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Circularly Polarized Square Patch Antenna with Central Slot Using Wearable Material

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ABSTRACT: This paper presents a micro strip square patch antenna at 2.4 GHz with a rectangular slot at the center of the square patch. The proposed micro strip square patch antenna with central slot has been designed using a textile (jeans) material with thickness 1mm, dielectric constant 1.7 and loss tangent 0.02. This flexible and maintenance free wearable antenna can be used for biomedical, security, and healthcare application in wireless communication system. The main advantage of wearable antennas is that they are designed using clothing material and can be able to transmit or receive wireless signal with wearable application. To feed the antenna inset feeding with a quarter wave transformer has been used. To fulfill the circular polarization, a rectangular slot at the center of the square patch has been cut. The proposed antenna offers approx -11 dB reflection loss, 2.23dB axial ratio and 25% antenna efficiency.

KEYWORDS: square patch antenna, wearable material, central slot, circular polarization.

1. INTRODUCTION

Micro strip patch antenna becoming increasingly useful because they can be fabricated directly onto a circuit board. Patch antennas are low cost, have a low profile and are easily fabricated. In this paper, a circularly polarized micro strip square patch antenna has been designed using textile material with thickness 1mm, dielectric constant 1.7 and loss tangent 0.02 [1] [2] [3].

Wearable antenna is very important element to be used for various future wireless standard applications [1]. Textile antenna is suitable for on body radio communication as it is flexible and comfortable to be integrated into clothing material [4]. The circularly polarized textile square patch antenna has been designed because due to circular polarization this antenna can receive signals in all planes. Most recent demonstration on wearable antennas for GSM and PAN to operate in the 2.4 GHz band and for GPS application are presented in [5], [6]. Antennas for wearable protective clothing intended for professional use under rough condition are presented and their behavior in various applications is discussed. In paper [7] presented rectangular ring textile antennas for body area network that are circularly polarized, covering a bandwidth of more than 190 MHZ.

The dielectric properties depend on the frequency, temperature, and surface roughness and also on the moisture content, purity and homogeneity of material. The real part of the relative permittivity ε_r, is called the dielectric constant, but one must note that it is not constant in frequency. The proposed antenna material has some important features in the design of wearable antennas. The dielectric constant (relative permittivity) of the proposed material is 1.7, loss tangent less than 0.025 and thickness 1mm. As textile material presents a quite narrow range of permittivity values, it is therefore their thickness, which value may presents much larger variations, that will mainly determine the bandwidth as well as the input impedance of the antenna and so its resonance frequency. For a fixed permittivity, the substrate thickness may be chosen to maximize the bandwidth of the planar antenna but this may not optimize the antenna efficiency. In general, the moisture absorption changes the properties of the fabrics. Because of this, textile material is performed in a conditional environment.

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II. ANTENNA DESIGN

The design of the proposed antenna on the textile material is shown in figure. A square patch of the length and width of 46.8 mm is used to design this antenna. Length and width of this antenna can be calculated by the equation shown below.

$$L=W=\lambda/2\sqrt{\varepsilon_r} \qquad \ldots (1)$$

A slot of dimension C×D (17 mm ×1.7 mm) has been cut at the centre of the antenna for circular polarization. Dimension of the slot is calculated by the equations shown below:

$$C= L/2.72 =W/2.72 \qquad \ldots(2)$$
$$D= C/10 =L/27.2=W/27.2 \qquad \ldots(3)$$

A square wave transformer at the feeding of dimension 21mm×3mm is used to matching the port and antenna impedance. Impedance of this square wave transformer is calculated as

$$Z_0=\sqrt{Z_A Z_P} \qquad \ldots (4)$$

Where,
Z_p = impedance of port
Z_0 = impedance of quarter wave transformer
Z_A = impedance of antenna

