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Design of Rectangular Textile Antenna for S-Band Applications

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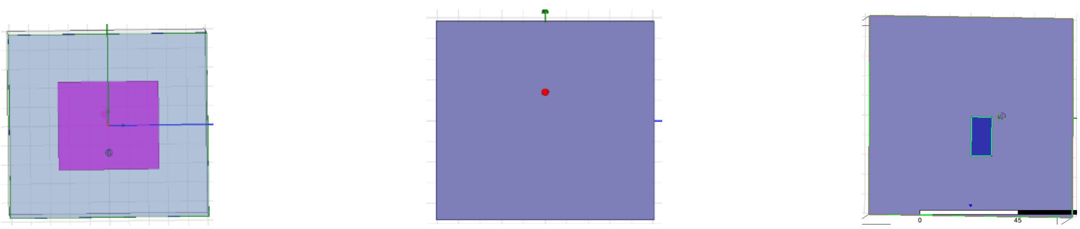
Abstract: In wireless and mobile communication, where the size of the antenna is a limitation, micro strip patch antennas are more advantageous. Due to rapid growth in the wearable communication industry, Now-a-days textile antennas are more popular. Wearable antennas are found to have more advantages due to their small size and can be integrated into a personal accessory. In this paper, we designed a narrow band textile patch antenna for an operating frequency of 2.8GHz with and without defective ground structure in the ground plane. The embedded DGS is a rectangular slot. The results are simulated using HFSS. The dimensions of the patch antenna are computed with high accuracy.

Keywords: Radiation Pattern, VSWR, Return Loss, Defective Ground Structure in Ground Plane (DGS), Gain

I. INTRODUCTION

Wearable textile antennas are made from fabric (or) textile material. These textile materials have a very low dielectric constant which reduces the surface wave loss. By using textiles, impedance bandwidth of antenna can be improved [1] Pranita et al observed that with the help of daily used fabric material antennas can be designed, which is of low cost and easily integrate into fashion garments. The wearable antenna integrates cloth into communication system. All wearable antennas are of lightweight, low cost almost maintenance-free. If a wearable antenna absorbs water its performance changes due to the high dielectric constant of water [2].Textile antennas are suitable for narrow bandwidth and cannot be used in ultra-wideband applications. To improve the bandwidth defective ground structure is implemented [3]. Ashok et al found that the dielectric constant, moisture, temperature, loss tangents, thickness, conductivity and deformation influence the performance and the characteristics of the textile wearable antenna. For integration into the cloth, the antenna should have stability and should be safe for the person's health when placed close to the body. Commonly denim textile with a dielectric constant of 1.6 is used as substrate in this antenna [4]. Purohit and Falguni tested textile antenna structures in order to get preliminary results on the performance of antennas. The antenna is designed with a substrate thickness of 1mm [5]. By using DGS the return loss of the antenna is increased, the high selectivity of frequency is increased [6]. DGS design has high resonant character and resonant frequency can be altered by changing shapes of slots such as fractal, dumbbell, circular, L-shaped[7]. DGS exhibits optimum fractional bandwidth and significant gain in comparison to plane ground. The defects introduced in the ground plane can be one or more. The defects are introduced to reduce harmonics and mutual coupling between elements [8]. Vivek Singh et al proposed a micro strip filter that has a very compact size. It has very low return loss, sharp cut-off, high insertion loss in the stop band and high return loss, low insertion loss in the pass band which is the desired characteristic of an ideal micro strip low pass filter. The defect in ground planar transmission line disturbs the shield current distribution in the ground plane. The defective ground is easy to implement and the antenna area is also reduced [9]. Nataraj et al reduced the maximum antenna size up to 59% as compared to the conventional antenna without much degradation of the performance of an antenna. By using DGS initially filter antennas are designed which are used for various applications.



(a) (b) (c)

Fig 1. Textile antenna prototype(a)front patch with the substrate (b)Ground plane without defective ground structure (c)Ground plane with Defective ground structure

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II. FORMULATION

The length and width of patch antenna are calculated using following formulae. The dielectric constant of patch antenna is also measured.

