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Design of Wearable Textile Antenna for Wireless and Medical Applications

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Abstract

In this dissertation work, a wearable textile antenna for wireless and medical applications has been proposed.During this work first we will design a textile antenna, namely, a rectangular microstrip patch antenna and then an annular slot antenna will be designed for wireless and medical applications.After designing two kinds of antennas,a comparison will be made between their results.In case,antenna gives moderate bandwidth and gain,1*2 or 1*3 antenna array will also be designed to improve antenna characteristics. Conductive textile, a copper-plated polyester fabric, will be used for fabricating antenna radiators and grounds. An insulating rubber fabric with optimum thickness of 0.78 mm and a permittivity of 3 will be used for preparing the substrates.The proposed antenna will be designed and all the results will calulated using user friendly CST Microwave studio Software.

Keywords: *Textile antenna, Polyester fabric,Rubber fabric,CST Microwave studio*

1. Introduction

As the amount of portable devices and wireless applications keeps increasing, the size of the devices keeps decreasing. Hence, the space inside a device becomes more and more valuable. Fundamental limitations set requirements for effective antenna operation, and therefore, it is understandable that antenna miniaturization tends to weaken the performance of an antenna. Because even a miniaturized antenna tends to be the largest component in a portable device, taking the antenna out is sometimes a good choice. Wearable antennas for in and on-Body Amount Networks (BAN) are plan by textile constituents, this is universally used and easily available. The plan of the antenna depends on depiction of their electric and electromagnetic possessions. A wearable processor is always on, does not confine the user's doings and is aware of the user's situation. The wearable antenna assimilates fabric into the communication system [2, 3]. The fast progress of wireless communication technology, numerous scientists are now paying accumulative attention to the study of wireless body area networks (WBANs). WBAN associates several electronic policies in and on the social body. The integration of the communication equipment as part of user clothing is widely recognized as a potential approach to increase the overall system performance. For example, a high performance circularly polarized antenna, which is ideal for satellite communication and navigation systems, is likely too large to fit in a mobile phone but can easily be hidden inside a sleeve of a jacket with existing material combinations. Patch antennas are particularly feasible for both on-body and off-body communication due to the low profile they utilize [1]. Antennas consisting of planar sheets are ideal to be fabricated using conventional manufacturing processes of textile industry. Furthermore, the ground plane of such antenna effectively shields the antenna from the body tissues [2]. This minimizes both detuning and reduction of antenna efficiency. However, circularly polarized patch antennas tend to be sensitive to bending effects [3 – 4]. Rectangular patch geometry is adopted for further examination of circularly polarized textile antenna. This geometry is shown to be relatively robust against bending effects [5].

The application of WBANs has been expanding in medical services, national defense, and wearable computing, and so on. Several frequency bands have been assigned for WBAN systems, such as; the Medical Implant Communication System (MICS: 400 MHz) band, the Industrial Scientific Medical (ISM: 2.4 and 5.8 GHz) band, and the Ultrawideband (UWB: 3–10 GHz). The wide ranging applications of WBAN's including, military, ubiquitous health care, sport, entertainment and many others have been categorized into two main areas by the IEEE 802.15.6 standard.

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2. Properties of Textile Materials

Textile materials that are used as an antenna's substrates are of two types: natural and manmade fibers. Man-made fibers subcategorized as synthetic fibers being polymers from their molecular structure. Many wearable antennas aspects contribute in the overall design features of the antennas. Some characteristics of the textile materials are given as: Absorption of Moisture The moisture changes the antenna performance parameters dramatically when a fabric antenna absorbs water because water has much high dielectric constant than the fabric. The fibers are constantly exchanging water molecules with the air and changes dynamic equilibrium with the temperature and humidity of the air surroundings. Regain, which is defined, by the ratio of the mass of absorbed water in specimen to the mass of dry specimen, expressed as a percentage represents the sensitivity of the fabric to moisture. Resonant frequency and bandwidth is reduced by the higher dielectric constant of water.

