

Ultra Wideband Fabric-Based Slot Antenna on Human Body for Medical Application

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ABSTRACT

In this paper a new UWB textile slot antenna has been designed with high precision. This work aimed to make closer steps towards real wearability by investigating the possibilities of designing wearable UWB antenna where textile materials are used for the substrate as well as the conducting parts of the designed antenna. The antenna is composed of three textile layers: the top and bottom are conducting layers and the third layer is a textile dielectric layer and sandwiched between these two conducting layers. The developed antenna offers flexible, light-weight and bendable properties, and can be easily incorporated into clothing using a simple iron-on adhesive process. The iron-on process allows for the fabric to be washed without losing its adhesion. The antenna shows better than 13 dB return loss and peak gain 5 ± 2 dB over FCC UWB from 3.1 to 10.6 GHz. The antenna's overall size is $5\text{mm} \times 5\text{mm}$.

KEYWORDS: fabric antenna, UWB, slot antenna, textile substrate, medical application.

INTRODUCTION

Using textiles for antenna development is an attractive option for many applications. Chief among these is the growing field of body area networks for narrow and ultra wideband applications. The key considerations for wearable electronics are to be lightweight, flexible, small size, inexpensive, able to withstand damage from obstacles (robust), and comfortable to wear [1-3]. Since the Federal Communications Commission (FCC) in 2002 approved the commercial use of frequency bands from 3.1 to 10.6 GHz for Ultra-wideband (UWB) systems, UWB antennas received more and more attention with the advancement of

communication technology [4-6]. Since 1997, wearable telecommunication systems have become popular topics in research institutions. Numerous papers have been published about the design, fabrication and applications of wearable antennas and systems [7-13]. Moreover, full success can be achieved only when the antenna and all related components are entirely converted into 100% textile materials where the use of embedded textile components guarantees washing of the electronic suit and accordingly reuse of it.

The use of textiles for wearable applications offers a low-cost, flexible solution when compared to rigid antennas. This flexibility becomes even more important when large arrays are required.

In this paper, we present the design process of a UWB slot antenna for use in wearable applications with detailed discussion about the concept, simulation. The organization of this summary paper is as follows. Sections II discuss the materials that have been used to accomplish the wearable antenna design. In Section III, we present the single element slot antenna, successive design steps, and a set of comparative results of the proposed antenna. The conclusion is given in Section IV.

TEXTILE MATERIAL SELECTION

The most important properties of textile materials that are mobilized in wearable applications are flexibility to conform to the body, comfort to touch, and softness. The antenna was designed using the triple-nickel-silver nylon rip stop conductive textile from Swift Textile Metalizing. The electrical resistance of this material is less than $0.05\Omega/\text{square}$ and conductive layer is 0.12mm thick. This material offers the best surface conductivity. As a substrate material, we focused on the nylon Cordura dielectric with permittivity of 2.05 and loss tangent of 0.025 . The thickness of the dielectric layer is 0.57mm , thus providing a flexible, lightweight alternative to thick textile or foam substrates. The fabric is coated on one side with nonconductive hot melt adhesive which make the attachment process easier by ironing the conducting fabric onto the surface of flannel fabric substrate material. The proposed conducting fabric can be washed as well as its ability to resist temperature up to 200°C .

ANTENNA DESIGN

In general, the design and construction of the UWB planer monopole antenna consist of a circular

patch to be placed at the top of the fabric substrate material, a microstrip/coplanar waveguide (CPW) feed line and a circular slot beneath the fabric substrate material. Using the properties for each textile layer, a slot antenna is designed which operates with bandwidth $5.5:1$. This antenna was designed in Ansoft's HFSS and is shown in Fig. 1

The return loss of the antenna is calculated and shown in Fig. 2 as a function of the patch radius " R_2 " and slot radius " R_1 ". The maximum bandwidth is achieved when $R_1=24\text{mm}$ and $R_2=14.5\text{mm}$. Additionally, the antenna performance with a CPW and microstrip feed is compared and return loss of the antenna vs. frequency with each feed line is shown in Fig 3. The antenna showed better performance with microstrip feed.