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

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

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}} \quad (3)$$

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{w}{h}+0.8\right)} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

L = Length of the patch
W = Width of the patch
ΔL= Length extension
ε_r= Dielectric constant of substrate
f_o= Resonant frequency
C = Velocity of light

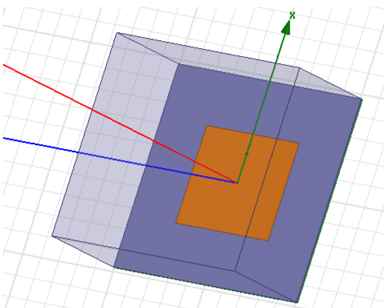
Table1: Physical dimensions of textile antennas

Parameter	Value(mm)
Textile antenna length	40
Textile antenna width	50
Feed point	14
Thickness of substrate(denim cloth)	1
Ground plane length	96
Ground plane width	101

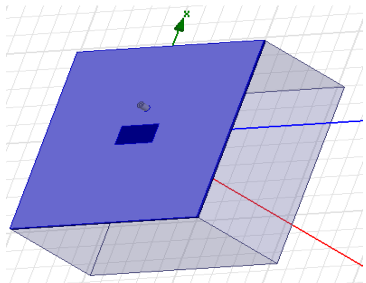
A ground plane is cut with a rectangular slot of length 10mm and width 20mm at the centre which act as DGS.

III. SIMULATION RESULTS

A textile rectangular patch antenna is designed with dimensions of length L = 40 mm and width W= 50mm as shown in fig1(a) and fig1(b) .The dielectric constant of textile is 1.6(denim cloth).The antenna is given with co-axial feed and the results are observed for return loss (S_{11}) , Gain, VSWR and normalized radiation patterns for E- plane and H-plane with $\emptyset = 0^0$and $\emptyset = 90^0$.The obtained results are presented in Fig 3.1, 3.2, 3.3 & 3.4. The textile antenna is resonating at a frequency of 2.8GHz which is a narrow band antenna with a bandwidth of 0.1 GHz and the gain of the antenna is 2.43dB with minimum front to back lobe ratio.
The above textile antenna with the DGS in the ground plane, the dimensions of rectangle slot of length 10mm and width 20 mm. The results for return loss (S_{11}), Gain, VSWR, E-plane and H-plane radiation patterns with $\emptyset = 0^0$ and $\emptyset = 90^0$ are presented in Fig 4.1,4.2,4.3& 4.4. It is found that antenna is resonating at the same frequency as that of the textile antenna without DGS in the ground plane i.e. 2.8 GHz. The return loss is found to shift from -25.6dB to -27.6dB and VSWR is found to have improvement from 1.11 to 1.08 and with a significant change in the radiation pattern i.e. with an improved front to back lobe ratio



(a) patch and substrate structure



(b) Ground plane with defective structure

Fig 2 (a)(b) Proposed antenna design using HFSS

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A.Simulation results without DGS in the ground plane:

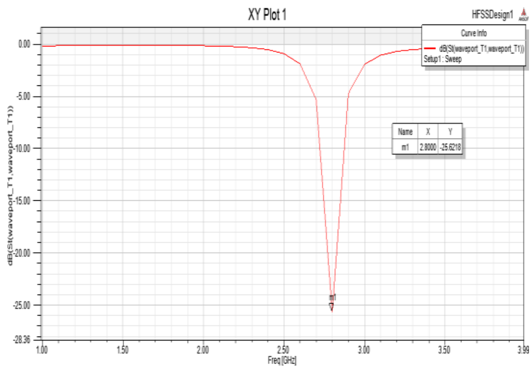


Fig 3.1 Simulated S_{11}without DGS in ground plane.