Since fabric antennas are used near the skin, the aspect of wetness of fabric due to human sweat becomes more important. In addition, wearable systems can be mounted on top of jackets or suits where the aspects of wetness raised up due to rain or washing the textile materials. Beyond these effects, when textile fibers absorb water they swell transversely and axially, causing tightening of the fabrics [5].

3. The Dielectric Constant of various Fabrics

The Dielectric Constant of the Fabrics is One of the most important parameters affecting the ability to transmit fast changing signals across the textile transmission line is the complex dielectric permittivity of the material or substrate. The return loss in the transmission line can be affected by this phenomenon. The complex permittivity is defined as; εr : ε = ε0εr = ε0(εr1 − jεr2) (1) Here ε0 is the permittivity of vacuum which is 8.854×10-12 F/m. In general, the frequency, temperature, and surface roughness and also on the moisture content, purity and homogeneity of the material affects the dielectric properties of materials. The real part of the relative permittivity, εr1, is called the dielectric constant. The ratio of the imaginary part to real part is called the loss tangent. $tan\delta$ = −jεr2/εr1 (2) Thus, the behavior of the material tested under a specific electric field orientation and frequency describes by the relative permittivity. Textiles materials have a very low dielectric constant because they are very porous materials and the presence of air makes the relative permittivity to one. Table 2 shows the dielectric properties of normal textile fabrics. The surface wave losses can be reduced by low dielectric constant. Therefore, increases spatial waves by the lowering the dielectric constant and hence increases the impedance bandwidth of the antenna, allowing the development of antennas with acceptable efficiency and high gain.

Table 1: Dielectric Properties of Fabrics

Sr. No.	Fabric	Dielecric Constant
1.	Felt	1.22
2.	Cordura	1.90
3.	Cotton	1.60
4.	Polyester	1.90
5.	Quartzel Fabric	1.95
6.	Rubber	3
7.	Silk	1.75
8.	Jeans	1.70

4. Design of Textile Patch Antenna

The three essential parameters for the design of any patch antenna using traditional method are:

(i) Frequency of operation (f_o):

The resonant frequency of the antenna must be selected appropriately. The resonant frequency selected for design is at 5.5-5.9GHz

(ii) Dielectric constant of the substrate (E_r):

The dielectric material selected for the design is Rubber textile material which has a dielectric constant of 3. A substrate with a high dielectric constant reduces the dimensions of the antenna.

(iii) Height of dielectric substrate (h):

For the textile patch antenna it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 0.78 mm.

The design parameters that are assumed and evaluated are shown in Fig.1 as below:

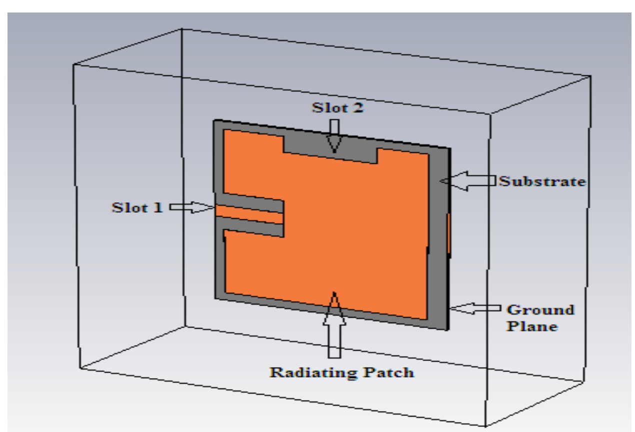

Figure 1(a): Perspective view of textile Antenna

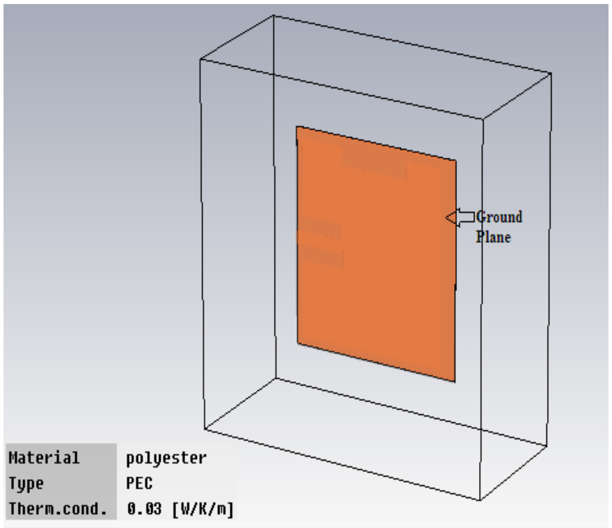

Figure 1 (b):Ground Plane of Textile Antenna using Polyester Fabric

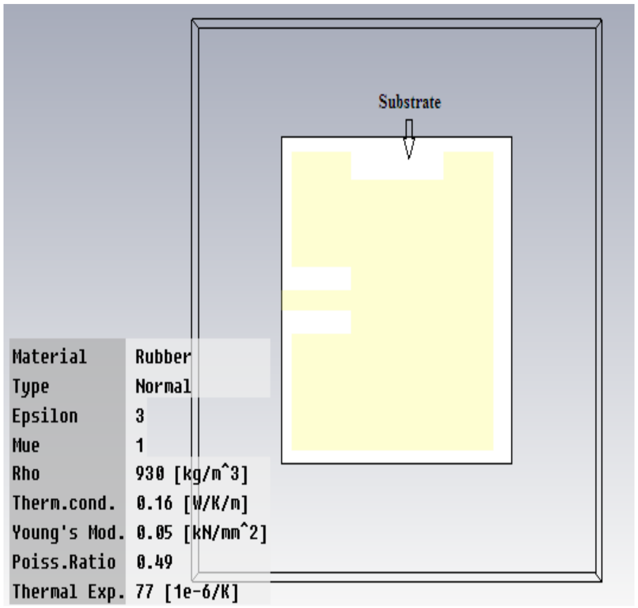

Figure 1(c): Subtrate of Textile Antenna made by Rubber Material

Figure 1(a) shows the structure of the textile rectangular patch antenna. The patch antenna consists of a conductive patch attached on the top of neoprene substrate with a ground plane on the bottom of the substrate. When the length of patch is approximately λg/2, where λg is the guided wavelength, the patch becomes resonant and the electromagnetic field can be radiated. The resonant length of the patch in the TM10 mode was 46.5 mm, and a microstrip inset feed line was used for signal excitation. The input impedance of the patch antenna at 186 Ω was transformed to 50 Ω by using a λg/4 impedance transformer. Figure 1 (b) shows the structure of Ground Plane made up of Polyester fabric. Its thermal conductivity is also has been specified in figure. Figure 1(c) shows the substrate of textile antenna made up of Rubber fabric. As we can observe, all the dielectric and thermal properties have been given in the figure. Table 3 lists the dimensions of the textile patch antenna.Geomatrical dimensions of the Textile antenna are given in the following table.

Table 1: Geometrical Dimensions of Textile Antenna

Sr. No.	Parameter Name	Dimensions in mm
1.	Length of Patch (L_p)	43 mm
2.	Width of Patch (W_p)	49 mm
3.	Length of Ground (L_g)	50 mm
4.	Width of Ground (W_g)	54 mm
5.	Width of Feed (W_f)	1.69 mm
6.	Dielectric Constant (Er)	3
7.	Height of Substrate(h)	0.78 mm

5. Design of Textile Annular Slot Antenna

Figure 2 shows the anticipated textile slot antenna in which the annular slot appears as a ring. The annular slot antenna consists of a circular slot on a conductive polyester ground plane.It is fed by a microstrip line, fabricated on the bottom of the rubber substrate. The d length of the slot circumference is approximately λg at the design frequency. The annular slot acts as a radiator with excitation current around the periphery of the slot. Because the substrate is thick, the feed line impedance of 50 Ω requires a line width of 1.69 mm, which may results, matched characteristic impedance. Therefore, the feed line was designed to have impedance of 50 Ω.[7-10]