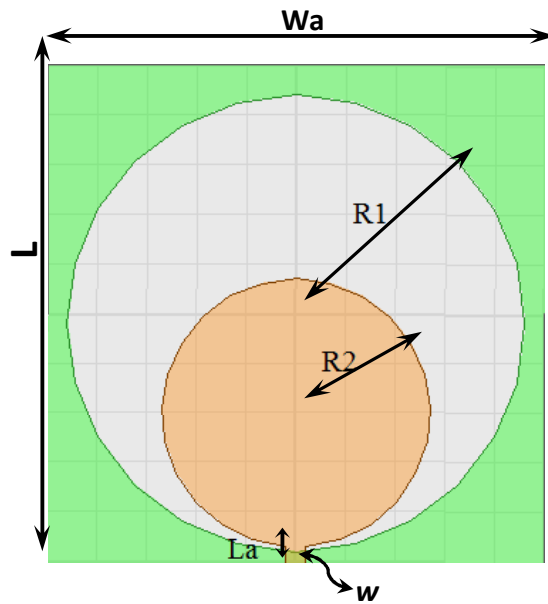
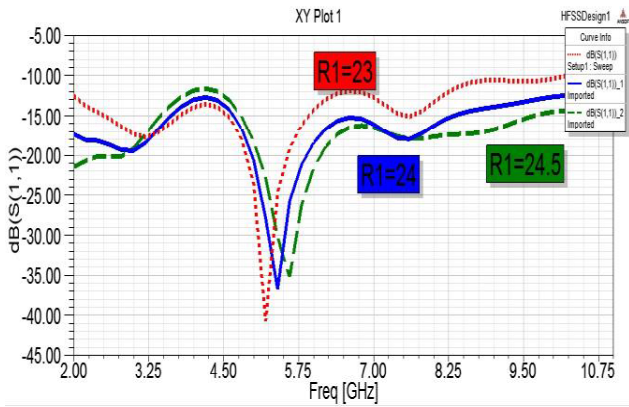
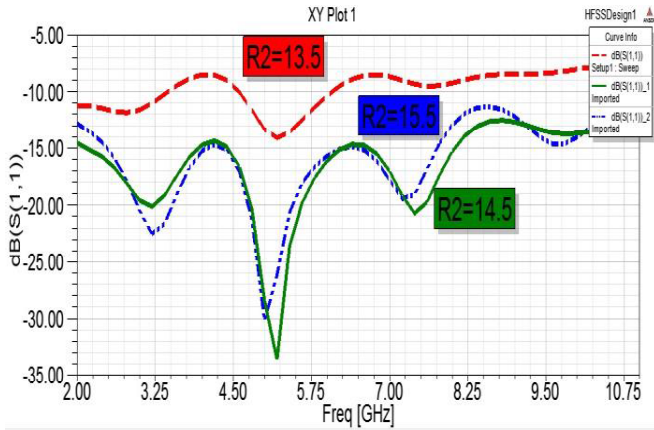


Fig.1. UWB fabric slot antenna with microstrip feed.



(a)



(b)

Fig.2. Return loss of the antenna vs. (a) radius of the slot, (b) radius of the patch.

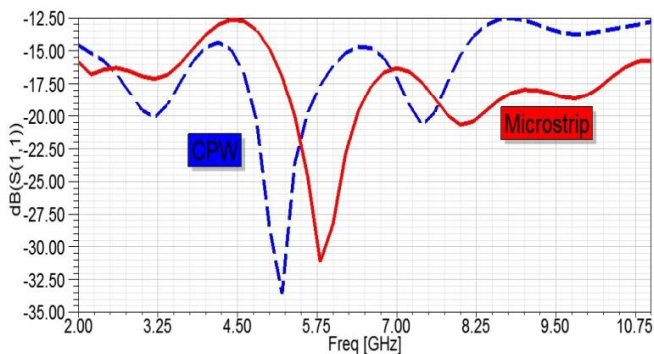


Fig.3. Comparison of the antenna return loss with microstrip and CPW feed.

The optimized dimensions of the proposed wearable textile UWB antenna with microstrip feed

are listed in Table I. With these dimensions, the simulated design produced good impedance matching with a reflection coefficient being below -13 dB all over the bandwidth from 2 to 11 GHz (140%) as shown in Fig 4.