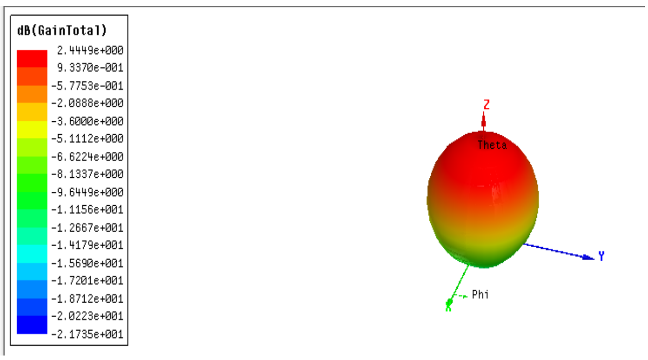


Fig 3.2 Gain without defect in ground plane.

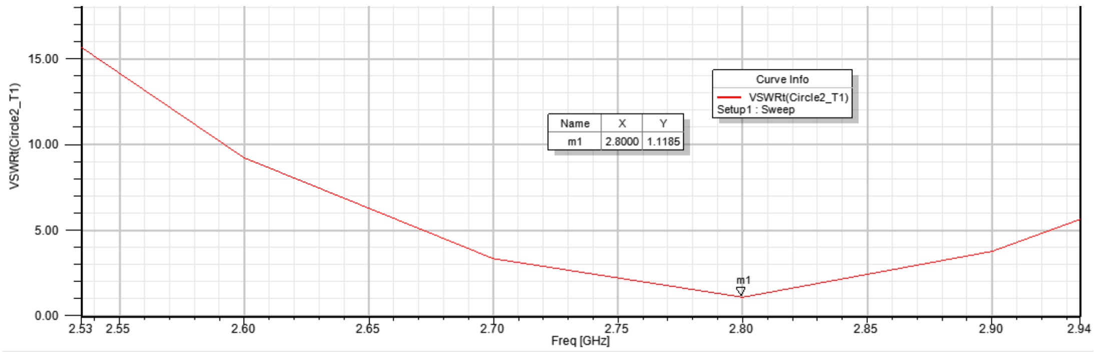
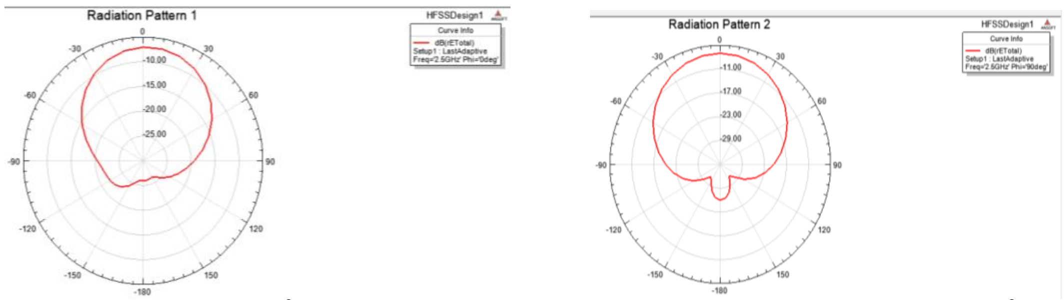


Fig 3.3 VSWR Plot



(a) E-Plane with $\Phi=0^0$

(b) H-Plane with $\Phi=90^0$

Fig 3.4 Normalized Radiation Pattern

B.Simulation results with defective ground structure in the ground plane:

