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DESIGN AND ANALYSIS OF DIFFERENT SUBSTRATE MATERIALS FOR UWB ANTENNA USED FOR BIOMEDICAL APPLICATIONS

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ABSTRACT

A CPW fed Micro strip patch antennas of size 25 x 25 x 1.6 mm^3 is proposed. The antennas are designed and analysed with different materials like FR4, RT Duroid, Polyester and Fleece. The proposed antenna possess a method to minimize the monopole patch antenna by loading the U strip over the predictable monopole patch antenna to lower the height of the antenna. The ground was vertically extended toward two sides of the single radiator. The antenna is simulated using MOM based CST microwave Studio. The antenna is practically fabricated. Measured results show a good concurrence with simulated results. The operating frequency band is 3-12 GHz (9 GHz) good agreement interms of return loss, Radiation pattern and VSWR. The designed structure is suitable for wireless and as well as biomedical applications[4][16].

Ketwords: *Biomedical materials, coplanar wave guide, Micro strip patch antenna, Ultra-wideband*

1. INTRODUCTION

In this era, antennas are an necessary part of any wireless communication system (WCS), with the technological advancements; antennas are playing even a bigger role. Due to the more developments in WCS, there is a demand for broadband antennas with high gain and bandwidth covering all frequency ranges [1]. Researchers have examined the dissimilar structures that can attain an UWB[28][30]. The micro strip UWB antennas have concerned much attention to their advantages like simple structure, low profile, high data rate, easy integration and easy fabrication. The UWB antenna mainly used for short range (10 m) high data WCS applications, peer to peer ultra fast communications and more applications. Due to this more applications the researchers dwell deep in the design of UWB antennas. Several monopole antennas, such as rectangular, rectangular patch and various slot antennas have been reported for compact UWB antenna. UWB band has been considered more effective for biomedical applications because of its high frequency bandwidth, which in terms allows the wavelength to be smaller as well to receive a higher bit rate after the practical antenna implementation [8][24][25].

As per the regulations of FCC stated on February 14 , 2002, frequency allocation for UWB is from 3.1GHz to 10.6GHz with a bandwidth of 7.5Ghz. UWB communication uses wireless communication with any modulation technique. Generally in UWB wireless communication data can be sent only in the form of short pulses of narrow with, so that the transmitting power for UWB communication is very less is less than 10% of Narrow band communication. Because of these alluring properties, UWB technology is widely use in many applications such as indoor positioning, radar/medical imaging and target sensor data gathering[2][6][7].

The UWB antenna will plays a major role in different wireless applications, instead this the UWB antenna mainly used for biomedical applications due to its low EIRP. In this paper, a coplanar waveguide (CPW) fed irregular compact U shaped patch UWB antenna with various slots is proposed[5][14]. The ground was vertically extended toward two sides of the single radiator. The proposed antenna is designed on a two generally available dielectric substrates like FR-4 and RT-Duroid, two biomedical material substrates of polyester and fleece[15][19][26]. The Basic Antenna design for considered for further analysed is shown in the figure 1 and the material properties are shown in table.1.

2. ANTENNA DESIGN

Table 1: Substrate materials used for proposed designs

S.NO	Materials used	Dielectric constant	Thickness (mm)	Loss tangent
1	RT-Duriod	2.2	1.6	0.0009
2	FR-4	4.3	1.6	0.025
3	Polyester	3.2	1.6	0.0029
4	Fleece	1.3	1.6	0.025

A.SUBSTRATE MATERIALS SELECTION

The permittivity of a substance is usually given comparative to that of free space which is known as relative permittivity or dielectric constant Єr. Different substrates having different dielectric constants and loss tangent affect the antenna concert in various ways[18][22]. Here, Fleece fabric with Єr =1.3, δ=0.025. Polyester with Єr =3.2, δ=0.0029. Rt Duroid with Єr =2.2, δ=0.0009. FR-4 with Єr =4.3, δ=0.025 are used as antenna substrates. Selection of material for designing the antenna is unique in this paper. Fleece fabric is outstanding in clothing, absorbency, durability, and flexibility. It is less flammable too. Properties of the fleece substance is pleasant to touch, very warm and provides warmth without weighing a lot, dries quick, never loses its properties during use, looks good-looking, and very good hygroscopic[9][10][21]. On the other hand Polyester includes high tensile strength, high resistance to stretching, durability and terrific electrical property whereas FR-4 is the primary insulating backbone upon which the huge majority of rigid printed circuit boards (PCBs) are produced. It is a compound substance composed of woven fibreglass cloth with an epoxy resin binder that is fire resistant. The patches are made of threads which is perfect electrical conductors (PEC)[3][12][20].