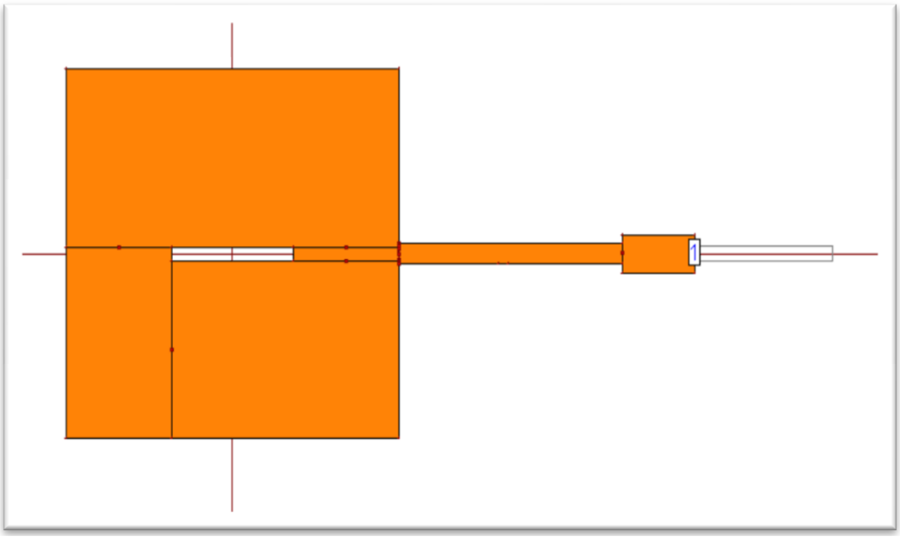

Fig.1: Square patch antenna with central slot

III. RESULT AND DISCUSSION

Simulation results of the designed antenna have been shown in table1. 1.

Table 1:--

Parameters	Result values
Return loss	-10 db (approx.)
Axial ratio	2.23 db
Efficiency	25%
Gain	2.2 dbi

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Return loss—From fig.3 it is clear that return loss at 2.4 GHz is -11 db approx. at 2.4 GHZ which is in good agreement.

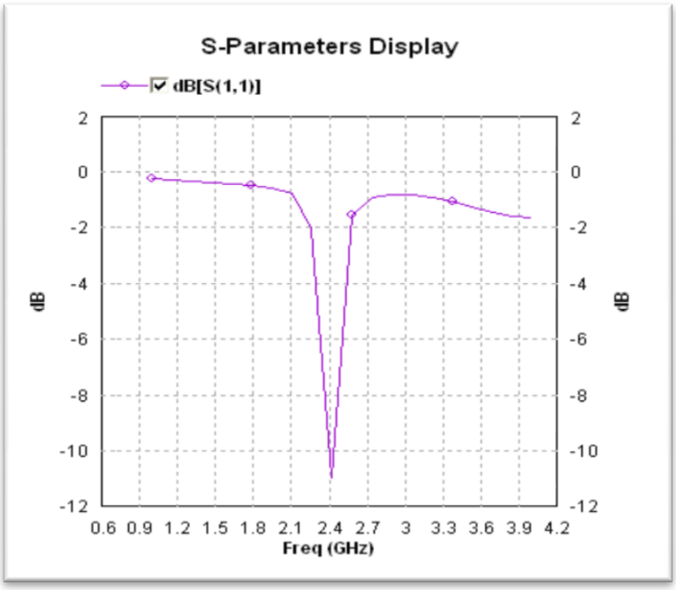

Fig.2: Return loss

Gain of the antenna — antenna gain relates the intensity of an antenna in a given direction to the intensity that would be produced by a hypothetical ideal antenna that radiates equally in all directions or isotropicaly and has no losses. Gain of the proposed antenna is 2.23 dbi which is shown in fig.3.

$$\text{Gain}=4\pi\left[\frac{radiation\ \ intensity}{antenna\ \ input\ \ power}\right]$$

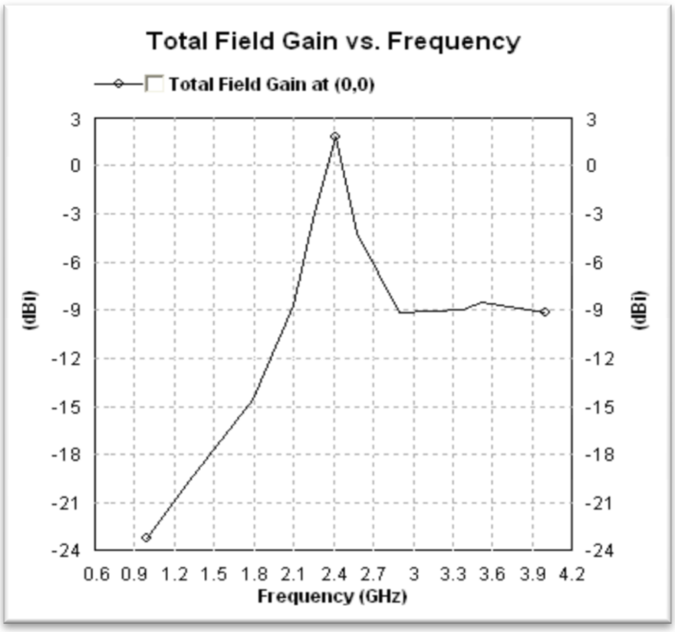

Fig.4: Antenna Gain

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Efficiency— the radiation efficiency is defined as the ratio of the total power radiated by the antenna to the total power accepted by the antenna at its input terminal during radiation. Efficiency of the proposed antenna is 25 % which is as shown in fig.5

