Design and Analysis of E Shape Defected Ground Antenna Using Matlab

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Abstract

This paper presents the design of E shape defected ground antenna at 4.75 GHz using matlab simulation & CST. The operating frequencies can have the same polarization plane. This antenna can be considered to consist of two connected resonators of different sizes. E shape microstrip patch antenna defected ground and without defected ground is analysed using Matlab and CST software comparison is made between them. This antenna is based on a thickness of 1.6mm Flame Retardant 4 (FR-4) substrate with a dielectric constant of approximately 4.4.

Keywords

E Shape Microstrip Patch Antenna, Matlab, CST Software, Flame Retardant 4 (Fr-4), Patch Width, Patch Length, Hexagonal, DGS.

I. Introduction

Defected ground structures (DGS) have been attractive to obtain the function of unwanted frequency rejection and circuit size reduction. Researches on the PBG had been originally carried out in the optical frequency. Recently, there has been an increasing interest in microwave and millimeter wave applications of PBG circuits. Various shapes of DGS structures have been appeared. Since DGS cells have inherently resonant property, many of them have applied to filter circuits. However, it is difficult to use a PBG structure for the design of the microwave or millimetre wave components due to the difficulties of the modelling. There are many design parameters, which have an effect on the band gap property, such as the number of lattices, lattice shape and lattice spacing. Another difficulty in using the PBG circuit is caused by the radiation from the periodic etched defects.

Many etched shapes for the microstrip could be used as a unit DGS. An LC equivalent circuit can represent the unit DGS circuit. The physical dimensions of the DGS affect the equivalent circuit parameters.

- Type of antenna: E shape micro strip patch antenna
- Ground shape: hexagonal shape
- Resonance frequency: 4.75 & 4.9 GHz
- Input impedance: 50 Ω
- Thickness: 1.6mm
- Dielectric constant (): 4.4

The specifications were chosen to design a light wave and compact Microstrip patch antenna. The Design of the whole structure is performed in the following steps.

II. Design

The parameters are given on the co-ordinate axis such as Width on y axis height on z direction and length on x direction.

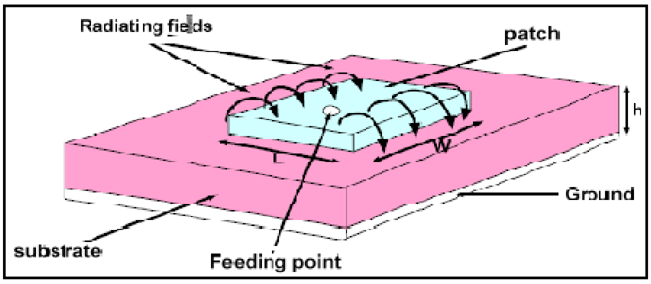

Fig. 1: Constructional View of Microstrip Antenna (Ms Paint)

There are three essential parameters for design of E shape microstrip patch antenna. Firstly, the resonant frequency (f) of the antenna must be selected appropriately. The frequency range used is from 4.5GHz -5GHz and the design antenna must be able to operate within this frequency range. The resonant frequency selected for this design is 4.75 GHz with band width of 890MHz. Secondly, the dielectric material of the substrate (Er) selected for this design is FR-4 Epoxy which has a dielectric constant of 4.4 and loss tangent equal to 0.002. The dielectric constant of the substrate material is an important design parameter. Low dielectric constant is used in the prototype design because it gives better efficiency and higher bandwidth, and lower quality factor Q. The low value of dielectric constant increases the fringing field at the patch periphery and thus increases the radiated power. The proposed design has patch size independent of dielectric constant. So the way of reduction of patch size is by using higher dielectric constant and FR-4 Epoxy is good in this regard. The small loss tangent was neglected in the simulation. Lastly, substrate thickness is another important design parameter. Thick substrate increases the fringing field at the patch periphery like low dielectric constant and thus increases the radiated power. The height of dielectric substrate (h) of the microstrip patch antenna with coaxial feed is to be used in dual-band frequencies. Hence, the height of dielectric substrate employed in this design of antenna is h= 1.6mm.

