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Simulation of Rectangular Patch Antenna with Jeans Substrate

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ABSTRACT: *There has been growing interest in researchers to merge wearable system technology with textiletechnology. Utilization of textile material for development of antenna has been rapid due to wearable computing. A wearable antenna is meant to be a part of clothing used for communication purpose such asTracking and navigation, health monitoring, fire-fighting and space and military applications. All these togetherhave resulted in research for flexible textile antennas. In this paper, textile antenna is designed for ISM bandfrequency 2.4 GHz. Ansoft HFSS is used for design simulation. Resonant frequency after simulation is exactly2.4GHz with return loss of -23.64dB.*

Key Words*-Microstrip Antenna (MSA),High Frequency Structure Simulator(HFSS),Return Loss(S11)*

I. INTRODUCTION

Flexible antennas are becoming ever more attractive, since the recent developments in wearable computing have opened several possibilities to integrate wireless functions to clothing. A key technology to achieve this goal is wearable electronics and antennas. Textile antenna is one of the most fascinating and cutting edge research areas of modern era. Body wearable antennas should be hidden and unobtrusive. In this paper, the discussion is about Microstrip antenna made up of textile material to preserve flexibility and comfort. This antenna has a flat, planar structure to be comfortably worn [14]. This antenna does not disturb the movement of the wearer as it is light weight and flexible. In case of wearable antennas it is quite difficult to have a flat antenna surface. Therefore, the designed antenna should be such that, even if the antenna is bent frequently, it should operate properly. Wearable substrate such as cotton, jeans, and leather can be used to prepare flexible antenna [15]. These antennas can be placed on the dress materials so it is easier to carry the antenna. Antennas constructed in part from conductive textile materials (also known as e-textiles) by means of standard textile manufacturing techniques. Those techniques are currently receiving increasing attention from antenna theorists and antenna manufacturers alike [16]. The paper will contain complete design flow and substrate material selection specifications. The design of wearable antenna is to be done as per the mathematical design carried out for a normal Microstrip patch antenna.

II. BASIC PATCH ANTENNA GEOMETRY

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1. [2] The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

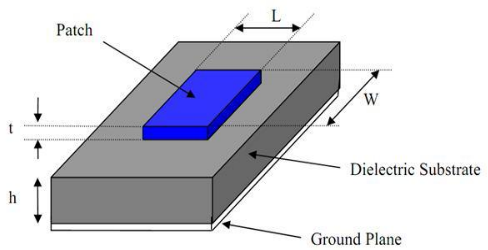

Figure 1. Structure of Microstrip Antenna.

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape [5]. For a rectangular patch, the length L of the patch is usually $0.3333\lambda_0 < \lambda_0 < 0.5\lambda_0$, where λ_0 is the free-space wavelength. The patch is selected to be verythin such that $t << \lambda_0$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.00\lambda_0 \leq h \leq 0.05\lambda_0$. the dielectric constant of the substrate (ϵ_r) is typically in the range $2.2 \leq \epsilon_r \leq 12$. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth [9]. Hence a compromise must be reached between antenna dimensions and antenna performance.

2.1 Antenna Design

In order to identify and verify the improvement for rectangular structure in microstrip antenna, the conventional Microstrip antenna design method is used [1].

Design steps:

Designing the patch antenna is to employ the following formulas as an outline for the design procedures.

i. Width (*W*):

$$\mathbf{W} = \frac{c}{2f_r\sqrt{\left(\frac{\varepsilon_r+1}{2}\right)}}$$

Where;
c - free space velocity of light, 3 x 108 m/s
f_r - frequency of operation
ϵ_r - dielectric constant

ii. Effective Dielectric constant (εreff):

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

Where
ϵ_r - dielectric constant
h - Height of dielectric substrate
W - Width of the patch

iii. Effective Length (Leff):

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$$

Where;
c - free space velocity of light, 3 x 108 m/s
fr - frequency of operation
ϵ_{reff} - effective dielectric constant

iv. Patch length extension (ΔL):

