Effects of bending on the radiation characteristics of a textile patch antenna

Luigi Vallozzi

Supervisor(s): Prof. Dr. Ir. Hendrik Rogier

Abstract— **The development of wearable intelligent textile systems has altered the concept of apparel, adding new functionalities like monitoring of vital signs and environmental parameters. Patch antennas completely made out of textiles are very suitable to be integrated in such systems, providing short range wireless communication between the system and a base station.**

Several prototypes of textile patch antenna have been already proposed in literature [1], [2]. The considered antenna exhibits sufficient gain and bandwidth to provide a reliable communication link in the 2.45 GHz ISM band. However, when integrated into garments, a textile antenna is subjected to bending, which affects the radiation characteristics such as gain and return loss. Investigations on the effects of bending on the radiation characteristics of a textile antenna were performed by means of measurements and simulations, conducted on a previously realized prototype. The results showed a minimal influence of the bending on the radiation characteristics, proving the robustness of the antenna on these effects.

I. Research context

Wearable textile systems are nowadays becoming a growing field of research. They extend the classical concept of garments, which are meant to protect our body from environmental influences, adding new functionalities without alteration of wearability and comfort. A wearable textile system represents a wearable interface which permits monitoring of the operator life signs and activity, as well as environmental parameters (e.g. temperature, position). This research focuses on the communication unit, and in particular the radiating device which was realized by a textile antenna. In particular we considered a previously proposed textile patch antenna [1] and we performed on it some investigations on the effects of the bending, by means of simulations and measurements.

II. Textile antenna

A. Description

The antenna which we considered for the investigations is a previously realized prototype of textile patch antenna [1], designed to operate in the 2.45 GHz ISM band and fully integrable into garments, such as firemen or other rescue workers suits. This prototype is a microstrip patch antenna made entirely out of textile materials, such as *Flectron* and *Zelt* for the patch and *Fleece* fabric for the substrate.

The topology of the prototype is the rectangular or quasi-square patch ring antenna, as depicted in Fig. 1. This is a well known configuration [3] which permits the excitation of two linearly polarized modes, each one associated with one of the two dimensions of the patch (L and W) and orthogonal in the space. The slight difference in length between the two sides results in a small shift between the two resonance frequencies of the two modes, thereby enlarging the -10 dB bandwidth. Moreover, by adjusting the length of the two sides it was possible to obtain a 90 degrees phase shift between the two modes, which results in a nearly circular polarization of the transmitted wave, around he frequency $f = 2.45$ GHz. The design was performed by means of the 2.5D EM simulator ADS Momentum®, by which an optimization of the antenna parameters was done. The optimization parameters, together with their final values are shown in Table I. The considered prototypes have a -10 dB bandwidth larger than the ISM band (about 164 MHz in the simulation), as shown in Fig. 2, which can account for possible frequency shifts due to dimensions tolerances in the manufacturing process, inaccuracies in the measured substrate parameters and bending of the antenna occurring in real on-body applications. In addition, the gain pattern was measured at $f = 2.45$ GHz, on the main planes

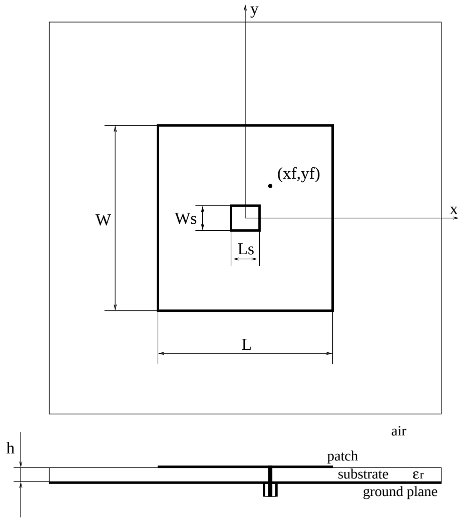

Fig. 1. Antenna topology

TABLE I
ANTENNA PARAMETERS

Optimized Parameters	Patch length $L = 49$ mm
	Patch Width $W = 52$ mm
	Slot Length $L_s = 8$ mm
	Slot Width $W_s = 7$ mm
	Feed Point $(x_f, y_f) = (7, 9)$ mm
Fixed Parameters	Substrate Height $h = 2.56$ mm
	Substrate Permittivity $\epsilon_r = 1.25$
	Patch materials: Flectron® or Zelt®
	Substrate material: Fleece fabric

L. Vallozzi is with the Information Technology Department, Ghent University, St. Pietersnieuwstraat 41, Ghent, Belgium. E-mail: Luigi.Vallozzi@UGent.be, Tel.: ++32/(0)92649530

of the antenna (i.e. xz and yz plane). The resulting patterns, in Fig. 3, show a maximum gain of about 7.5 dB in the broadside direction, which is sufficient for a reliable wireless communication link.

