Design of textile antennas for smart clothing

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Abstract— **In recent years, the emergence of wearable intelligent textile systems exhibited the need for wireless communication tools to provide stand alone suits. Eventually the availability of new electrotextiles enables manufacturing these antennas out of textile material, making them fully integratable in smart clothing.**

This research exploits the potential of textile materials for use in this new antenna technology. The design focuses on antennas for wireless body LANs (Local Area Networks) operating in the 2.45 GHz ISM band. Therefore the electromagnetic behavior of textile materials in this high frequency domain is required. Furthermore the flexibility of textile materials is advanageous for fashion designers but a real challenge for antenna designers! Robust planar textile antennas will be proposed of which field simulations are compared with reflection and transmission measurements of the prototypes.

Keywords—**Wearable textile systems, smart clothing, electrotextiles, textile antenna**

I. INTRODUCTION

A continuous advance in material development together with a constant evolution in electronics enables the integration of technologies into our clothing in order to increase its functionalities. This results in wearable textile systems offering functions such as monitoring of life signs, positioning and activity [2]. In addition, the need for wireless communication tools for this smart clothing results in the concept of wearable antennas. Because preserving the wearing comfort is a crucial issue in the development of smart clothing, interdisciplinary research started into the design of fully integratable textile antennas.

II. DESIGN METHODOLOGY

A. Microstrip patch antenna

A microstrip patch antenna seems most appropriate to be produced out of textile material mainly because of its compact geometry and planar profile. It consists of a metallic radiating patch on top of a dielectric substrate, which is mounted onto a conducting ground plane to protect the body from radiation.

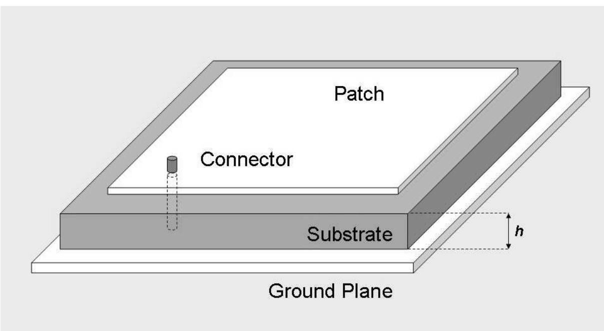

Fig. 1. A microstrip patch antenna

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B. Design criteria

Our goal was to design antennas for short range communications (<100m), known as the Wireless Local Area Network (WLAN). A frequency band allocated for this purpose is the unlicensed 2.45 GHz ISM band [1], covering a bandwidth of 83.5 MHz between 2.4 and 2.4835 GHz. Furthermore, we aimed at a radiation of 90% of the incoming power in this frequency range. This is achieved when the antenna's power reflection coefficient $20 \log \mid S_{11} \mid <$ -10dB.

C. Material selection

Three electrotextiles were selected because of their low surface resistivity to be used for patch and ground plane: *FlecTron*®, *Zelt* and *Shieldit*™. They are very flexible nylon fabrics plated with copper and/or tin. Furthermore the *Shieldit*™ fabric has an adhesive backing allowing us to iron it onto the substrate. As nonconducting substrate material, fleece fabric was chosen. To design an antenna, substrate-related parameters such as thickness h, electrical permittivity ϵ_r, loss tangent $tan\delta$ have to be defined. Apart from the thickness (2.56 mm for the fleece fabric), the values of these parameters are unknown for any given textile material in this high frequency range. Therefore we first designed simple rectangular antennas to deduce the electromagnetic parameters by comparing simulations with measured results.

D. Antenna design

A single feed rectangular ring antenna as shown in Figure 2 was designed [1]. The geometry was deliberately kept simple to facilitate the cutting of the patch out of the electrotextile, hence increasing the accuracy.

III. RESULTS

The rectangular ring antenna was manufactured using an electrotextile both as radiating patch and ground plane. Three different electrotextiles were used: *FlecTron*®, *Zelt* and *Shieldit*™. The electrotextiles *FlecTron*® and *Zelt* were glued onto the substrate, while the patch was additionally stitched to improve the fixing. The adhesive backing of the *Shieldit*™ fabric allowed us to iron the patch onto the substrate. This improved the fixing but likewise changed the electromagnetic properties of the overall substrate. Therefore this antenna had to be redesigned. The length and width of antenna and gap, together with the position of the feeding point of the three antennas are given in the table below. The electrical permittivity and loss tangent of the substrate material, in case the electrotextiles are glued (*FlecTron*® and *Zelt*) and ironed (*Shieldit*™), are given in Table I.