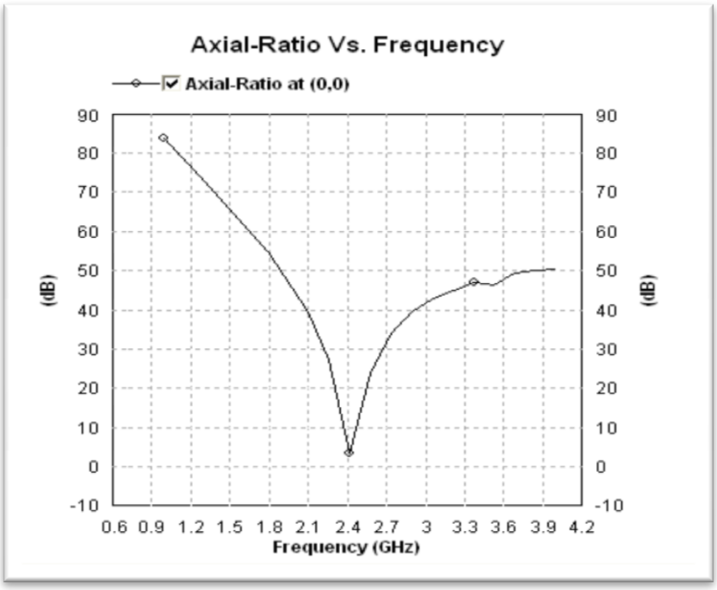

Fig.6: Axial Ratio

Radiation pattern— radiation pattern of the designed antenna is shown in fig. 7 at ϕ=0, 90^0

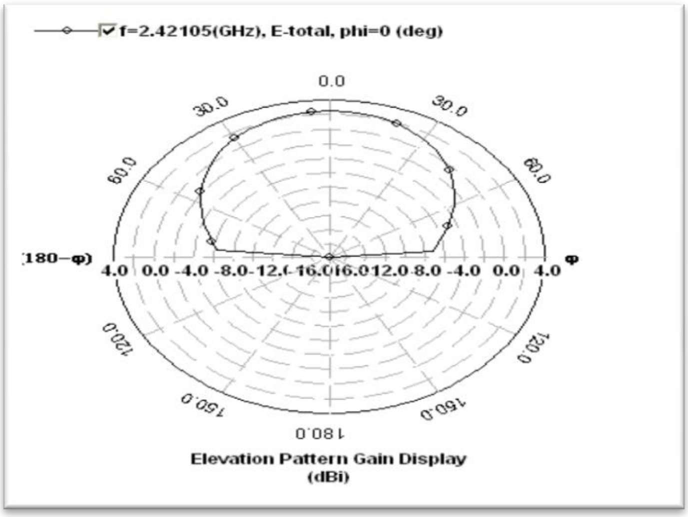

Fig.7:(a) Radiation pattern at ϕ=0^0

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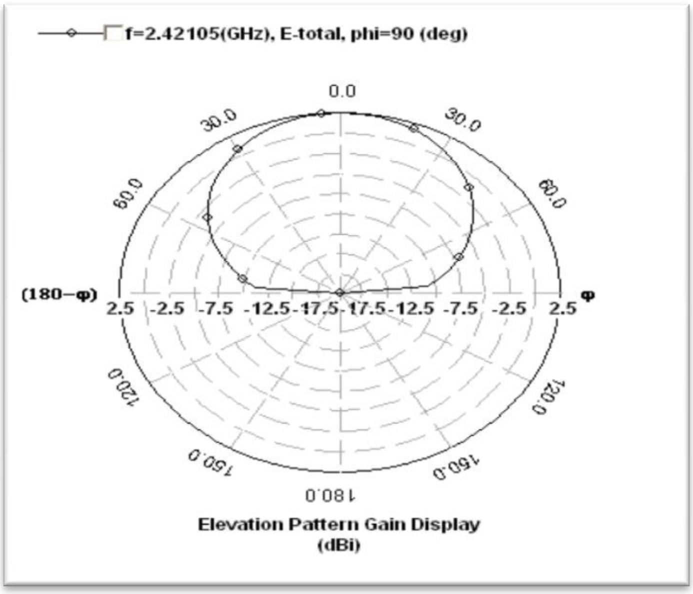

Fig.7(b): Radiation pattern at ϕ=90^0

IV. CONCLUSION

In this paper designed a circularly polarized square patch micro strip antenna. The characteristics of proposed antenna have been investigated through different parametric studies using IE3D simulation software. The proposed antenna has achieved good impedance matching, stable radiation pattern and high gain. The slot antenna can be used for wireless communication, on body communication, military and medical application in the 2.4 GHz frequency range. The bandwidth and efficiency performance of a planar micro strip antenna is mainly determined by the substrate dielectric material is a compromise between efficiency and bandwidth of the antenna.

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