III. Physical Parameters of the Antenna

Step 1: calculation of width (w) width of the patch [1]

$$W = \frac{c}{2f\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Step 2: Calculation of Effective dielectric constant .The effective dielectric constant is:

For W/h ≤ 1:

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(\frac{1}{\sqrt{1+\frac{12h}{w}}}\right)$$

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For W/h>1

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\left(1 + 12\,\frac{h}{w}\right)^{-0.5} + 0.04\left(1 - \frac{w}{h}\right)^2\right]$$

Step 3: Calculation of the Effective length. The effective length is:

$$Leff = \frac{c}{2f\sqrt{\varepsilon eff}}$$

Step 4: Calculation of the length extension (ΔL). The length extension is [2]:

$$\Delta L = \frac{.412h(\varepsilon eff + .3)(\frac{w}{h} + .264)}{(\varepsilon eff - .264)(\frac{w}{h} + .8)}$$

Step 5: Calculation of actual length of patch (L) .The actual length is obtained by [3]:

L = Leff-2ΔL

Step 6: Calculation of Directive Gain of the antenna Directive Gain of the antenna is

$$\mathbb{G} = \eta\mathcal{D}$$

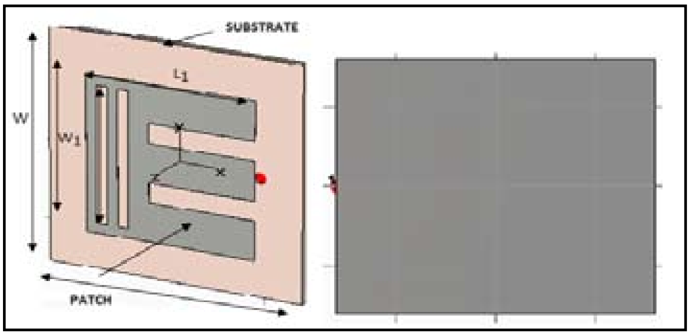
Step 7: Ground dimension For practical considerations, it is essential to have a finite ground plane if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, the ground plane dimensions would be given as [4]

$$Lg = 6h + L \;; \qquad Wg = 6h + w :$$

fig. 2 & 3 shows a typical design example for a E shape patch antenna without defected ground shape and with defected ground structure operated at 4.9 and 4.75 GHz respectively. The E shape radiating patch and the ground plane is an fr-4 substrate of thickness 1.6 mm. the ground plane has dimensions of 120 × 120 mm². Reasonable agreement between the simulation results and measured data is seen. For the operating band, a wide impedance bandwidth of MHz (5120-4240 MHz), or about 18.73 % referenced to the center frequency (4750 MHz), is obtained.

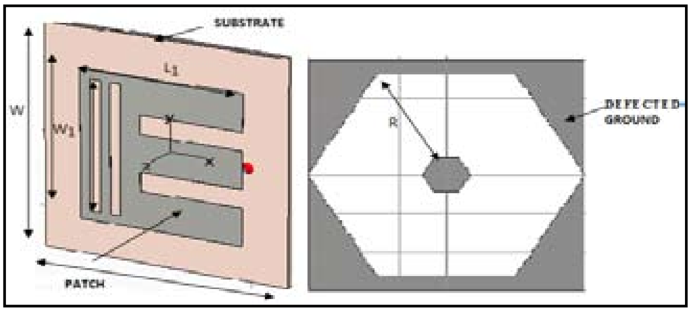
Table 1: Antenna Parameters

Parameter	Dimensions (mm)
Length of ground plane (L)	120
Width of ground plane (W)	120
Length of patch (L1)	80
width of patch (W1)	80
Radius Of Hexagonal (R)	50
Height of substrate (H)	1.6



Front view back view

Figure 2: Proposed E Shape Micro Strip Patch Antenna in CST Without Defected Ground Plane



Front view back view

Figure 3: Proposed E Shape Micro Strip Patch Antenna in CST using Defected Ground Plane

IV. Simulation and Results

The return loss of the E Shape antenna without DGS is -14 dB obtained at the center frequency of 4.9 GHz & with DGS -35db obtained at centred frequency of 4.75 as shown in figure 4 & 5. This indicates with defected ground structures return loss & bandwidth increased. Comparison between two is shown in figure 6. Thus, the bandwidth obtained from the return loss result is((5.12-4.24)/4.75) 18.61% which signifies(5.12-4.24 GHZ) 880 MHz. Fig 7 &8 shows reflection coefficient without &with DGS.

