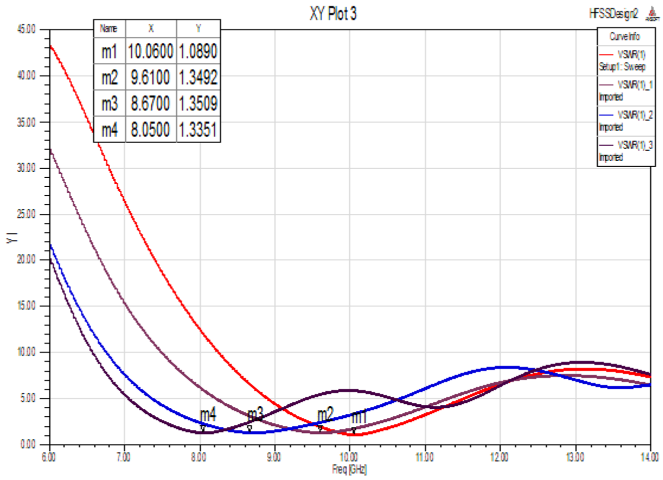


(b) Circular Patch

Fig.3.Impedance Matching Plots



(a) Rectangular Patch

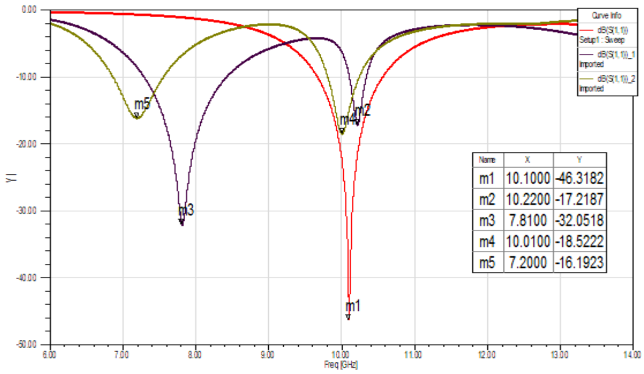


(b) Circular Patch

Fig. 4.VSWR

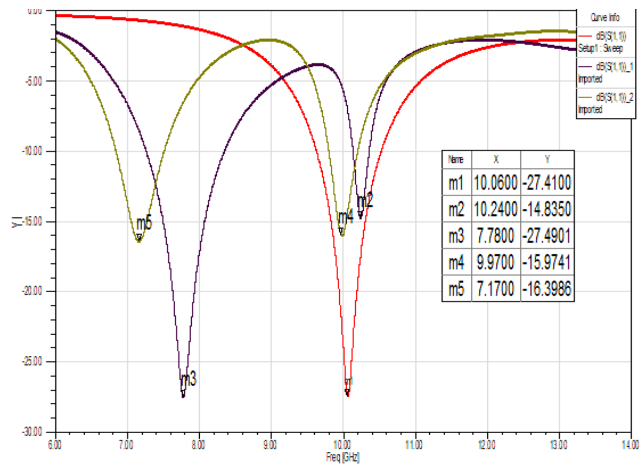
Figures 4(a) and 4(b) shows the VSWR plots of the rectangular and circular patch antennas respectively for the operating modes A, B and C.

In mode D and E operations it is observed that by incorporating the DGS compactness is observed along with dual frequency of operation which is depicted in the figure 5. Figures 5(a) depicts a comparison plot of the impedance matching graphs of the designed antenna with two DGS modes of D and E with the conventional antenna without any DGS structure and figure 5(b) depicts the impedance matching comparison plots of the designed circular patch antenna with two DGS modes of D and E with the conventional circular patch antenna without any DGS structure.



(a) Rectangular Patch

The proposed rectangular patch antenna is having a dual frequency of operation at the frequencies of 10.2GHz and 7.81GHz whereas the proposed circular patch antenna is also having a dual frequency of operation at the frequencies of 10GHz and 7.1GHz[1-10].



b) Circular Patch

Fig. 5.Impedance Matching Plots

Figures 6(a) and 6(b) shows the VSWR plots of the rectangular and circular patch antennas respectively for the operating modes D and E.

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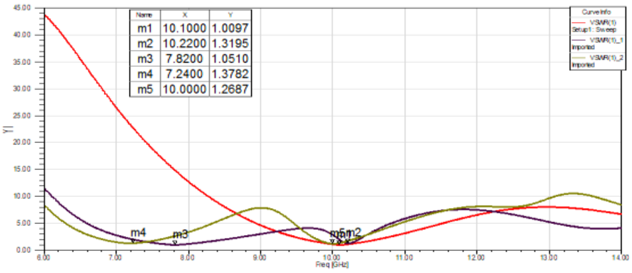
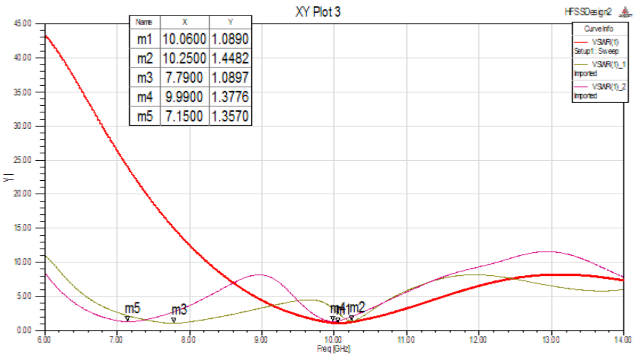