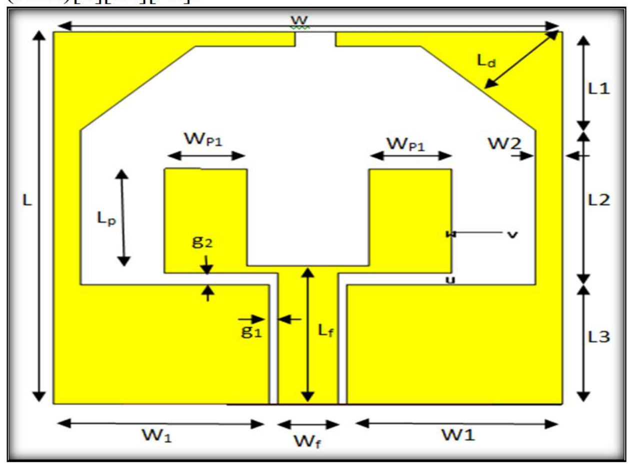

Figure 1: Basic U slot antenna

Table 2: Dimensions of the U slot antenna

Dimension	Value (mm)
L	25
W	25
W1	10.6
L1	8
L2	16
L3	1
W2	1
g1	0.4
g2	0.8
Ld	3
Lp	7
Lf	8.8
Wf	3
H	1.6

In this work, first considering the Basic U slot CPW antenna is as shown in fig.1 and their dimensions are included in Table 2. Based on the current distributions of the radiating element the patches are modified are shown in fig.2. In fig 2 the ground is same as that of the basic U slot antenna. The shape of the U slot is modified from design 1 to design 4. In design 1, the irregular U slot is modified by etching of two stubs (one in the centre of left and right rectangles with stub 1 dimensions and another stub with dimensions of the stub 2 at the lower middle parts of the two rectangle sides of

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the U slot shown in the Design 1, the dimensions of the stubs are shown in table 3). Modification of Design 1 with the lower stub 2 dimensions with stub 3 dimension in the lower part for getting Design 2. Up to Design we are concentrating on lower part etching, the Design 3 and Design 4 are Upper part etching with the reciprocal to the Design 1 and Design 2. From Design 1 to Design4, all the designing and simulations are carried out in MOM based CST Microwave Studio. With the substrate material properties are shown in Table 1 and the radiating element used is copper[6][11][17].

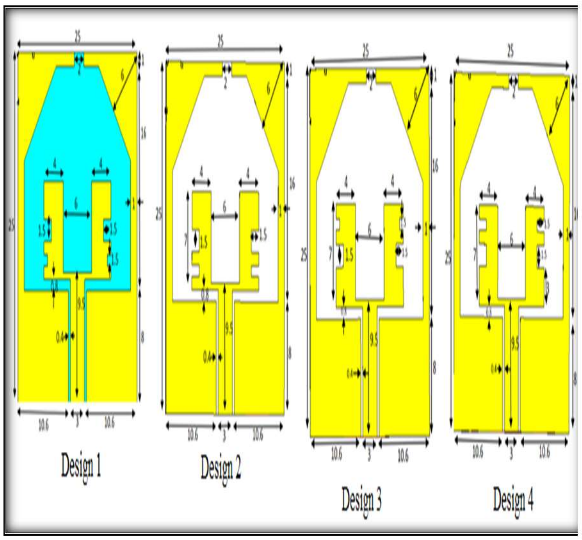

Figure 2: Proposed Antenna Design

S.No	Stub	Dimension (length x depth)
1	stub 1	1.5 x 1.5
2	stub 2	0.75 x 0.75
3	stub 3	1.5 x 0.75

Table 3: 3 Dimensions of the stubs

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

The Design 1 to Design 4 are Designed and simulated using MOM based 3D EM Simulator. These four antennas are implemented using the four different substrates (two generally available materials of FR4, RT Duroid and two biomedical materials polyester and fleece)[13][16][27]. From the fig3 (a-c) shows the simulation Results of return loss, VSWR and Radiation pattern of proposed antennas of fig 2 are implemented using the RT Duroid material. The simulation result shows the best result of 3.5-12 GHz operating frequency of antenna and the bandwidth of 8.5 GHz with return loss -49 dB at the frequency 8.35 GHz obtained for design 4[4][29].

