The Effect of Different Dielectric Constant on Same Microstrip Patch Antenna Design

Zeeshan Alam, S.K.Sriwas, Atul Kumar Dwivedi, Yatharth Shankar Misra

Abstract*: This paper demonstrate the effect of textile material (Jeans) on U.W.B. we all familiar with the information that U.W.B is in between 3.1 to 10.6 GHz, That is assigned by the society of F.C.C (Federal Communication Commission) in 2002.The convoluted design present in this paper, It has designing frequency of 2.4 GHz & we have used IE3D software for simulation. The bandwidth, gain, directivity & efficiency of textile antenna are 109%, 6.69dBi, 6.7dBi, 99.6% respectively and bandwidth, gain, directivity, efficiency of reference antenna are 103%, 7.21dBi, 7.28dBi, 99.5% respectively. Here we are deploying line feed method technique for simulation.

Keywords*: T and Square shaped; IE3D Software, satellite communication; Mobile communication, RADAR communication, U.W.B (Ultra Wide Band).

I. INTRODUCTION

The field of wireless technology crave for the antenna which has potential to perform the respected function, hence the U.W.B system attract more attention in industries and research areas [1]. U.W.B has a number of eye catching properties like bandwidth. Microstrip patch antenna plays a distinguished role in the field of wireless communication due to less weight, compact size, and low manufacturing cost [3]. All antennas is sandwich between patch and ground plane. There are number of different dielectric constant which varies according to the material type. The patch segment is made up of Gold or Copper. The ground plane is already considered as infinite. The efficiency of antenna depends on shape, size & feed point location. T shape patch antenna has more potential but at the same time it has complex structure [3]. It gives better result in U.W.B. Here in this paper we have compared the different property of reference antenna on FR4 material Vs textile antenna & also provide related reference data & graph associated with design.

II. ANTENNA DESIGN

The proposed model of two different antennas having a perfectly conducting patch, the ground plane with FR4 substrate and the textile substrate are composed. The FR4 & jeans antenna has same dimensions in mm .the dimensions are compared & show with the help of following table.

PARAMETERS	FR4	TEXTILE
Resonant frequency	2.4	2.4
Substrate Thickness	1.6	1.6
Dielectric constant	4.4	1.7
Loss Tangent	0.0013	0.025

$$w=\frac{1}{2f_r}\sqrt{\frac{2}{\varepsilon_{r+1}}}$$

(1)

C= Speed of light = $3x10^8$ m/s, Effective dielectric constant =4.4& 1.7, fr= 1.857GHz

$$\text{ref} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\sqrt{1+\frac{12h}{W}} \quad (2)$$

h=1.6 mm, The extension length ΔL

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon ref+0.3)(0.264+\frac{W}{h})}{(\varepsilon ref-0.258)(0.8+\frac{W}{h})} \quad (3)$$

The length of patch antenna is given as;

$$L = \frac{c}{2fr\sqrt{\varepsilon reff}} - 2\Delta l \quad (4)$$

The length and the width of the ground plane

Lg = L+6h =38.84mm (5)

Wg= W+6h=47.47 mm (6)

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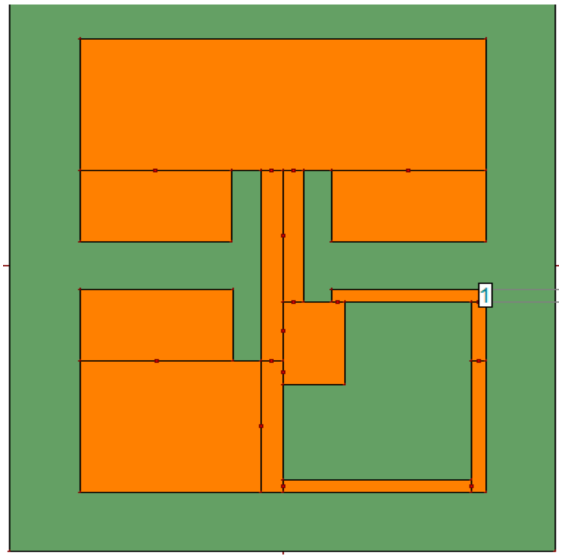

