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Design of a Square Patch Textile Antenna for S-Band Applications

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ABSTRACT

In most of the communications, antenna is an essential element. Many researchers have done studies on patch antennas, wearable button antenna and electro textiles. For a wide range of applications such as health monitoring, physical emergency services for the care of children and elderly people, wearable devices have more demand as they can be located on body or anywhere on personal accessories like helmets, shoes, etc. Here we designed a wearable textile square patch antenna with a dimension of 40mm. The antenna is designed and analyzed for both with and without DGS in the ground plane. The antenna operates at a resonant frequency of 2.8GHz. The antenna is designed and simulated using HFSS software. The dimensions of the antenna are computed with accuracy.

Keywords: Return loss, radiation pattern, textile patch antenna, distorted ground structure in ground plane.

I.INTRODUCTION

In mobile communications, Wearable devices have attracted much interest over few years as they are potentially improving in a wide range of applications. There is a growing interest in the research of wearable system technology. The design strategies are quite different compared to conventional antennas. Sen Yan et.al obtained a good simulation measurement agreements for the antenna in terms of reflection and radiation properties. [1] Now a days, there is an increasing need for a smart wearable antenna with the development of textile technology. Kai-hong Wang et.al proposed when an antenna was placed close to the human body, its performance will not be affected significantly. [2] Wearable antennas are more popular due to its profound potential in a variety of emergency services such as police, paramedics, fire-fighters and soldier location tracking as part of military applications. There are several existing and forthcoming wireless applications that either require or can benefit from one or more antennas that are directly stitched on a piece of clothing or a garment or integrated into personal accessory invested by Sanjeeva Reddy et al. Results show that high impedance bandwidth values are obtained with Jean's wearable dielectric when compared to the conventional FR4 substrate. [3] Small antennas are crucial in the development of wearable wireless communications systems. Low efficiency is the major disadvantage of small antennas. Albert Sabban found that Metamaterial and fractal technology are used to develop small antennas with high efficiency. The antenna gain is around 8dbi with 90% efficiency. [4] In the field of wearable technology wearable textile antenna is the Primary requirement. Wearable textile antennas use flexible construction materials which include fabric with planar structure. Properties of the textile antenna such as bandwidth, efficiency, input impedance, etc. Depending upon the type of substrate materials used.

These properties are mostly determined by the substrate dielectric constant. Fabric material dielectric constant accurate value has to be calculated from the resonant frequency of patch antenna proposed by **Pranita Manish Potey**. From the analysis, he found that from daily used fabric material antenna can be designed, which is low cost and easily integrates into fashion garments. [5] More commonly wearable devices are applied to clothes, it may be relevant to develop antennas that can be easily integrated into a garment, such as a textile antenna. These antennas consist of a textile conductive element integrated with another textile material acting as substrate and have the advantage of being lightweight, flexible, easy to produce, relatively inexpensive, and easily integrated into a garment. The substrate of the antenna was made from denim textile, and the conducting layers were made from a copper and nickel-plated polyester fabric. A parametric study was made to determine the influence of an antenna bending around its length and width on its performance parameters in chest, leg, arm, or wrist integration for wireless body area network (WBAN) scenarios. David Ferreira et. Al reported the Results that the bending curvature has a significant influence on gain and overall radiation pattern compared to a flat antenna. The antenna radiation front-to-back ratio decreases with the increase in bending curvature. [6] DGS will help in reducing the back radiation of conventional antenna. DGS has now widely used to enhance the performance of microstrip antenna. DGS often used for size reduction, cross-polarization reduction, mutual coupling reduction, etc. DGS is realized by etching off a certain shape defect on the ground plane which can increase the effective capacitance and inductance proposed by H. Alias et al. Antenna with DGS incorporated has a reduced back lobe level. [7] Slots or defects integrated on the ground plane of microwave planar circuits are referred to as Defected Ground Structure. Mukesh Kumar Khandelwal, presented various applications of DGS, that is, miniaturization, multi-band performance, bandwidth enhancement, gain enhancement, mutual coupling suppression between two elements, higher mode harmonics suppression, cross-polarization suppression, notched band creation, and circular polarization achievement. [8] The future generations of wireless communication, known as fifth-generation (5G), demanding antennas with numerous features such as wide impedance bandwidth, good radiation features, multiband operation and low cost. Printed antennas can afford these requirements by some adjustments in the basic structure of these antennas like using the defected ground structure techniques (DGS) Samineh et al. reported that the good impedance matching (less than -10 dB in S11 parameter) can be achieved. [9]