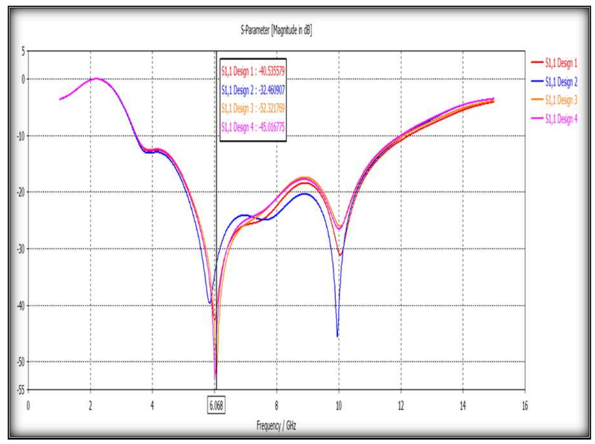

Fig 3(a): Return loss parameter performance of proposed antennas with RT Duroid material

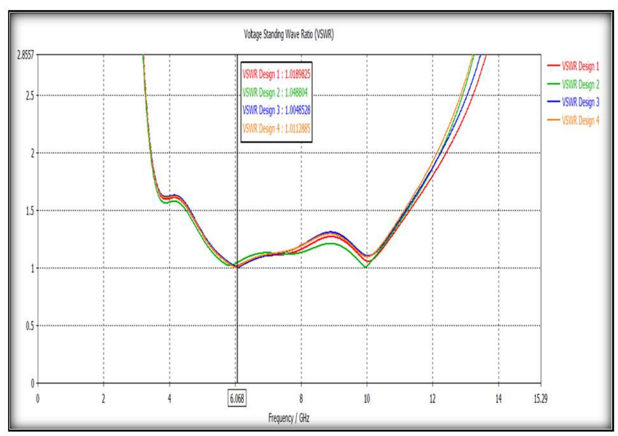

Fig 3(b): VSWR parameter performance of proposed antennas with RT Duroid material

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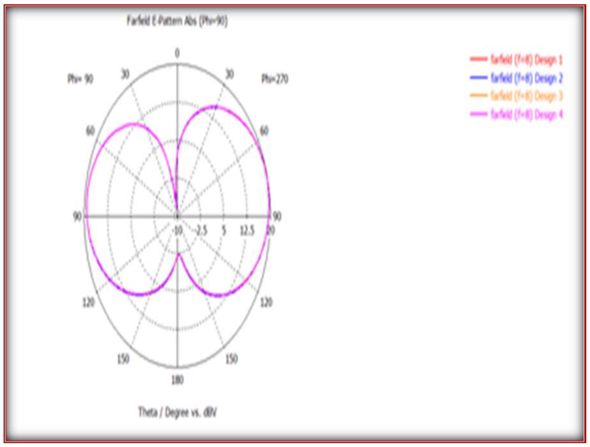

Fig 3(c): Two Dimensional radiation pattern performances of proposed antennas with RT Duroid material

From the fig 4(a-c) shows the simulation Results of return loss, VSWR and Radiation pattern of proposed antennas of fig 2 are implemented using the FR4 material. The simulation result shows the best result of 3.5-12 GHz operating frequency of antenna and the bandwidth of 8.5 GHz with return loss -63.4844 dB at the frequency 3.36 GHz of Design 4 gets

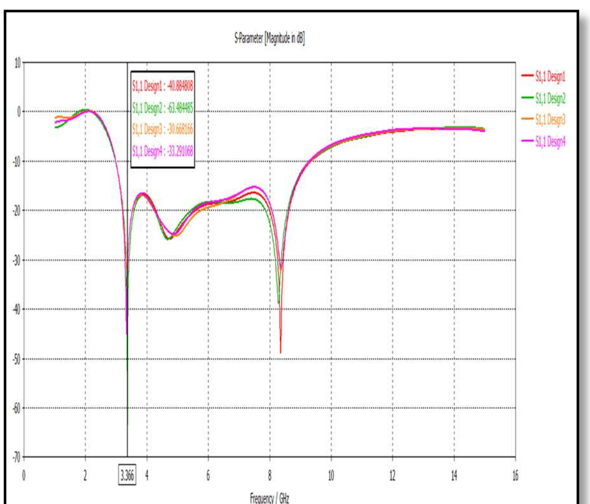

Fig 4(a): Return loss parameter performance of proposed antennas with FR4 material