[1] Internationally reserved part of the radio spectrum for noncommercial Industrial, Scientific and Medical purposes

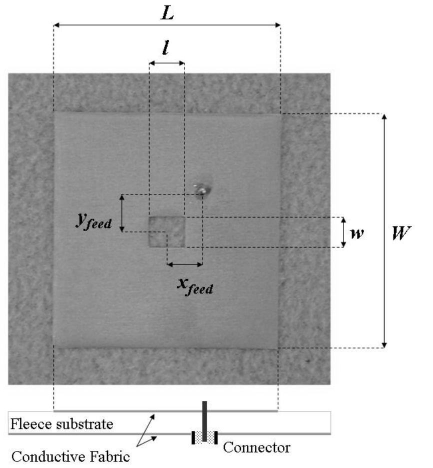

Fig. 2. Single feed rectangular ring antenna in textile material

TABLE I
ANTENNA DIMENSIONS

	W (mm)	L (mm)	w (mm)	l (mm)	x_{feed} (mm)	y_{feed} (mm)
FlecTron®,	52	49	7	8	7	9
Zelt	52	49	7	8	7	9
Shieldit™	53	51	7	8	7	9

The antenna characteristics were measured using an HP 5810 C Vector Network Analyzer. The results of the three antennas indicate good accordance between simulation and measurement. All prototypes exhibit a larger bandwidth than predicted by simulation, indicating the presence of losses. However, all antennas cover the complete 2.45 GHz ISM band.

A second prototype of each antenna was made. These transmitter/receiver antenna pairs were tested in the anechoic chamber to provide additional information about their transmission characteristics in terms of gain and polarization. Figure 5 shows that the antenna gain is similar both when the antennas are in aligned and in rotated (90^o) position in relation to each other, indicating that the antennas are nearly circularly polarized. This means that, when an identical antenna is used as receiver, no alignment between the two antennas is required. For wearable applications this is a desired situation.

IV. CONCLUSIONS

A design methodology was presented for textile antennas. The proposed topology is a rectangular ring antenna, operating in the 2.45 GHz ISM band and with a sufficiently broad bandwidth. These rectangular ring textile antennas, made with off-the-loom electrotextiles *FlecTron*®, *Zelt* and *Shieldit*™ as conductive material and fleece fabric as nonconducting substrate material, all complied with our design criteria for use in WLANs. However, the applied gluing technique has to be considered in the design of the antenna.

TABLE II
SUBSTRATE PARAMETERS

	ϵ_r	tanδ
with glued electrotextile	1.25	0
with ironed electrotextile	1.15	0.004

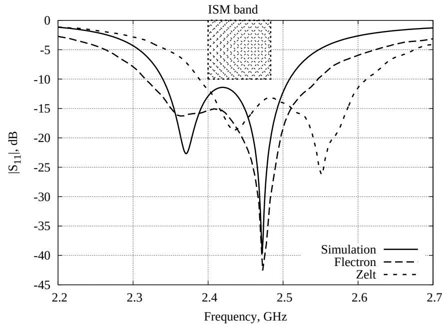

Fig. 3. Simulated and measured characteristic of the *FlecTron*® and *Zelt* antennas

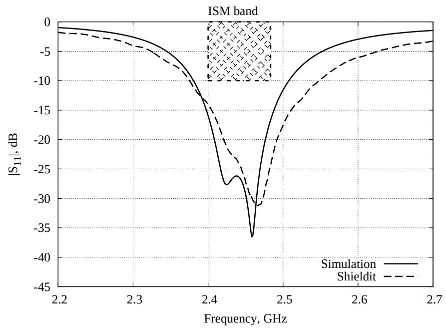

Fig. 4. Simulated and measured characteristic of the *Shieldit*™ antenna

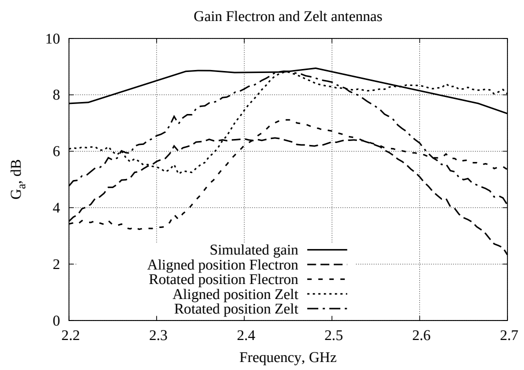

Fig. 5. Gain of *FlecTron*® and *Zelt* antennas

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REFERENCES

[1] A. Tronquo, H. Rogier, C. Hertleer, L. Van Langenhove, *A Robust Planar Textile Antenna for Wireless Body LANs Operating in the 2.45-GHz ISM band*, Electronics Letters 42, 2006.

[2] L. Van Langenhove, C. Hertleer, M. Catrysse, R. Puers, H. Van Egmond, D. Matthys, *Smart Textiles*, Wearable eHealth Systems for Personalised Health Management, IOS Press, 2004.

048

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