Effect of Textile Properties on a Low-Profile Wearable Loop Antenna for Healthcare Applications

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ABSTRACT

In this paper, numerical and experimental studies on performance evaluation of low-profile wearable loop antenna for healthcare monitoring applications are conducted. Parametric studies on the effect of textile cotton fabric properties, considering the electrical permittivity and substrate thickness, as well as bending effects are investigated in order to evaluate the trend on loop antenna's resonance behavior. Experimental validation is also carried out and comparison is made. Good agreement between modeled wearable loop antenna and the fabricated one was obtained, with almost 3% shift in resonance frequency, due to the estimated textile properties within the simulation model. The effect of implanting the wearable antenna on close-proximity to a modeled arm phantom is also numerically studied and assessed.

MOTIVATION

The main aims of this research work are:

- ***to deeply investigate the effect of textile properties on performance of wearable loop antenna***
- ***to enhance impedance bandwidth of wearable loop antenna when in close-proximity to metallic reflectors".***

WEARABLE LOOP ANTENNA DESIGN AND FABRICATION

- For convenience, a rectangular loop antenna is designed to operate within the 2.45 GHz-ISM band.
- In this study, four textile loop antennas are modeled and fabricated with various widths, as shown in Fig. 1.

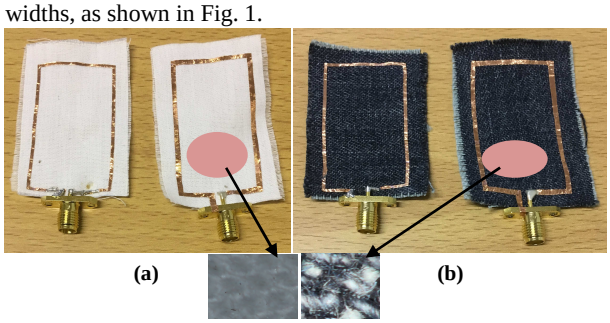


Fig. 1. Fabricated wearable loop antenna on various textile fabrics: (a) in cotton with widths of 1*mm* and 2*mm* (left-to-right); and (b) in Jeans with widths of 1*mm* and 2 *mm* (left-to-right). Insets provide close-up microscopic images of fabrics.

RESULTS

- Effects of several textile parameters on the performance of the wearable loop antenna are investigated:

A) Textile fabric type and loop metallic width

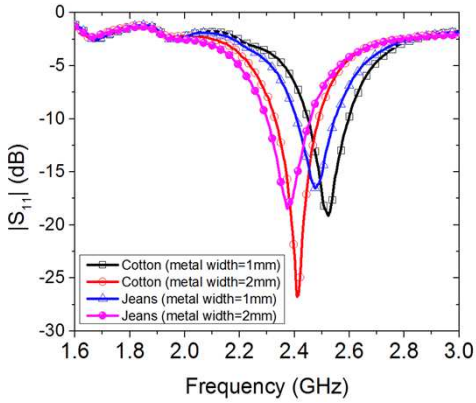
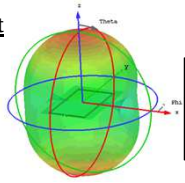


Fig. 2. Measured reflection coefficient of the wearable loop antenna with two different fabrics: Cotton and Jeans, with metallic loop made using conductive copper tape (two versions per textile, copper widths of 1*mm* and 2*mm*.)

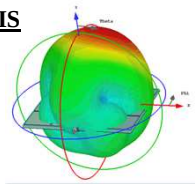
FAR-FIELD RESULTS

Loop without HIS



An increase in Gain by 2 dB when using HIS.

Loop with HIS



RESULTS (Cont'd)

B) Textile fabric electrical properties considering permittivity, losses, and thickness variation

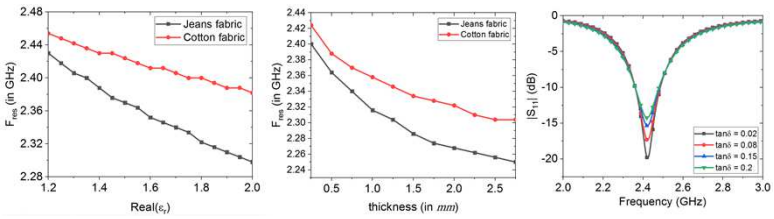
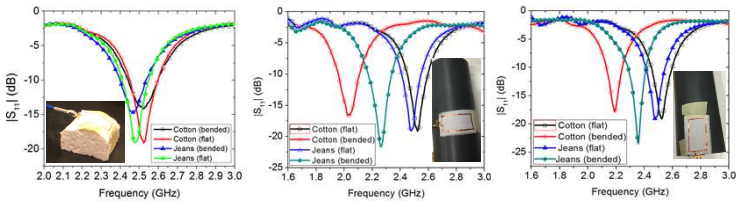


Fig. 3. Numerical parametric study of textile electrical parameters on wearable loop antenna resonance.

C) Bending effects



(a) **(b)** **(c)**

Fig. 4. Measured reflection coefficient for the cotton-based textile loop antenna when in bending conditions: **(a)** on foam, **(b)** E-plane bending on solid PVC cylinder, and **(c)** H-plane bending on solid PVC cylinder.

D) Impedance bandwidth enhancement using planar high-impedance surface (HIS) structure

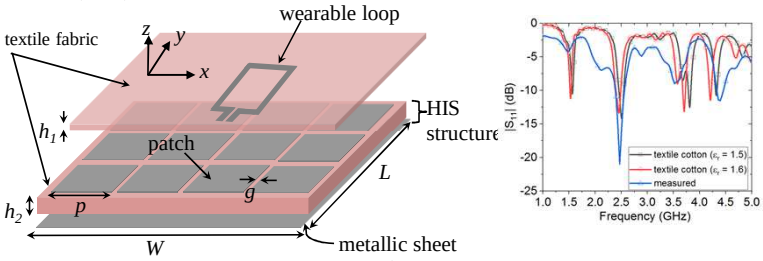


Fig. 5. Impedance bandwidth enhancement of grounded wearable loop antenna results.

E) Biological effects

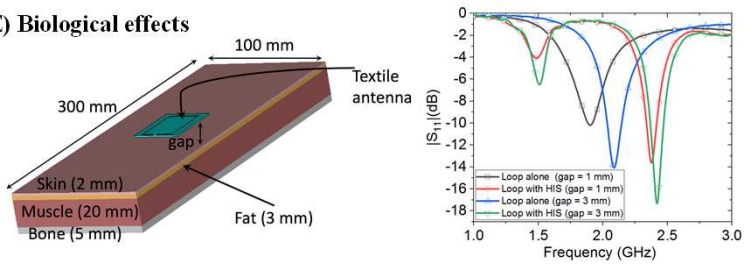


Fig. 6. Numerical results showing effect of placing the wearable loop antenna with and without HIS surface in close-proximity to a modeled human arm.

CONCLUSION

- Effects of textile parameters on performance of wearable loop antenna are numerically and experimentally studied.
- Impedance bandwidth enhancement of grounded wearable loop antenna is also investigated, where good performance is achieved using planar high-impedance surface structure.