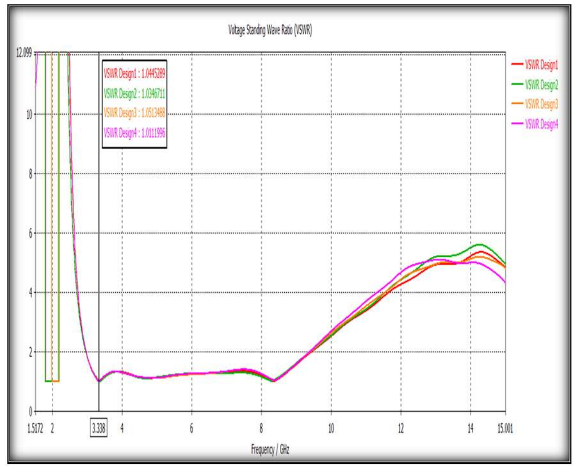

Fig 4(b): VSWR parameter performance of proposed antennas with FR4 material

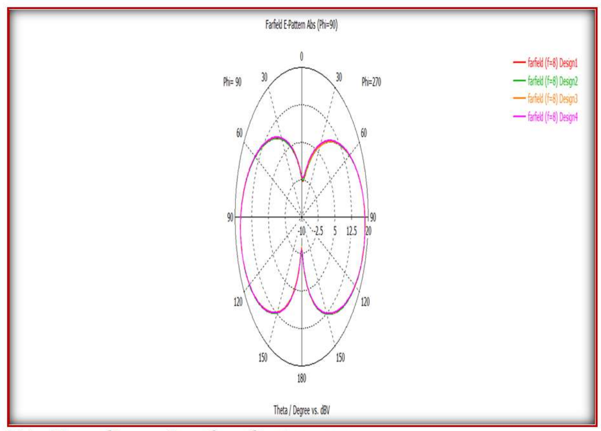

Fig 4(c): Two dimensional radiation pattern performances of proposed antennas with FR4 material

From the fig 5(a-c) shows the simulation Results of return loss, VSWR and Radiation pattern of proposed antennas of fig 2 are implemented using the Polyester material. The simulation result shows the best result of 3.5-12 GHz operating frequency of antenna and the bandwidth of 8.5 GHz with return loss -32.3160 dB at the frequency 8.36 GHz obtained for Design4

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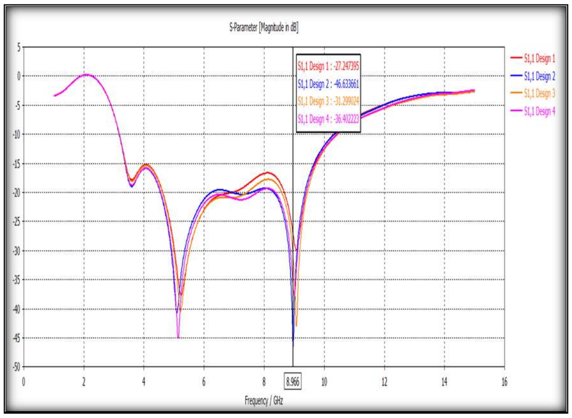

Fig 5(a): Return loss parameter performance of proposed antennas with Polyester material

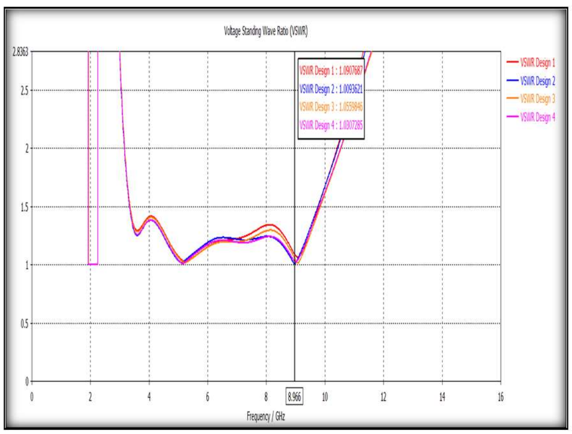

Fig (5b): VSWR parameter performance of proposed antennas with Polyester material