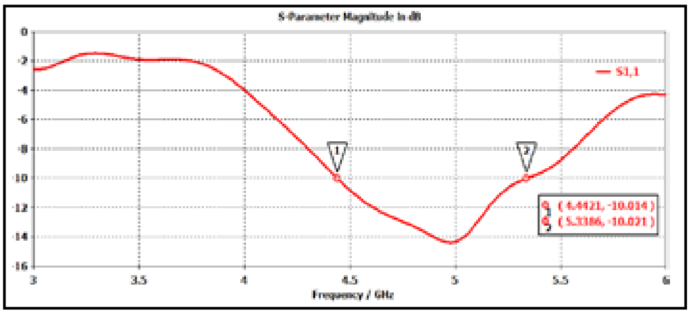


Figure 4: Simulated Return Loss for E Shape Antenna Without DGS Using CST

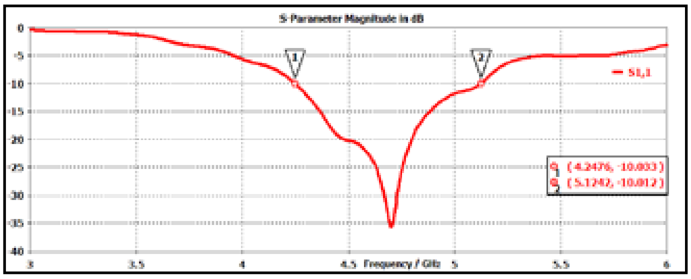


Figure 5: Simulated Return Loss for E Shape Antenna With DGS Using CST

Figure 6: Simulated Return Loss for E Shape Antenna with & without DGS Using Matlab

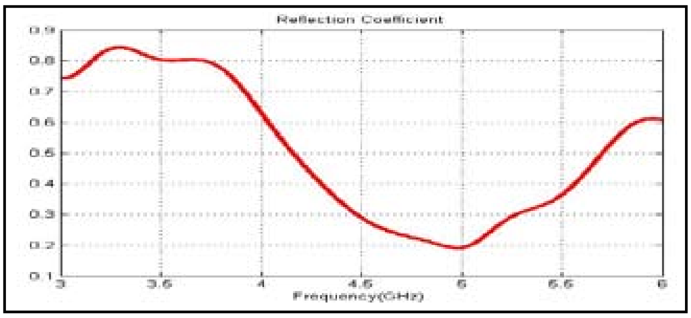


Figure 7: Reflection Coefficient Plot of Without DGS Using Matlab

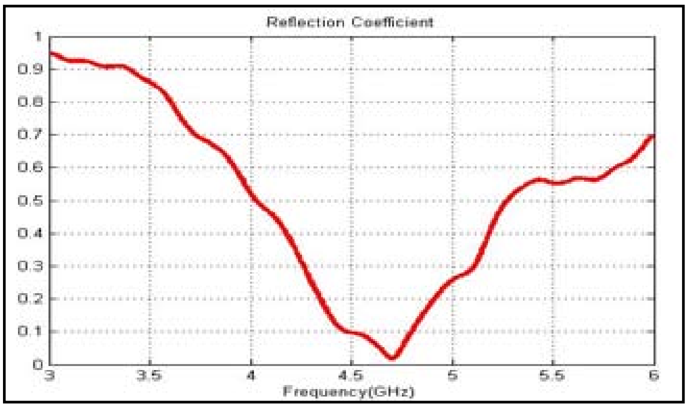


Figure 8: Reflection Coefficient Plot of DGS Using Matlab

Figure 9 & 10 shows the variation of VSWR with frequency. VSWR is one of the important parameter of antenna which is related to return loss. It is almost equal to one in the pass band of proposed antenna.The relation between return loss and VSWR is:

Return loss (dB) = 20log10 [(VSWR+1)/(VSWR-1)]