II.DESIGN FORMULATION

The dimensions of patch antenna are computed using the equations given below:

$$B = \frac{C_0}{2f_r\sqrt{\frac{(\varepsilon_r+1)}{2}}} \tag{1}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h_0}{B}\right]^{\frac{-1}{2}} \tag{2}$$

$$A_{eff} = \frac{C_0}{2f_r\sqrt{\varepsilon_{eff}}} \tag{3}$$

$$\Delta A = 0.412h_0\frac{(\varepsilon_{eff}+0.3)\left(\frac{B}{h_0}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{B}{h_0}+0.8\right)} \tag{4}$$

$$A = A_{eff} - 2\Delta A \tag{5}$$

Where A is the length of the radiating element in millimeter, B is the width of the radiating element in millimeter, f_r is the resonance frequency in GHz, c_0 is the speed of light in vacuum, ε_r is dielectric constant of the textile substrate material.h_0 is the height of thesubstrate.ΔA is change in length.

Table1: Physical dimensions of textile antennas:

Parameter	Value(mm)
patch length	40
Patch width	4
Feed point	14
Thickness of substrate	1
Ground plane length	96
Ground plane width	101

A dumbbell shaped slot is cut in the ground plane of textile antenna to get DGS in ground plane.

III.SIMULATION RESULTS

A textile square patch antenna is designed with the dimensions of 40mm side length which is shown in Figure1(a), Figure 1(b). The dielectric constant of textile (denim cloth) is 1.6.The antenna is given with co-axial feed. The reflection coefficient S_{11}, VSWR, Gain and normalized radiation patterns for E- plane with and H-plane with $\emptyset = 0^0$ and $\emptyset = 90^0$are obtained and the results are presented in Figure 2.1, Figure 2.2, Figure 2.3. It is found that the textile antenna is resonating at a frequency of 2.8 GHz.It is a narrow band antenna with a bandwidth of 0.1GHz and a gain of 2.4dB with minimum back lobe. The same patch antenna with DGS in ground plane(dumbbell slot) was designed and results for return loss, Gain, E-plane and H-plane radiation patterns with $\emptyset = 0^0$and $\emptyset = 90^0$ are presented in Figure 3.1, Figure 3.2, Figure 3.3. It is found that the antenna is resonating at same frequency. The return loss has been found to be at -14.3dB and gain is found to be 1.8. The radiation pattern has less back radiation.

(a) (b) (c) (d)

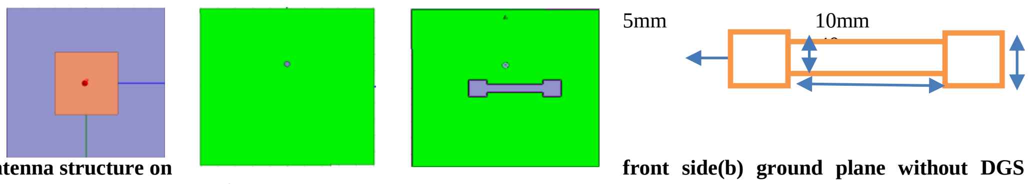


Figure 1. (a) Antenna structure on front side(b) ground plane without DGS (c) ground plane with DGS (d)dimensions of dumbbell slot.