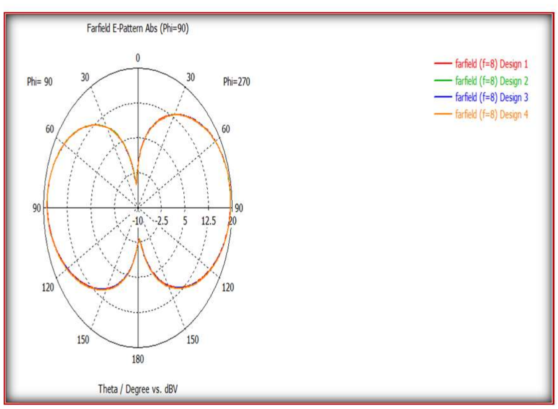

Fig (5c): Two dimensional radiation pattern performances of proposed antennas with Polyester material

From the fig 6(a-c) shows the simulation Results of return loss, VSWR and Radiation pattern of proposed antennas of fig 2 are implemented using the Fleece material. The simulation result shows the best result of 3.5-12 GHz operating frequency of antenna and the bandwidth of 8.5 GHz with return loss -45.0850 dB at the frequency 3.338 GHz of Design 4 gets

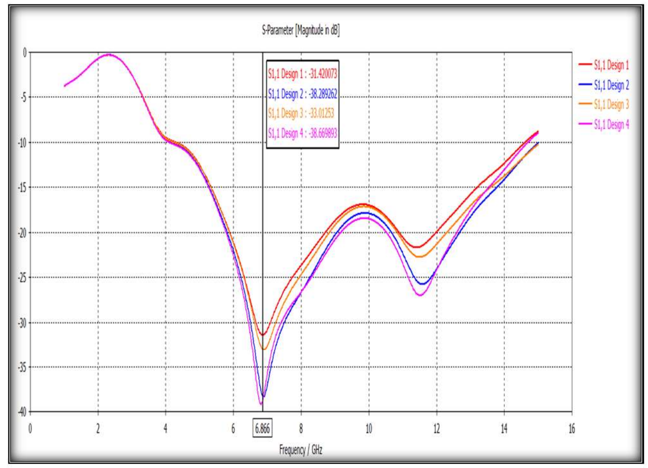

Fig 6(a): Return loss parameter performance of proposed antennas with Fleece material

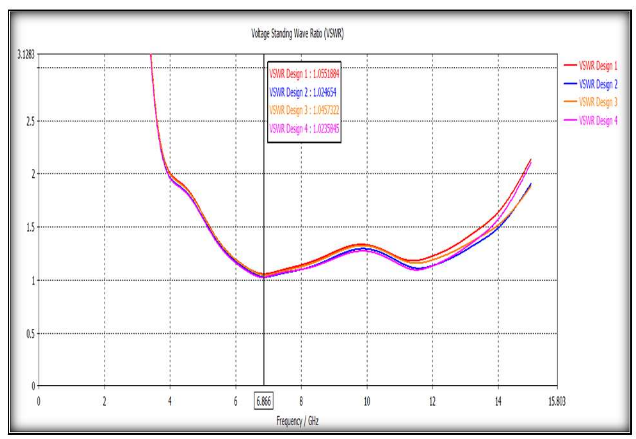

Fig 6(b): VSWR parameter performance of proposed antennas with Fleece material

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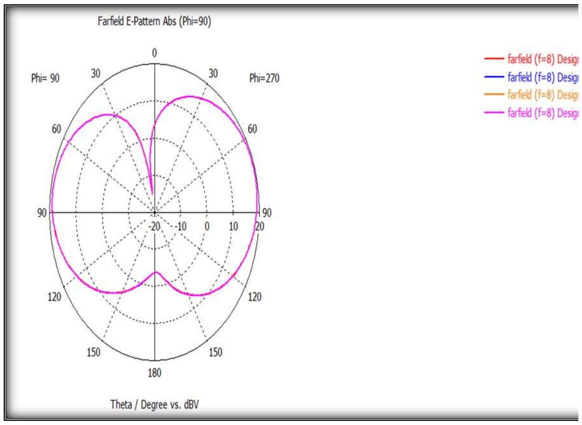