Figure 1: Design of proposed antenna

The above proposed model has patched and ground plane. This design is fabricated using glass epoxy (FR4) as well as textile (jeans), the reason of using FR4 & Textile materials are

- Easy to available
- Low costing

It has some specific properties like-

- Relative permittivity is of 4.4 & 1.7 respectively.
- Loss Tangent is 0.0013 & 0.025 respectively.

In this specific design the thickness is of 1.6mm for the resonating frequency at 2.4GHz. As in figure 2, we have cut two ''T'' at horizontal and also mirror image of each other. We have already mentioned that we were deploying line feed. The equation (1) to (3) gives the information of width, effective dielectric constant & length of patch antenna but in this paper we only used $1/6^{th}$ of its part for the betterment of result. The below mentioned table 1 is the result of dimensions that is derived from equation (4)-(5)-(6).As we are already mentioned in our paper , the specific formula used to abstract the information of patch length, patch width, ground length, and ground width respectively.

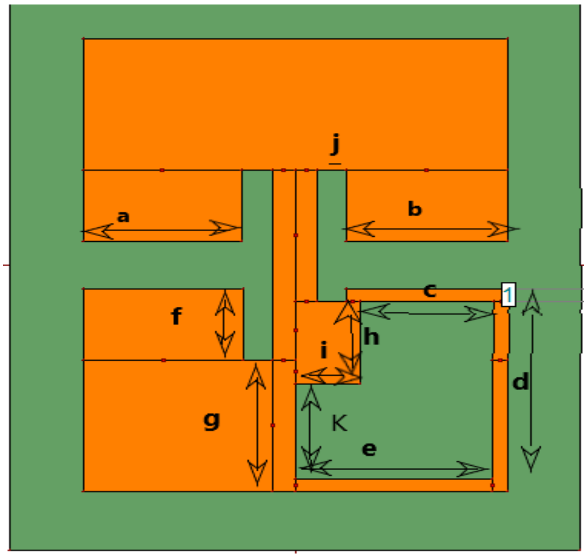

Figure 2: Proposed antenna design

TABLE 1.PARAMETERS AND DIMENTIONS

PARAMETERS	DIMENTIONS (mm)
a	**11**
b	**11**
c	**9.0**
d	**15**
e	**13.5**
f	**6**
g	**11**
h	**7**
i	**4.5**
j	**2**
k	**8**
L_g	**38.84**
W_g	**47.47**
L_p	**29.24**
W_p	**37.87**

III. RESULT AND DISCUSSION

The results of the design is simulated through IE3D (2015) software, the simulated result includes the following -

- Return loss
- VSWR
- Gain
- Directivity
- Efficiency

The Return loss is a graph of reflection coefficient(dB) Vs frequency(GHz).The return loss for the above mentioned patch design is inserted below in Fig(3), Having resonation frequency at 2.9GHz, 4.2GHz, 5.06GHz, 6.30GHz& also consist return loss of -25.26, -18.76, -23, -31.03dB respectively. The bandwidth is 103.57 %. The lower frequency and upper frequency are 2.7GHz & 8.5 GHz respectively.

Now we change the substrate from FR4 material to textile material & also inserted a comparison graph in Fig 3. Having resonating frequency at 4.45 GHz and 7.96 GHz and return loss of -24.76, -20.89dB respectively. The bandwidth is expanded to 109%.The lower and upper frequencies are 3.7, 12.69GHz respectively.