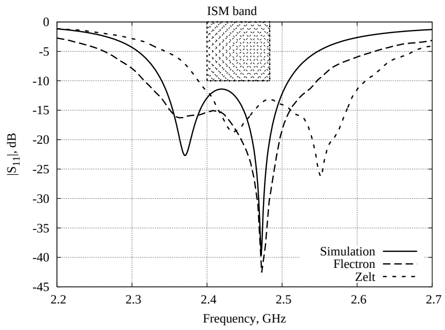

Fig. 2. Simulated and measured return loss

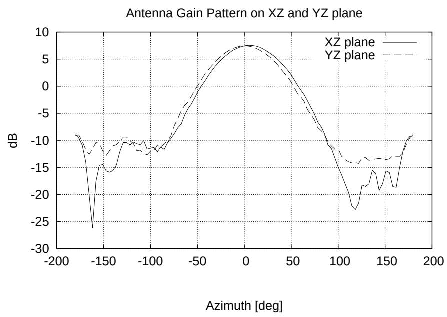

Fig. 3. Measured Gain Patterns

III. Effects of bending

In a realistic on-body application, the antenna is supposed to be integrated into a suit, then it will be subject to bending. For this reason we investigated the effects of the bending on the return loss and gain pattern, by means of measurements and simulations. In the measurements, we simulated the bending which occurs in real working application attaching the antenna to the surface of plastic cylinders with diameters $D = 12$ cm ($\simeq$ leg diameter) and $D = 7.5$ cm ($\simeq$ arm diameter), as shown in Fig.4.

First we measured the return loss when the antenna was subjected to bending with $D = 12$ cm and $D = 7.5$ cm. The result of these measurements, in Fig.5, show that the bending partially suppresses one resonance mode, but the ISM band remains still covered.

Then we measured the gain pattern in different situations: planar state, with bending of $D = 12$ cm and $D = 7.5$ cm, around the Y and X axis of the patch. Comparing the curves obtained by these measurements, we could have an idea of the qualitative behavior of the gain pattern as a function of the bending. In Fig. 6 it is clearly shown that an increase of the bending (i.e. decrease of D) produces a decrease of the maximum gain, in the broadside direction, and an enlargement of the -3 dB main lobe angular width; this means that the antenna becomes less directive, making it capable to detect a broader angular range of direction of arrivals. Moreover, one can notice that the maximum gain still has a sufficient value, of about 5 dB , even with the most severe bending of $D = 7.5$ cm.

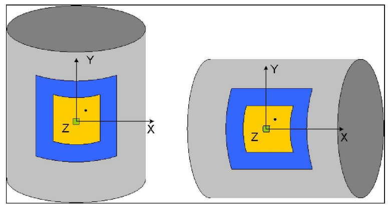

Fig. 4. Bending of the antenna around X and Y axis

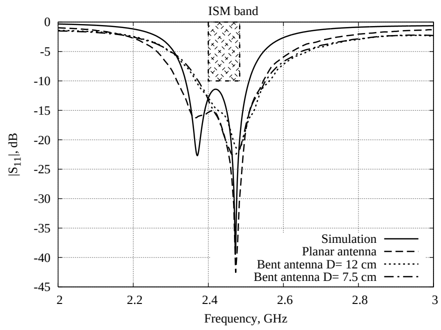

Fig. 5. Simulated and measured return loss of the bent antenna

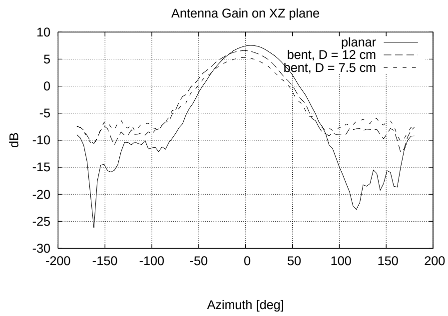

Fig. 6. Gain patterns of the bent antenna

IV. Conclusions

The effects of bending on a textile patch antenna were investigated. The considered prototype already showed good performances in the planar state. The measurements and simulations performed on the realized prototype showed that the bending produces a partial suppression of one of the two modes of the antenna, a decrease of the gain and an enlargement of the main lobe width. However, the rectangular ring topology, adopted for the considered prototype, still fulfils the design criteria on return loss, bandwidth and gain, under bending, with $D = 12$ and $D = 7.5$ cm, around the main axes of the patch.

References

[1] A. Tronquo, H. Rogier, C. Hertleer, and L. Van Langenhove, "Robust planar textile antenna for wireless body LANs operating in 2.45 GHz ISM band," Electronic Letters, vol. 42, no. 3, 2006.

[2] C. Hertleer, A. Tronquo, H. Rogier, L. Vallozzi, and L. Van Langenhove, "Aperture coupled patch antenna for integration into wearable textile systems," IEEE antennas and wireless propagation letters, vol. 6, pp. 392–395, 2007.

[3] C. A. Balanis, *Antenna Theory: Analysis and Design*. New York: Harper and Row, 1982.

Effects of bending on the radiation characteristics of a textile patch antenna

Luigi Vallozzi
Supervisor(s): Hendrik Rogier

The development of wearable intelligent textile systems has altered the concept of apparel, adding new functionalities like monitoring of vital signs and environmental parameters. A patch antenna completely made out of textiles is very suitable to be integrated in such systems, providing short range wireless communication between the system and a base station. A textile patch antenna was designed in order to provide a sufficiently large bandwidth for wireless communications in the ISM band. By carefully choosing the topology and the textile materials, a low-losses, light-weight and flexible antenna was obtained. The prototype exhibits a sufficient gain and bandwidth to provide a reliable communication link. However, when integrated into garments, the antenna characteristics can be influenced by the presence of the body and the bending. Our investigations on these effects showed a minimal influence on the radiation characteristics.This research contributes to the upcoming generation of apparel.

8ste FirW Doctoraatssymposium

start
doelstelling
organisatie
programma
richtlijnen voor auteurs
belangrijke data
posterprijs
locatie
registratie
bestanden indienen
archief
contact
links

EN NL

5 december 2007 :: Het Pand :: Gent :: België