Fig 6(c): Two dimensional radiation pattern performances of proposed antennas with Polyester material

A. Validation of proposed antennas

The proposed antennas are fabricated and tested. Due to easily availability with low cost of FR4, we fabricate the proposed antennas and the fig 7 shows the fabricated prototypes. For measuring the return loss and VSWR parameter of the proposed antennas uses the VNA (Vector Network Analyzer). The measured return loss and VSWR parameter shown in fig 8(a & b)[23][25].

Fig 7: prototypes of proposed antennas with FR4 material.

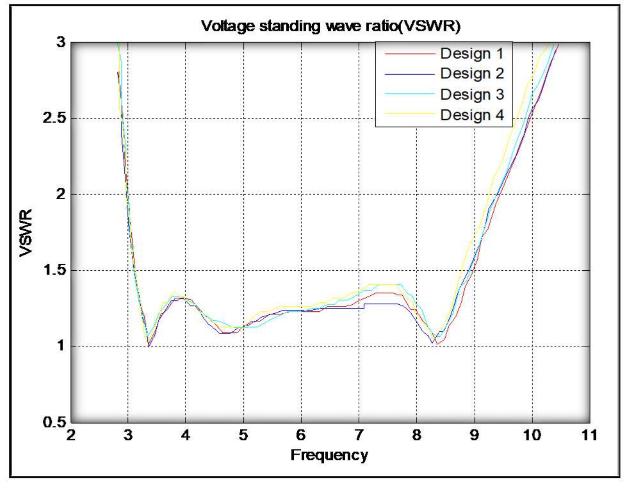

Fig 8(a): validation of Return loss parameter of proposed antennas of FR4 material

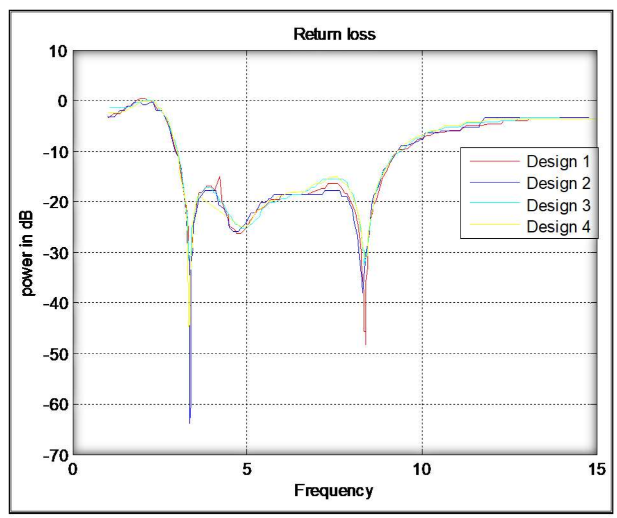

Fig 8(b): validation of VSWR parameter of proposed antennas of FR4 material

4.COMPARATIVE STUDY OF THE PROPOSED MODELS:

In this we proposed four different models for ultra wide band applications. Model one resonates at a frequency of 3.06Ghz to 9.2Ghz with minimum return loss of -48.223dB, with VSWR of 1.for Model 2 resonant frequency 3.06Ghz to 9.3011Ghz with minimum return loss of -63Ghz, VSWR of 1.8082. Model 3 resonates at 3.06468 GHz to

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9.3657 GHz with minimum return loss of -31.127dB, VSWR 1.Model 4 resonates at 3.0253 GHz to 9.2482 GHz with minimum return loss of -44.809dB, VSWR 1.262.as per the observations second model is best suited model for ultra wide band applications.

5.CONCLUSION

A new CPW fed compact UWB antenna with four different slots are proposed. The antennas are designed using four different materials, two materials are generally available FR4 and RT Duroid and other two are biomedical materials like Polyester and Fleece. The simulations are carried for all four materials with four different structures. The simulation results are good agreement in terms of Return loss, VSWR and radiation pattern. Four different patch slot antennas are fabricated using the FR4 substrate due to its low cost. The fabricated prototype is good agreement with simulated return loss and VSWR parameter. The proposed antennas are used for any UWB applications. Major limitation of ultra wide band antenna for biomedical applications is its low gain. Gain enhancement can be possible by using optimisation methods.