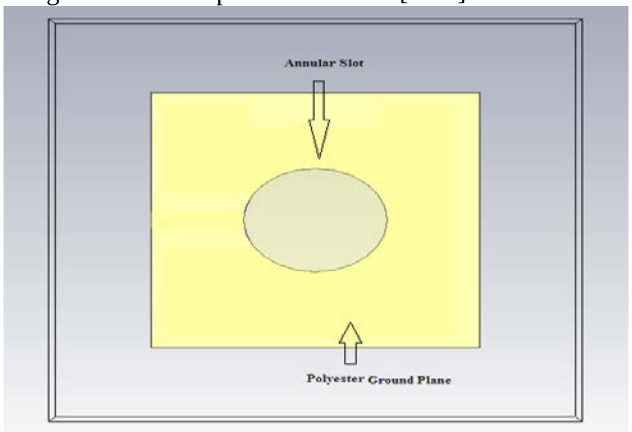

Figure 2 : Annular Slot on conductive Ground plane

Dimensions of slotted ring have been optimized many a times in order to make antenna resonate at desired frequency bands.

6. Measured Results and Comparison

Figure 3 (a) and (b) show the simulated and measured S11 responses of the experimental textile patch antenna and Textile Annular Slot Antenna. As we can observe that Textile antenna radiates at two bands 5.5 GHz and 7.6 GHz with -18.7 dB and 7.5 dB return loss respectively. On the Other hand, Textile Annular Slot Antenna radiates at 5.8 GHz and 7.6 GHz bands with return loss of -46 dB and -43 dB respectively. After comparison we analyzed that Textile annular slot antenna gives more than 42% and 45% improved performance as compare to Textile antenna.