A. Simulation Results without DGS in ground plane

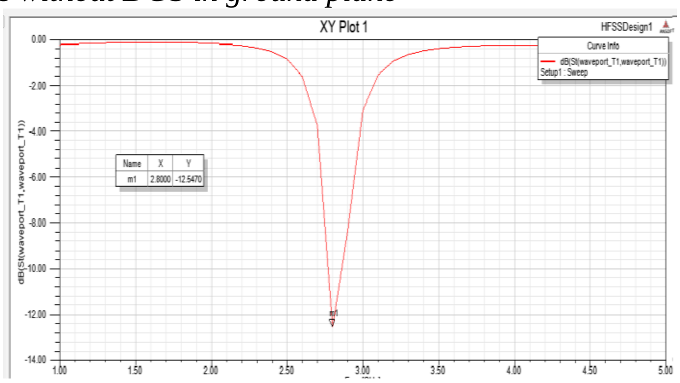


Figure2.1 Return loss(s11)

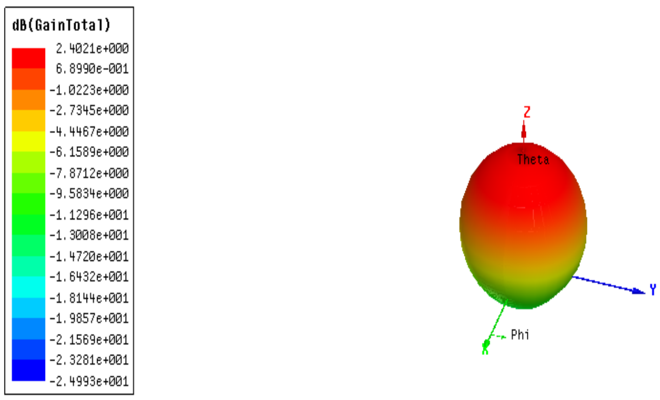


Figure 2.2 Gain

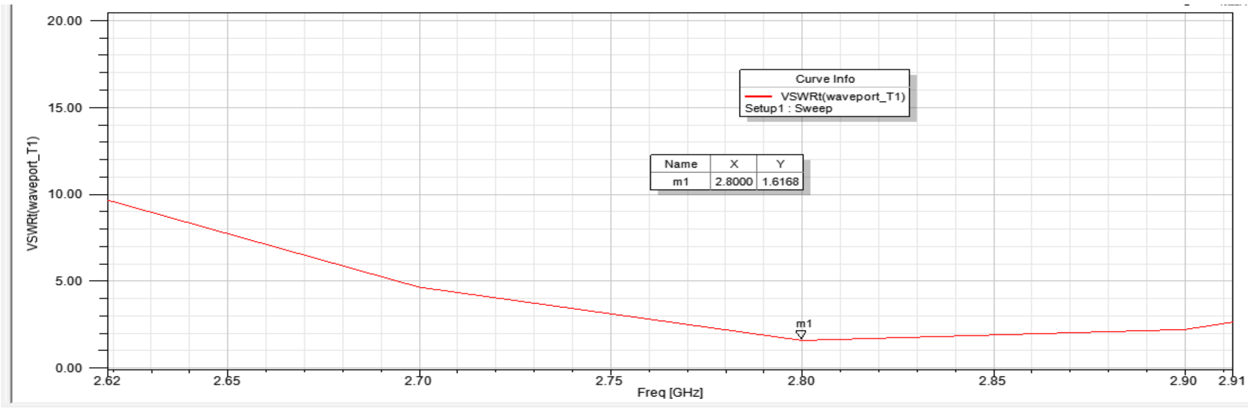
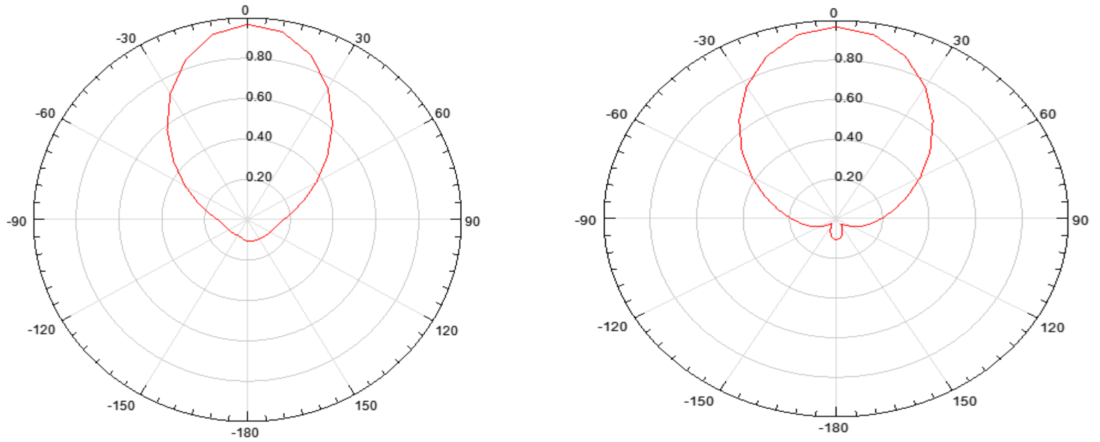