6.FUTURE SCOPE:

Antenna is basically designed for bio medical applications**.** Extend this work by replacing the dielectric substrate with bio implantable material for biomedical applications. Also test the antenna with other feeding network.

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The observation results of four antennas with four different materials are shown in table 4.

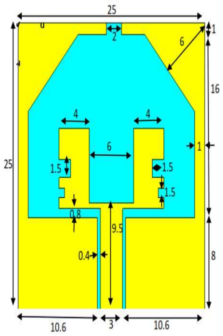
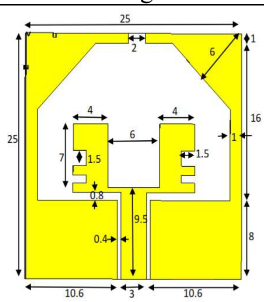
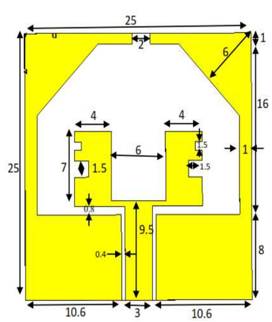
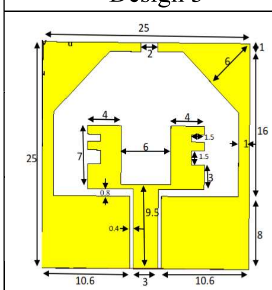
Antenna Figure	Material Name	Normal Material/ Wearable Material	Return Loss	VSWR	Band width	Gain	Directivity	Radiation pattern (Main lobe Magnitude)
 Design 1	Rt Duriod Єr=2.2, δ=0.0009	Normal Material	-42.6724	1.0148	8.7939	5.02dB	5.21dBi	19.8dBv
	FR4 Єr=4.3, δ=0.025		-49.0088	1	6.3596	3.97dB	4.58dBi	18.6dBv
	polyester Єr=3.2, δ=0.0029	Wearable Material	-43.0043	1.0142	8.4841	4.83dB	4.87dBi	19.5dBv
	Fleece Єr=1.3, δ=0.025		-33.593	1.0454	10.775	4.74dB	5.33dBi	19.5dBv
 Design 2	Rt Duriod Єr=2.2, δ=0.0009	Normal Material	-47.2	1.0087	8.805	5.01dB	5.2dBi	19.8dBv
	FR4 Єr=4.3, δ=0.025		-63.4844	1	6.3485	3.96dB	4.58dBi	18.7dBv
	polyester Єr=3.2, δ=0.0029	Wearable Material	-44.9731	1	7.2559	4.82dB	4.86dBi	19.5dBv
	Fleece Єr=1.3, δ=0.025		-30.6731	1.0602	10.564	4.7dB	5.33dBi	19.5dBv
 Design 3	Rt Duriod Єr=2.2, δ=0.0009	Normal Material	52.3217	1.0048	8.5837	5.02dB	5.22dB	19.8dBv
	FR4 Єr=4.3, δ=0.025		-32.31607	1	6.3702	4dB	4.55dBi	18.6dBv
	polyester Єr=3.2, δ=0.0029	Wearable Material	-46.6336	1	7.1674	4.81dB	4.8dBi	19.5dBv
	Fleece Єr=1.3, δ=0.025		-38.3332	1.0245	10.277	4.73dB	5.31dBi	19.5dBv
 Design 4	Rt Duriod Єr=2.2, δ=0.0009	Normal Material	-52.7099	1.00464	8.5511	5.02dB	5.21dBi	19.8dBv
	FR4 Єr=4.3, δ=0.025		-45.085	1.011	6.3264	3.93dB	4.5dBi	18.6dBv
	polyester Єr=3.2, δ=0.0029	Wearable Material	-37.5871	1	7.1563	4.83dB	4.87dBi	19.5dBv
	Fleece Єr=1.3, δ=0.025		-31.42007	1.05531	10.332	4.7dB	5.3dBi	19.5dBv

Table 4: Result analysis of Normal and Wearable materials for different antenna structures