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

v. Actual length of patch (L):

$$L = L_{eff} - 2\Delta L$$

2.2 Textile Material Selection Issues

There are three main issues. First issue is related to the antenna substrate material selection. It is needed to know the electrical behavior of the material in order to select suitable substrate. This material data is not available and therefore electrical characterization of different textile materials is required. This is not a completely trivial task and different measurement techniques have to be used in order to evaluate parameters, e.g. dielectric constant. Second issue deals with the antenna performance under bending condition or stress. Since antenna is assembled in clothing it experiences different kind of bending conditions. The real issue is to maintain the critical antenna parameters at acceptable levels in all conditions regarded as normal operation environment. Such parameters are: Axial ratio (robust against bending), Operating frequency (stability due to bending), Efficiency (prevent human tissue to degrade efficiency). Third issue deals with the actual fabrication. The main concern is how to make the antenna robust enough against manufacturing tolerances.

Textile materials such as fabric and yarn are basically assemblies of fibers. The fibers are generally made of linear long chain polymers and have large length to diameter ratio. The electrical conductivity of most of these fibers is very low so that they can be used as a dielectric for textile antennas. The permittivity of a material is usually given relative to that of free space which is known as relative permittivity or dielectric constant ($€_r$) . Dielectric constants of the antenna substrate have a significant role in the antenna designing. Different substrates having different dielectric constants affect the antenna performance in various ways. Textile materials that are used as an antenna's substrates can be divided into two main categories, natural and man-made fibers. On the other hand, textile materials generally have a very low dielectric constant, which reduces the surface wave losses and improves the impedance bandwidth of the antenna.

III. ANTENNA MODELING

In this paper, rectangular structure have been designed and analyzed. The desired resonant frequency of antenna is 2.4GHz. To calculate antenna dimensions by conventional method, we need to provide some data like substrate height, its dielectric constant etc. in this work we are using jeans material as a substrate for antenna. Its specifications are given below.

Table 1: Different parameters

Parameter	Value
Thickness	1 mm
Dielectric constant	1.7
Loss Tangent	0.025

Moreover, in order to meet the requirement of design, partially ground is implemented. In particular, this process can be related to the fact that ground plane acts as an impedance matching element that controls the impedance bandwidth of the patch. Thus, it creates a capacitive load that neutralizes the inductive nature of the patch to produce nearly pure resistive input impedance. The conductive surfaces and the ground plane of the designed antenna are made up of copper tape with a thickness of 0.03 mm. The simulations were carried out using Ansoft HFSS software And the textile antenna characteristics were studied. Figure.1 below shows HFSS model for Textile antenna. A 50 ohm microstrip feed line was provided for the antenna feed; hence the position was determined according to [19].

3.1 S11Result

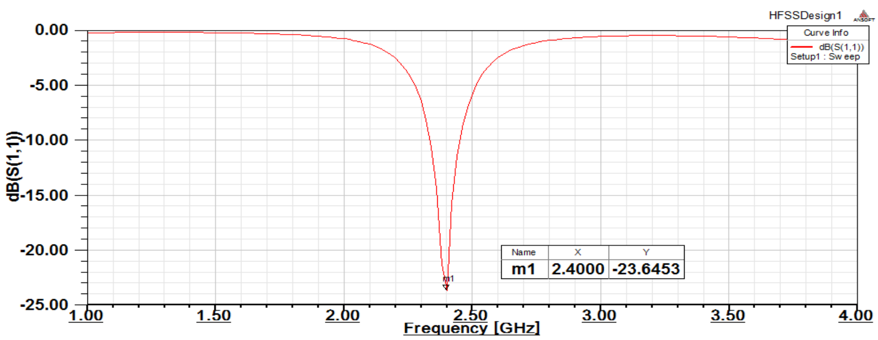

Figure 2. Return Loss

IV. CONCLUSION

The performance of microstrip Antenna is mainly depend on its structure. The resonance frequency of the Microstrip antenna depends on their dimensions of the patch, on the substrate material as well as its thickness and on the feed line. Consequently, the characteristics of the patch antenna can be adequately identified according to the application wished for an antenna. The modeling of antenna using the HFSS software is essential for the variation of the shape of the antenna, the substrate nature and thickness in order to obtain a structure which resonance frequencies wished. A small variation of each of these parameters influences the resonant frequency.

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