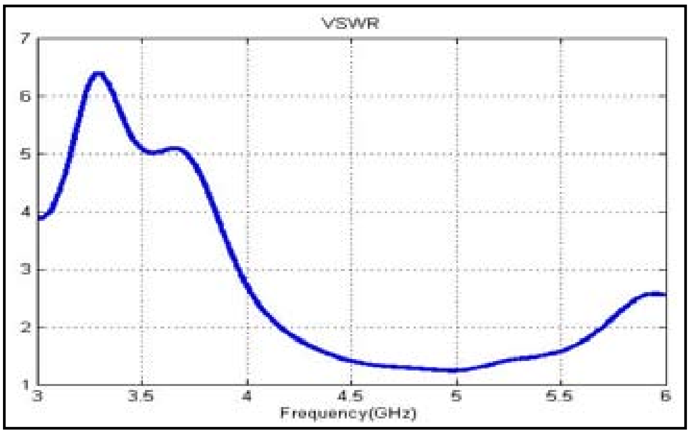


Figure 9: VSWR Plot of Without DGS Using Matlab

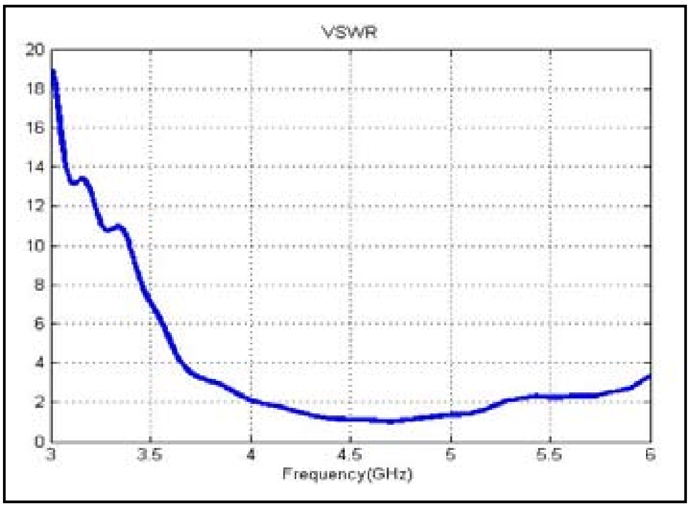


Figure 10: VSWR Plot of With DGS Using Matlab

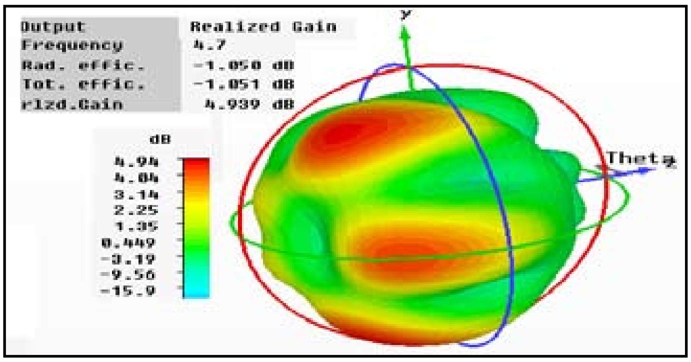


Figure11: Gain plot at 4.7GHz with DGS (Using CST)

Directivity

Directivity the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. The directivity of anisotropic radiator is D = 1

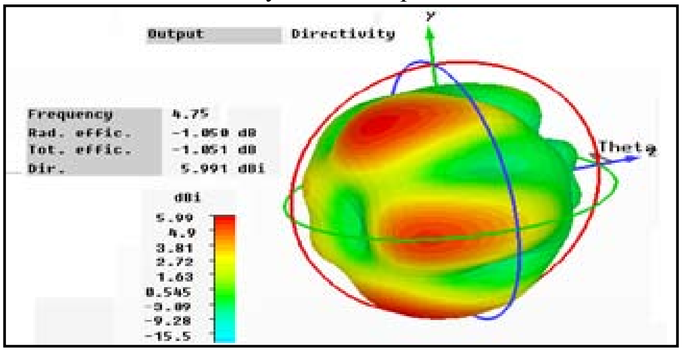


Figure 12: Directivity Plot at 4.75Ghzwith DGS (Using cst)

V. Conclusion

In this paper, we presented the design of an E shape patch antenna covering the 4.2GHz–5.12 GHz frequency spectrum. It has been shown that this design of the E shape defected ground patch antenna produces a wider bandwidth of approximately 18% with a stable radiation pattern within the frequency range.DGS increased returnloss(s11) value and higher bandwidth as compared to without DGS. The Design Antenna (DGS) exhibits a good impedance matching of approximately 50 Ohms at the center frequency and gain is 4.94db & directivity 5.99db obtain. This antenna can be easily fabricated on substrate material due to its small size and thickness. The simple feeding technique used for the design of this antenna make this antenna a good choice in many communication systems.

References

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