UWB Antennas on Conductive Textiles

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***Abstract*—Textile antennas fabricated using conductive E-threads are highly attractive for applications requiring conformality, flexibility, and robustness. However, most E-thread antennas reported to date operate at frequencies < 3 GHz. This is because of losses at higher frequencies, typically associated with surface roughness and imperfect metallization. In this work, we study the performance of ultra wideband (UWB) textile antennas at much higher frequencies. Specifically, we fabricated and studied the performance of: a) a textile spiral antenna operating at 1–6 GHz, and b) a textile patch antenna operating at 3–11 GHz. As expected, losses increase with frequency. However, results show that the textile antennas can still operate up to 11 GHz. In this case, the achieved realized gain is about 5 dB lower than simulations based on perfect electric conducting (PEC) surfaces.**

Keywords—conductive textiles, E-threads, embroidered antennas, flexible antennas, UWB textile antennas.

I. Introduction

Textile antennas are becoming attractive for several applications, including airborne, wearables, RFIDs, medical sensors, etc. [1]-[3]. Recently, we introduced a new class of textile antennas based on automated embroidery of conductive E-threads [4]-[6]. The proposed textiles are highly flexible, conformal, lightweight, and robust. Importantly, they achieve embroidery accuracy as high as 0.1mm, viz. similar to typical Printed Circuit Board (PCB) fabrication processes [6].

However, most E-thread antennas, reported to date, operate at frequencies < 3 GHz [5], [7], [8]. This is due to increased losses at higher frequencies, typically associated with surface roughness and imperfect metallization. In this work, we study the performance of UWB textile antennas at frequencies up to 11 GHz. Specifically, we present two antennas as follows: a) a textile spiral antenna operating at 1–6 GHz, and b) a textile patch antenna operating at 3–11 GHz. Measured realized gain data are presented, and are compared with simulations that assume perfect electric conducting (PEC) surfaces.

II. Textile Antennas

Two UWB textile antennas are fabricated and tested. The first is an Archimedean spiral antenna operating at 1–6 GHz (see Fig. 1(a)) [6]. It has a diameter of 160 mm and was "printed" on an organza fabric. The second is a 75 mm × 85 mm patch antenna that operates at 3–11GHz (see Fig. 1(b)).

(a) (b)

Fig. 1. UWB textile antennas: a) spiral antenna operating at 1-6GHz, and b) patch antenna operating at 3-11GHz.

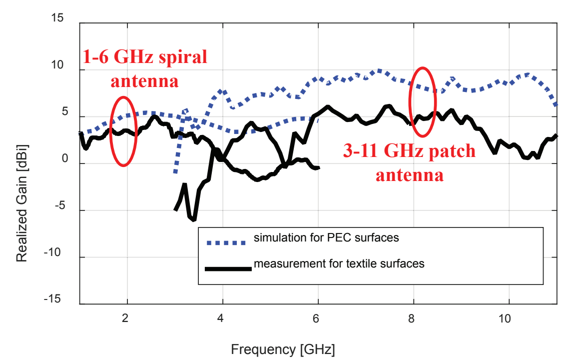

Fig. 2. Simulated vs. measured realized gain of UWB spiral and patch textile antennas.

The patch and ground planes are both "printed" using conductive textiles, and placed on a flexible polydimethylsiloxane (PDMS) substrate ($\varepsilon_r = 3$, $\tan\delta = 0.004$).

The textile surfaces were realized using Elektrisola E-threads, 0.12 mm in diameter [9]. These composite E-threads consisted of 7 twisted silver-plated copper filaments. As demonstrated in [6], they exhibit excellent mechanical strength and flexibility, low DC resistance of 1.9 Ω/m, and allow for geometrical precision down to 0.1 mm. For fabrication, an automated embroidery process was employed using a programmable embroidery machine, as described in [4].

III. RF Performance

The antennas' simulated vs. measured boresight realized gains are given in Fig. 2. As would be expected, measurements agree very well with simulations for frequencies up to around 3 GHz. At higher frequencies, the textile prototypes exhibit lower realized gain as compared to simulations. This was expected and can be attributed to losses from roughness and imperfect metallization of the textile surface. Overall, results show that the textile antennas can still operate up to 11 GHz. However, the realized gain is expected to be about 5 dB lower than simulations based on PEC surfaces.

IV. Conclusion

Textile antennas fabricated using an automated embroidery process were already demonstrated in the past. However, antennas fabricated using this technology are typically limited to operation frequencies < 3 GHz. This is because of losses associated with the textile surfaces at higher frequencies. In this work, we took a step forward and fabricated textile antennas that operated at frequencies up to 11 GHz. Results show that textile antennas can still operate beyond 3 GHz. However, realized gain is expected to be about 5 dB lower as compared to their PEC counterparts.

At the conference, we will show further results assessing the performance of the embroidered antennas at frequencies beyond 3 GHz.

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