TABLE I: OPTIMIZED DIMENSIONS OF THE UWB SLOT ANTENNA

Parameter	L	W_a	$R1$	$R2$	w	La
(size)mm	50	50	24	14.5	2	4.5

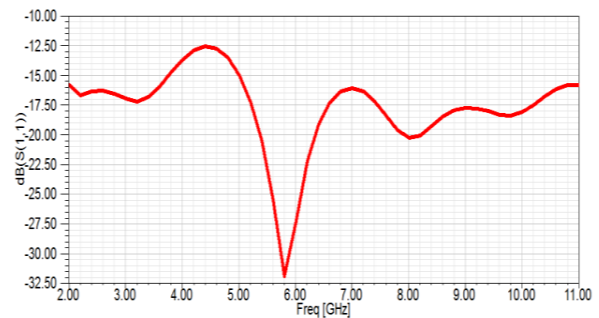
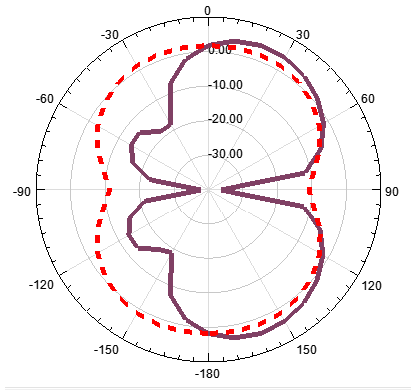


Fig.4. Return loss of the UWB slot antenna with optimized dimensions.

The E-plane and H-plane radiation patterns for this antenna are presented in Fig. 5 at discrete frequencies of 5 GHz, 7 GHz and 9 GHz. The peak gain of the proposed antenna versus frequency in the main beam direction is shown in Fig. 6. It has a maximum gain of 5 ± 2 dB within 3-11 GHz.



— E-plane; - - - H-plane
Fig.5. Radiation Patterns of the antenna (a) 5 GHz, (b) 7 GHz, (c) 9 GHz.

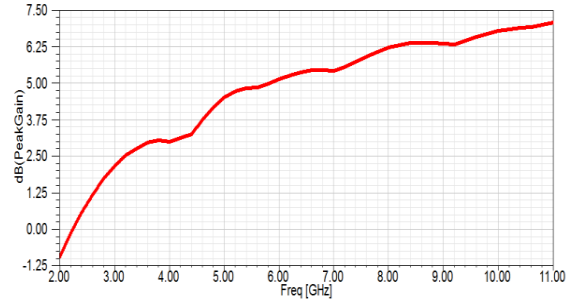
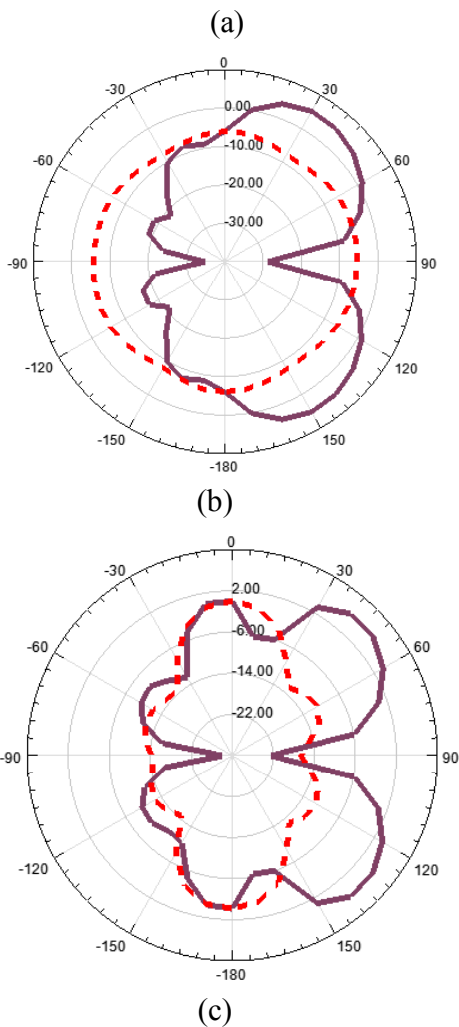


Fig.6. Maximum Gain of the UWB antenna.



I. CONCLUSION

In this paper, we have proposed a UWB wearable slot antenna using fully textile materials. The antenna was fed by microstrip line and CPW line for comparison and was shows that microstrip had better performance. The antenna provides more than 140% bandwidth with compact size and flexible materials. It has a maximum gain of 5 ± 2 dB within 3-11 GHz and better than -13dB return loss over 2-11 GHz.

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