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Wrist-Worn RFID Antenna Printed on Additive Manufactured Flexible Substrate

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***Abstract*— We assess the feasibility of fabricating a flexible RFID wrist-worn antenna printed on a substrate manufactured using 3D-printing technology, as to enable full customization of the bracelet at low cost. Numerical results show adequate power transmission to the RFID chip. Also, the fabricated prototype shows enough flexibility to be bent around the wrist.**

***Keywords*— 3D-printing, additive manufacturing technique, antenna design, bracelet, on-body antenna, Radio Frequency Identification (RFID), wearable antenna.**

I. INTRODUCTION

Additive manufacturing techniques (AMTs), in particular 3D-printing, are booming and revolutionizing the fabrication of prototypes, as well as enabling new technologic concepts at very low cost [1]. Antenna engineering is one of the fields where the role of AMTs is most evident. Examples include various microwave components [2], horn antennas [3], and dielectric lenses [4], among other. The applications range from space communications [5], 5G backhaul [4], to wireless body area networks [7], [8], for example. The latter, in particular, is an active research field which aims at deploying pervasive communication networks in the vicinity of the body [9]-[14].

In this paper, we design a bracelet antenna to operate at ultra-high frequencies radio-frequency identification (UHF-RFID) band. The antenna is designed as to minimize the influence of the body on the antenna performance, thus maximizing the achievable range. The antenna substrate is fabricated by 3D-printing technology using a flexible material known as TPU by Ultimaker [15]. This device is intended for the identification and localization of people in indoor environments, while allowing customization of the substrate material at a low cost.

II. NUMERICAL SETUP

The proposed antenna was designed to be worn around the wrist like a bracelet. Such devices suffer strong influence from the body, which may decrease significantly the efficiency. As a result, the design described next includes a ground plane, as to prevent the energy to be absorbed by the body and maximize the power radiated perpendicularly to the body.

The antenna consists of two patches and a loop, similar to the design in [14]. We have added a meander as to achieve compact design. The antenna was optimized using Computer Simulation Technology (CST) [16]. The numerical setup included a dielectric cylinder with diameter of 70 mm a complex permittivity of 41.5 – j17.2 at 900 MHz to represent the body. The antenna was bent around the dielectric cylinder, similar to the envisioned application – Fig. 1 (a).

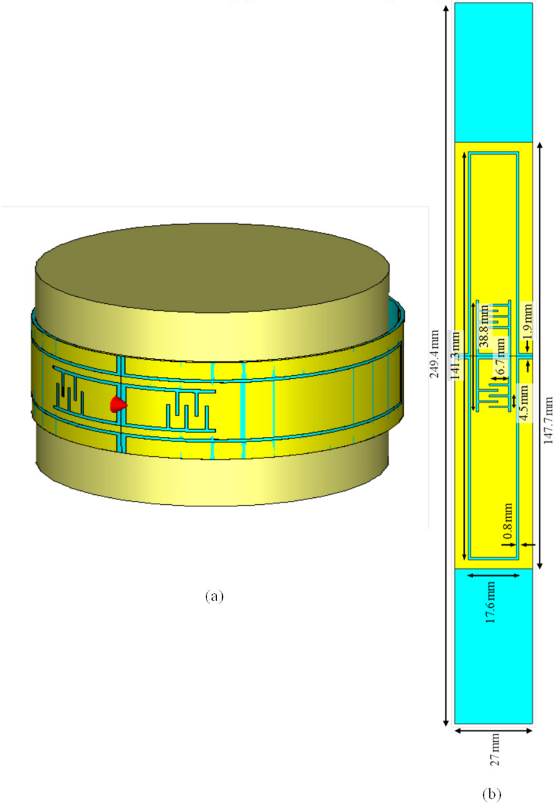


Fig. 1: (a) Numerical setup with the antenna bent around the dielectric cylinder that mimics the body (b) geometry and dimensions of the proposed antenna.

III. ANTENNA DESIGN AND OPTIMIZATION

Based on the setup described in the previous section, we tuned the antenna parameter values, as to maximize the power transmission coefficient to the RFID chip. The latter has an impedance of 28 – j204 Ω at 900 MHz (ALIEN Higgs-3 IC [17]), as illustrated in Fig. 2. In the same figure, we plotted the simulated impedance of the final version of the antenna, which corresponds to the conjugate of the impedance of the RFID chip. The dimensions of the optimized design are presented in Fig. 1 (b), which corresponds to a transmission coefficient of 99% at 885 MHz, well within the RFID band.

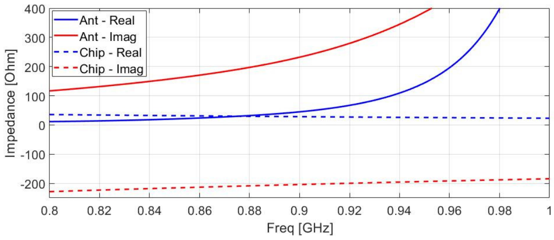
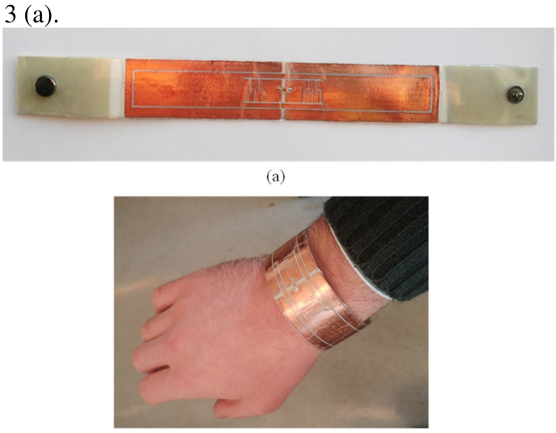


Fig. 2: Impedance of antenna and RFID chip.

The bracelet antenna was fabricated using a 3D-printed substrate known as TPU [15]. To this end, we glued a copper tape, as to print the circuit using photolithography. On the opposite face of the substrate, we have similarly glued a ground plane. A photograph of the prototype is illustrated in Fig. 3 (a).


(a)

(b)

Fig. 3: Fabricated prototype of the RFID bracelet antenna (a) planar structure and (b) bent around the wrist.

Initial tests reveal enough flexibility to withstand bending around the wrist, as shown in Fig. 3 (b). Experimental results will be shown at the conference. We assessed the sensitivity of the antenna and power transmission coefficient to manufacturing imprecisions (e.g. dimensions of 3D-printed substrate). This is an important requirement, as to ensure the feasibility of the intended additive-manufacturing process.

IV. CONCLUSION

Additive manufacturing technologies enable the fabrication of low cost devices and are playing a key role in fast prototyping. Here, we combine conventional photolithography technique used in the fabrication of printed circuits and 3D-printing, for the manufacturing of a flexible bracelet RFID antenna. The antenna includes a ground plane, in an attempt to minimize the influence of the body on the antenna performance. Moreover, the numerical results show adequate impedance matching and good transmission coefficient to the RFID chip. Also, the fabricated prototype is sufficiently flexible as to withstand bending around the wrist. Lastly, we have included two snap buttons to the prototype, in order to be easily worn on and off.

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