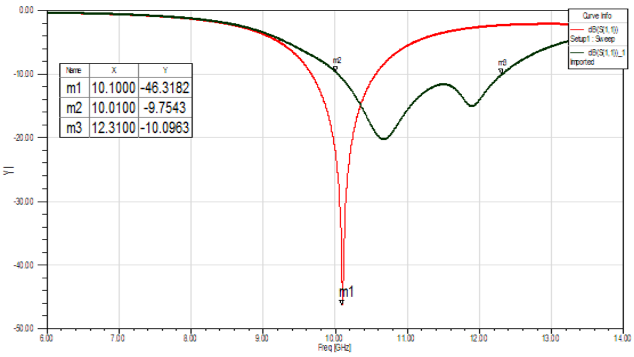
(a) Rectangular Patch



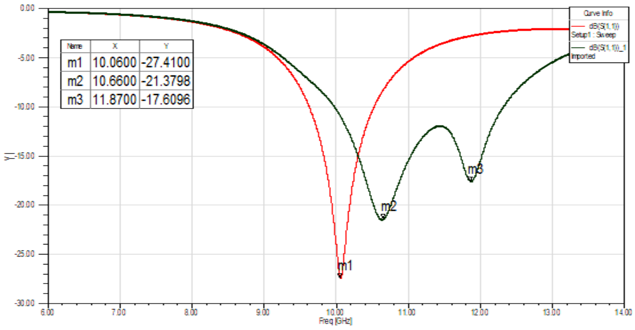
(b) Circular Patch

Fig.6.VSWR

In mode F operations it is observed that by incorporating the DGS bandwidth enhancement is observed which is shown in the figure 7. Figures 7(a) depicts a comparison plot of the impedance matching graphs of the designed antenna with a single DGS modes of F with the conventional antenna without any DGS structure [11-13].



(a) Rectangular Patch

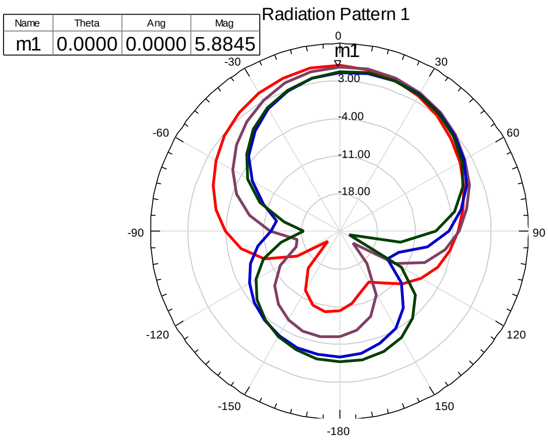


(b) Circular Patch

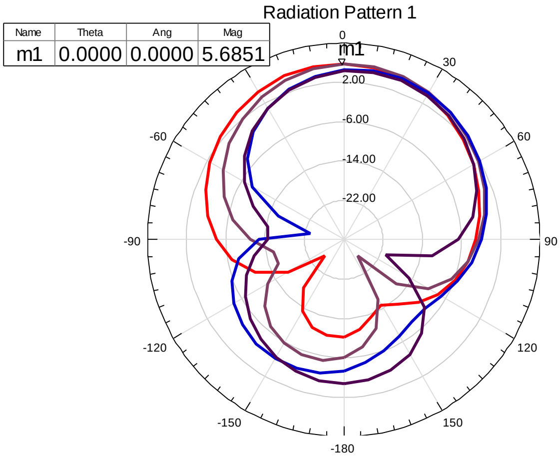
Fig. 7. Impedance Matching plots

Figure 7(b) depicts the impedance matching comparison plots of the designed circular patch antenna with single DGS mode F with the conventional circular patch antenna without any DGS structure. The proposed patch antennas with DGS are having a impedance bandwidth of 2.3GHz.

The variation of gain of antennas for different DGS modes of operations of A, B and C are depicted in Fig. 8. It is observed that there is no considerable variation in the gain of the antenna and it is almost constant for all the DGS modes with a small negligible variation of 0.7dB. The peak gain of the antenna is 5.88dB for rectangular patch and 5.68dB for circular patch antenna.



(a) Rectangular Patch



(b) Circular Patch

Fig. 8. Radiation Pattern

IV CONCLUSIONS

In this paper a study on antenna parameters like impedance characteristics and radiation characteristics for a simple microstrip patch antenna with rectangular and circular patches employing a defected ground structure are presented. Six different modes of operations with different DGS's are studied. Different modes of operation are having different impedance characteristics like compactness, dual band operation and wide impedance bandwidths. The effect on the antenna characteristics due to the modification in the continuous ground are been successfully investigated.

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