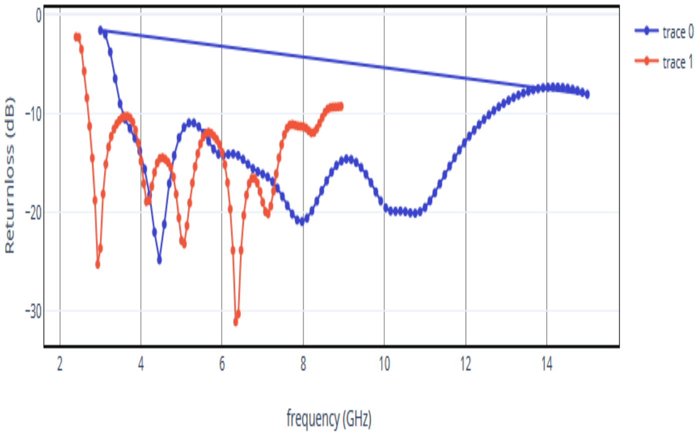

Figure 3: Return loss vs. frequency

VSWR is generally used to graph between Maximum to Minimum voltage, which is stored inside the dielectric. For its maximum efficiency it must lies between the values of 1 to 2.In Fig 4 we have inserted a comparison graph of different dielectric constant (FR4 & Textile).The table (2) shown below in the "***conclusion***" section shows that the frequency at which V.S.W.R starts and end. We should always keep in mind that the idol value of V.S.W.R is always lies between 1 to 2 on y-axis.

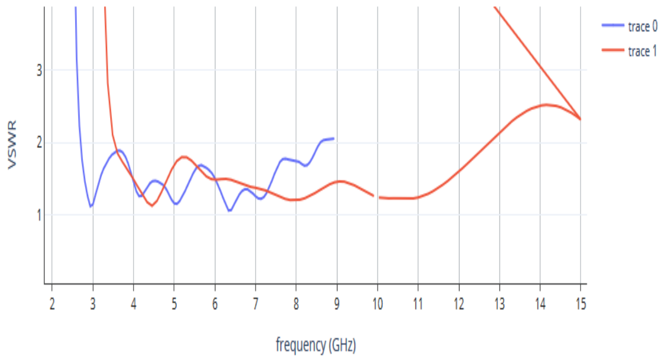

Fig.4 VSWR vs. frequency

Gain plays a major role in antenna that defines the total power radiated in specific direction. The unit of gain is dBi. The way to understand this, It is a logarithmic value of power based on isotropic antenna. In the below given Fig (5) define a relationship between gain and frequency. The graph also shows that it has gain of 7.2 dBi, which is quite large. Now if we change the dielectric substrate to Textile the gain is slightly reduced to 6.69dBi.A comparison graph is inserted to support this statement.

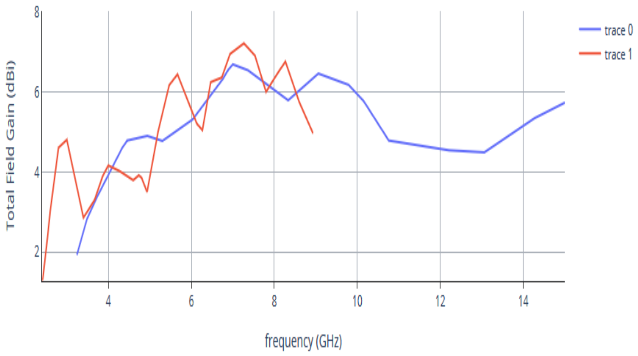

Fig 5: Gain Vs frequency

The term directivity is defining as a fundamental antenna parameter .It help us to calculate how directional of an antenna radiation pattern is. The Fig (6) shows the directivity graph of proposed antenna. The graph shown below shows the directivity of 7.2 dBi. The directivity can also be understood as; it is a fundamental antenna parameter.. An antenna that radiates equally in all directions would have effectively zero directionality, and the directivity of this type of antenna would be 1 (or 0 dB).Similarly we change the substrate of dielectric material to textile from FR4 material. The Directivity is also reduced from 7.2 to 6.7dBi.A graph of comparison between FR4 & Textile material is inserted below to support this analytical statement.