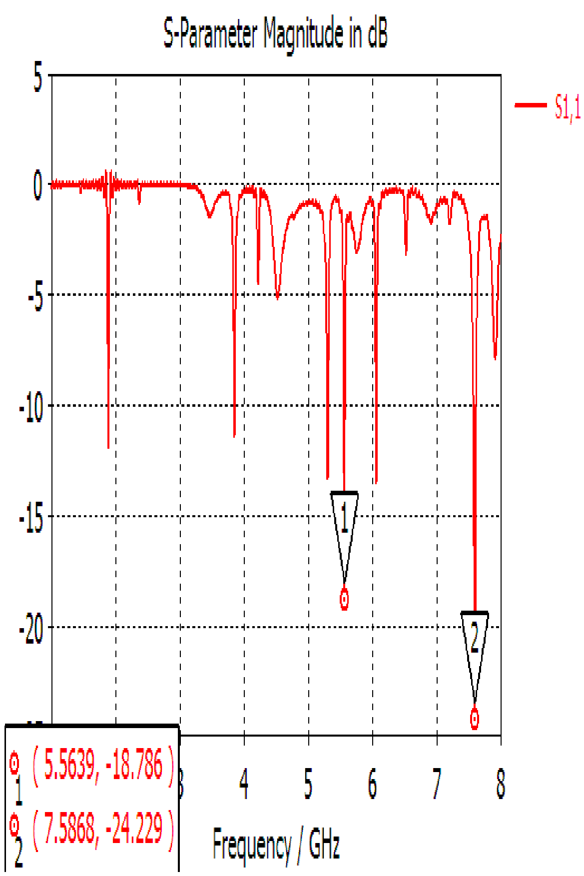

Figure 3(a): Return Loss of Textile Antenna

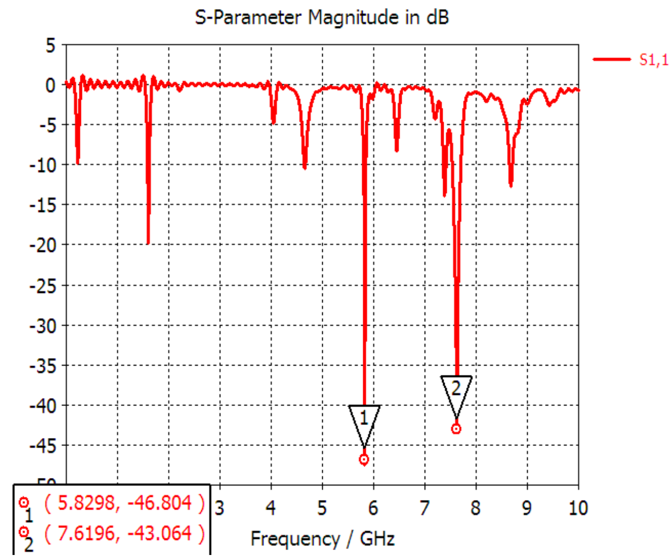

Figure 3(b): Return Loss of Textile Annular Slot

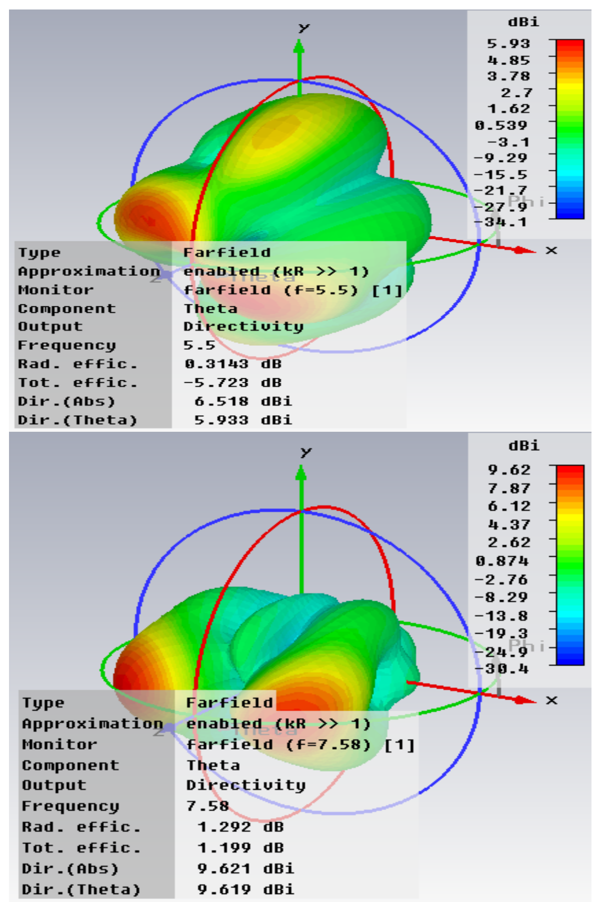

Figure 4(a) and (b):Directivity/Gain Plot at 5.5 GHz and 7.6 GHz frequency for Textile Antenna