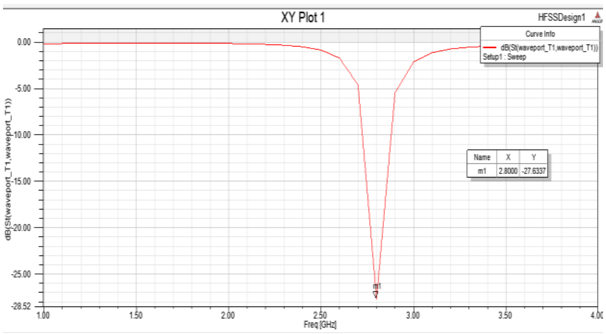


Fig 4.1 Simulated $S_{11}$with DGS in ground plane

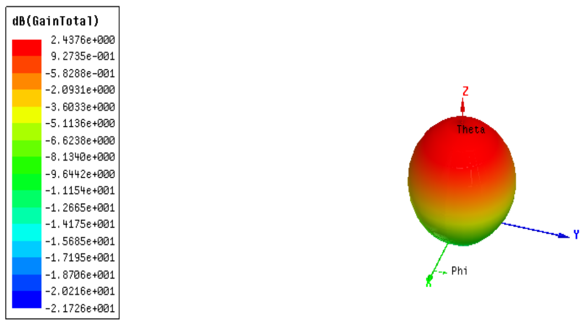


Fig 4.2 Gain with defect in ground plane.

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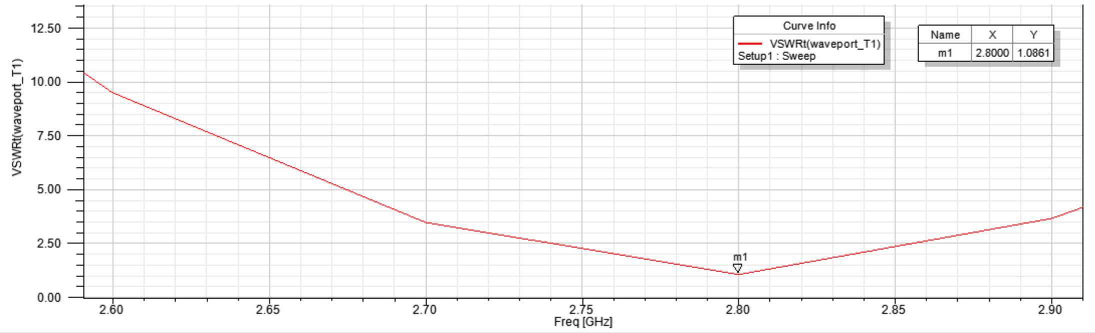
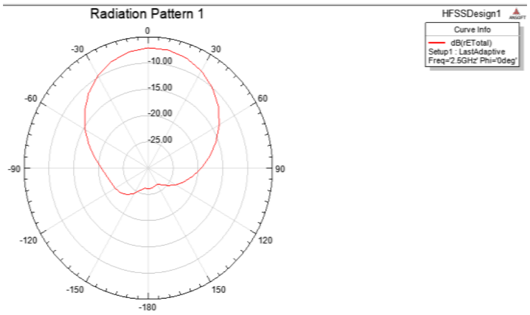
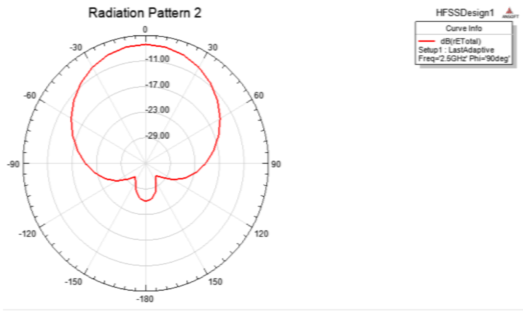


Fig 4.3 VSWR Plot



(a) E-Plane with $\Phi=0^0$



(b) H-Plane with $\Phi=90^0$

Fig 4.4 Normalized Radiation Pattern

Table2: Comparison table for simulated results

	S_{11}indB	VSWR	Gain in dB
Ground plane without DGS	-25.6	1.11	2.44
Ground plane with DGS	-27.6	1.08	2.43

IV. CONCLUSION

In this paper a textile antenna with and without DGS in the ground plane is designed. Both the textile antennas resonate at 2.8GHz frequency. Using HFSS the simulated results of both the textile antenna are obtained. Return loss at 2.8 GHZ are -25.6 dB and -27.6 dB, VSWR are 1.15 and 1.08 for textile antenna without and with DGS in the ground plane. It is found that return loss for antenna with DGS is less than antenna without DGS in ground plane. Summarized comparisons are presented in Table2. The Textile antenna designed acts as a narrow band antenna and is suitable for S-band applications.

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BIOGRAPHY

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