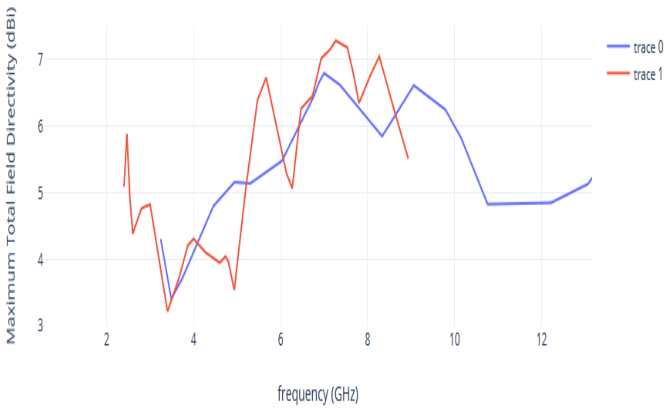

Fig 6: graph of directivity vs. frequency

The **efficiency** of an antenna is mathematical ratio of the power deployed to the antenna with respect to the power releases from the antenna. A antenna with good efficiency has all of the power present at the antenna's input radiated in a direction or vice – versa due to impedance mismatch. The Fig 7 shows the graph of efficiency of this proposed antenna at different dielectric substance is 99.5 and 99.6% respectively. The Fig given below support our statement

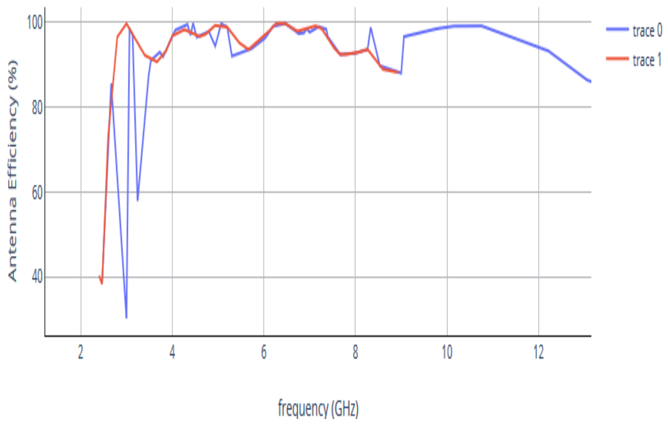

Fig 9: Antenna Efficiency (%) vs. Frequency (GHz)

IV. CONCLUSION

The rectangular & T shape microstrip patch antenna is fabricated over FR4 and Textile material also simulated for U.W.B applications. As we have seen the return loss covers wide range from 2.7 GHz to 8.5GHz for (Fr4) and for Textile it covers from 3.7 to 12.69 GHz, which covers UWB of 3.6GHz to 10.6GHz plus some RADAR frequency. Which are described by FCC Another parameter like Gain, Directivity, and VSWR also came with good performance. we can say it is perfect for U.W.B application. A comparison table is inserted below for detailed analysis of effect to change the substrate.

TABLE 2: COMPARISION OF PARAMETER

S.No	parameters	FR4	Textile
1	Bandwidth	103%	109%
2	VSWR	2.7 to 8.5GHz	3.7 to 12.69GHz
3	Directivity	7.28dBi	6.7dBi
4	Gain	7.21dBi	6.69dBi
5	Efficiency	99.5%	99.6%

So as we can say from the reference of above table parameter like Bandwidth, VSWR, Efficiency has increased with lowering the dielectric constant whereas parameter like directivity and Gain decreases.

Summary-

This paper helps to understand the design as well as fabrication of the antenna with FR4 and Textile. Textile antennas are constructed over jeans. The copper element work as patch element. From the reference of table listed just above the summary or under conclusion topic we understand that the parameter Bandwidth, VSWR, Efficiency is directly proportion to the Dielectric constant but in the case of Gain and Directivity it is not or in other word it is inversely proportion to Dielectric constant. All the data and analysis is mention in table from in the section of conclusion.

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