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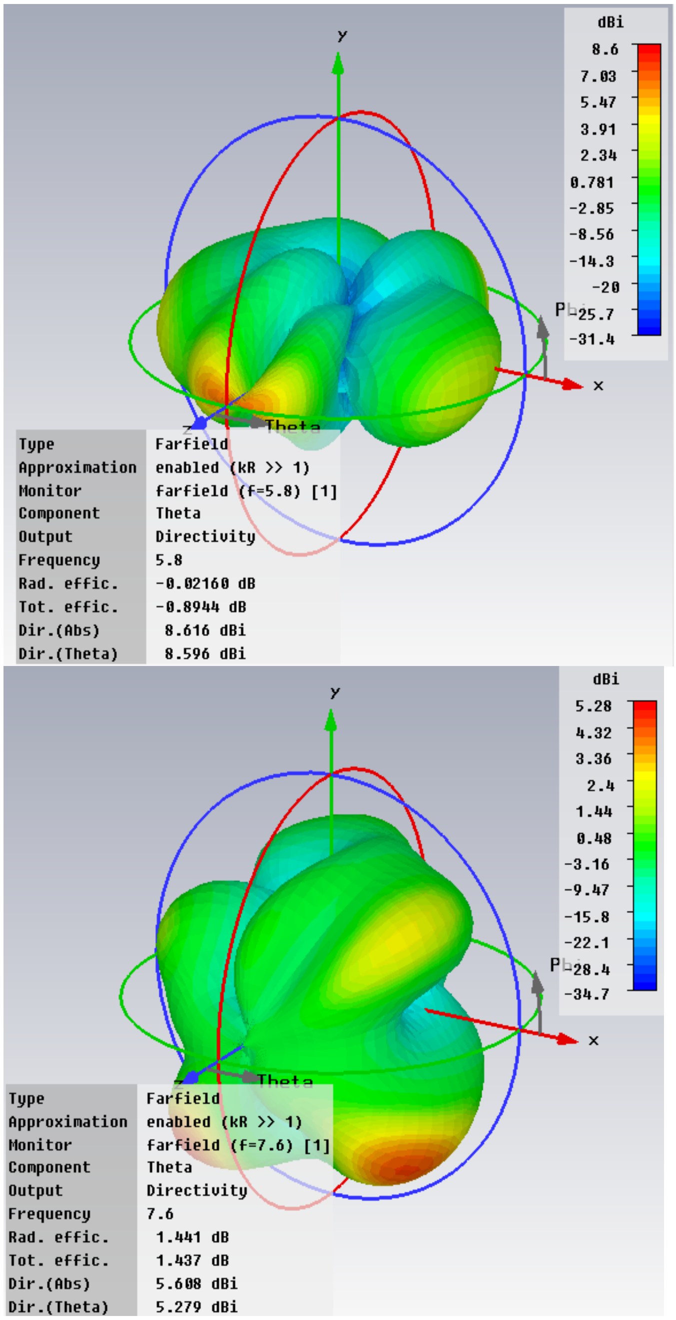

Figure 5 (a) and (b) : Directivity/Gain Plot at 5.8 GHz and 7.6 GHz frequency for Textile Annular Slot Antenna

Figure 4 and 5 show the directivity gain/pattern of Textile Antenna and Textile Annular Slot Antenna. At 5.5 GHz and 7.6 GHz there is gain of 5.9 dB and 9.6 dB respectively for the Textile antenna. On the other hand, at 5.8 GHz and 7.6 GHz there is a gain of 8.5 dB and 5.2 dB respectively. The resultant gain values conclude itself that Both the antenna are properly radiate in one direction and they are highly directive.