Figure 2.3 VSWR plot



(a) **(b)**

Figure 2.4Normalized Radiation Pattern(a)Normalized E plane pattern with Φ=0^0(b)Normalized H-Plane with Φ=90^0

B. Simulation Results with DGS in ground plane

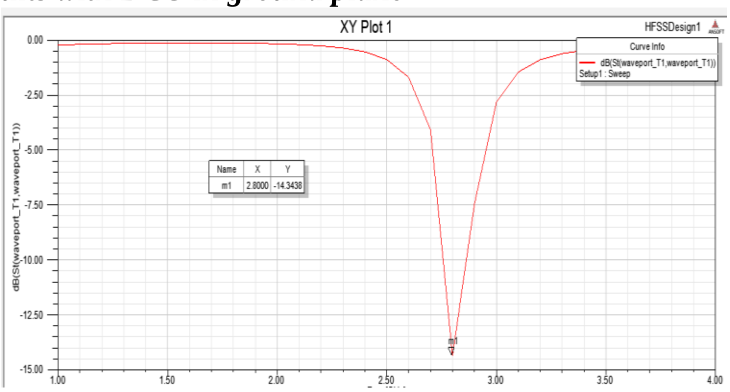


Figure3.1 Return loss(s_{11})

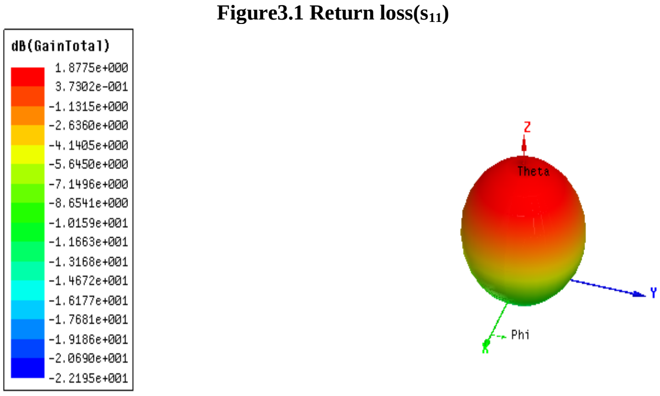


Figure 3.2 Gain

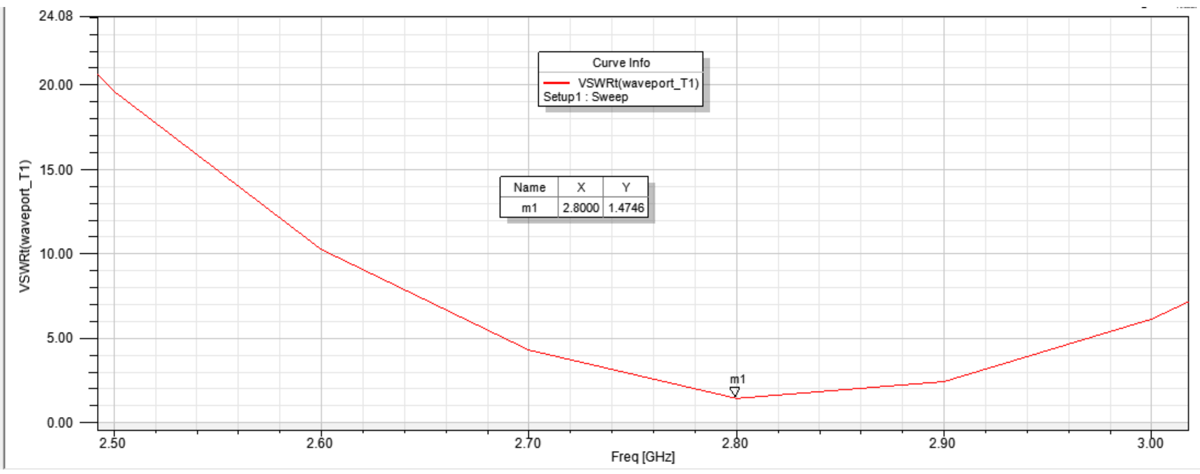
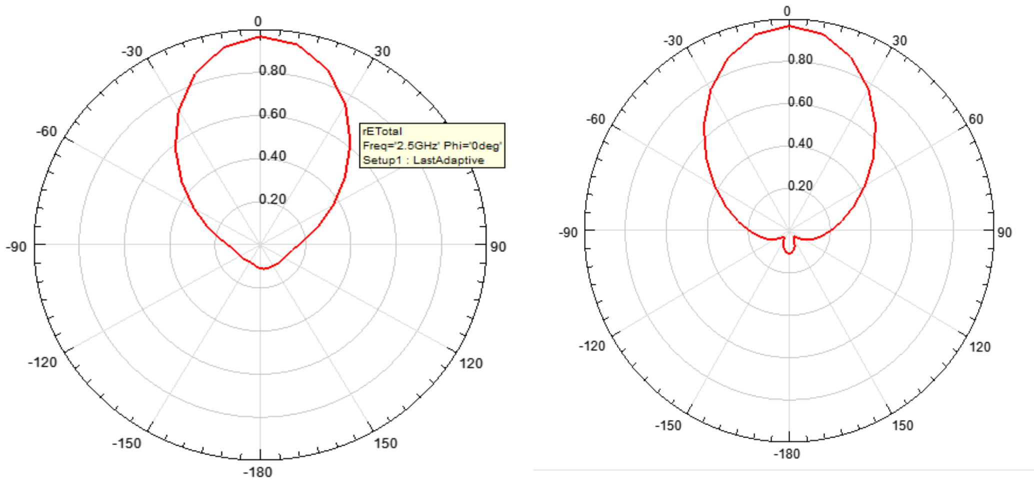


Figure 3.3VSWR plot



(b)

Figure 3.4 Normalized Radiation Pattern (a)Normalized E plane pattern Φ=0^0 (b)Normalized H-Plane with Φ=90^0

Table2: Comparisonof simulated results with and without DGS

	S11 in dB	VSWR	Gain in dB
Ground plane Without DGS	-12.5	1.6	2.4
Ground plane With DGS	-14.3	1.4	1.8

IV.CONCLUSION

A square textile patch antenna is designed with and without DGS in ground plane. The simulation results are obtained using HFSS and both the antennas are resonating at the same resonant frequency of 2.8 GHz. The return loss for the antenna with and without DGS are -12.5dB and -14.3dB, it is observed that there is an improvement in return loss. VSWR obtained for the antenna with and without DGS are 1.6 and 1.4, it is observed that there is improvement in VSWR. The radiation pattern of antenna with DGS in ground planehas better front to back lobe ratio than antenna without DGS in ground plane. These antennas are suitable for s-band applications.

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BIOGRAPHY

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