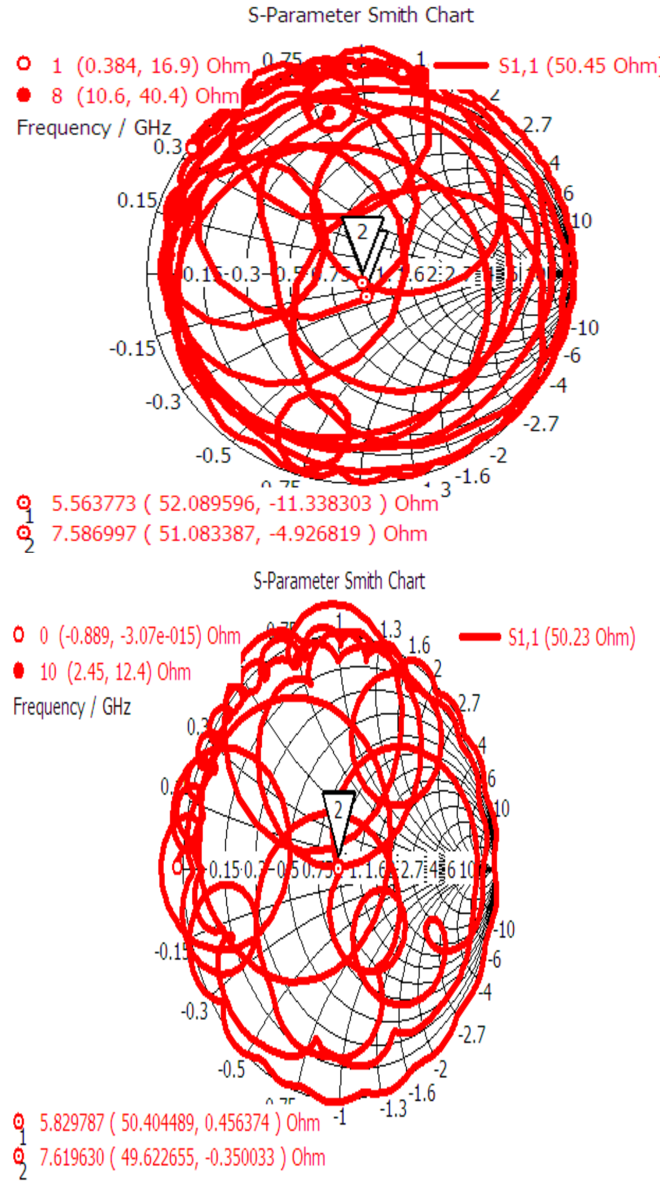

Figure 6 (a) and (b) : Smith Chart Plot for Textile Antenna and Textile Annular Slot Antenna

Figure 6 (a) and (b) show smith chart plot for Textile antenna and Textile Annular slot antenna. From the figures we can see that input impedance for both the antennas is perfectly matched which is of 50 ohms. We achieved this matched input impedance without using any external device. Optimized value of width of line feed results matched input impedance.

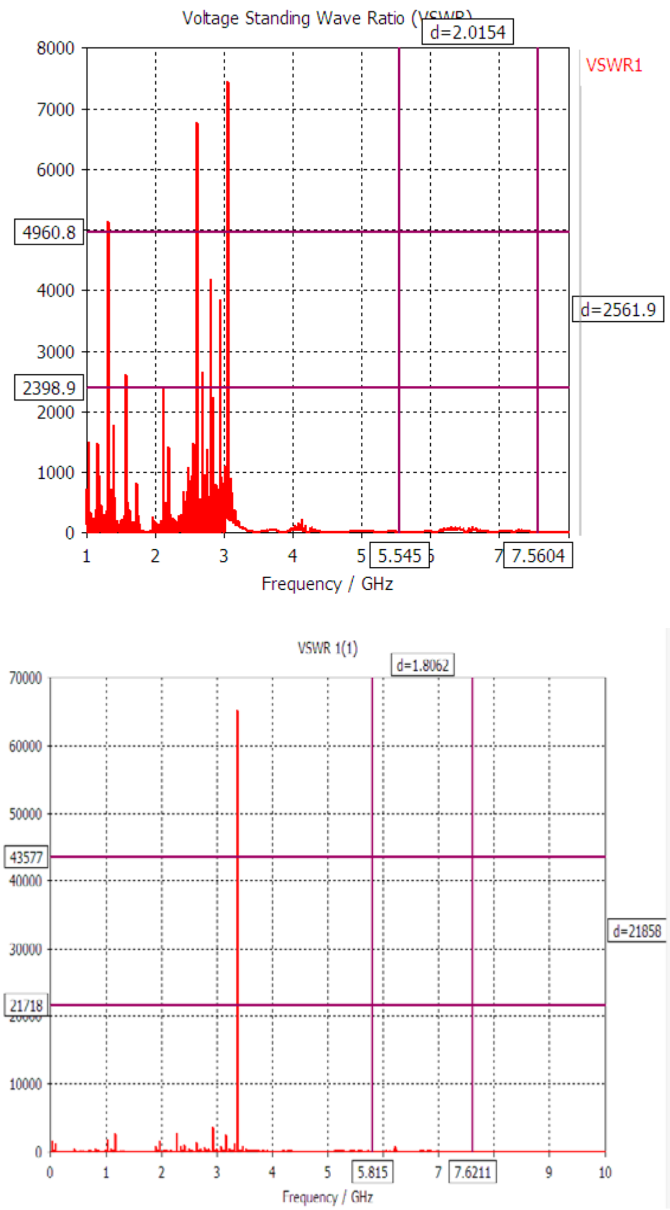

Figure 7 (a) and (b): VSWR Plot for Textile antenna and Annular Textile antenna.

Figure 7 (a) and (b) show the VSWR plot for Textile Antenna and Textile Annular Antenna. As we can from figures that VSWR is of up to 2 for both. The antennas. Ideal values for VSWR are 1 and practical values for VSWR are 2.Lower the values of VSWR lesser the voltage standing wave ratios.

Conclusion

In the projected work, we designed wearable Textile antenna. First, we designed Textile antenna which resonates at 5.5 GHz and 7.5 GHz. It gives return loss of -18 dB and -24 dB respectively, Gain of 5.9 dB and 9.6 dB respectively and VSWR value up to 2. After this we designed Textile Annular slot antenna which resonates at 5.8 GHz and 7.6 GHz respectively. It gives return loss of -46 dB and -43 dB respectively, Gain of 8.5 dB and 5.2 dB, VSWR value up to 2.After comparison between Textile antenna and Annular Textile Antenna, we analyzed that Textile Annular Antenna results great performance over Textile antenna. Designed antennas are made of polyester and rubber fabric therefore it can be used with wearable clothes. As it is resonates at 5.5-5.8 GHZ and 7.6 GHz bands so it can be used for various medical and wireless applications.

References

[1] C. A. Balanis, “AntennaTheory” JohnWiley & Sons, 3rd edition, 2005 chp-4 pp.
722-784
[2] H Singh, “Electromagnetics and Antennas”, Katson publication, New Delhi, 2nd edition.
[3] Kuo-Sheng Chin, Chi-Sheng Wu,” designs of textile antenna arrays for smart clothing applications,june 2018
[4] Sudhir Shrestha, Mangilal Agarwal,., “Microstrip Antennas for Direct Human Skin Placement for Biomedical Applications”july 2010 .
[5] Chan Hwang See and Khalid G Samarah “A Printed Wideband MIMO Antenna for Mobile and Portable Communication Devices”, APACE 2003. Asia-Pacific Conference on Applied Electromagnetics, pp: 38 – 41, 2003.
[6] Guang-ming Zhang,Hong-jing Song,Bing-zhong Wang, Qin-ying Qin,” A Novel dual-band microstrip antenna for WLAN Applications”, IET International Communication Conference on Wireless Mobile and Computing, pp:269-271, 2010.
[7] Raghava N.S. De A., Arora P. , Malhotra S. ,Bazaz, R. ; Kapur S. , Manocha R.,“A Novel Patch Antenna for Ultra Wideband Applications”, International Conference on Communications and Signal Processing (ICCSP), pp:276-279, 2011.
[8] Taheri M.M.S., Hassani H.R., Nezhad S.M.A., “UWB Printed Slot Antenna With Bluetooth and Dual Notch Bands”, IEEE Antennas and Wireless Propagation Letters, Vol-10, pp: 255-258, 2010,
[9] Parmar Kapil and Kumari Runa and Behera S K, “M-Shaped dielectric resonator antenna for WLAN applications”, International Conference on Devices and Communications (ICDeCom), pp-1-4, 2011.
[10] Nguyen T. D., Lee D. H., Park H. C., “Design and Analysis of Compact Printed Triple Band-Notched UWB Antenna” IEEE Antennas and Wireless Propagation Letters, pp-403, 2011.