Effect of Conductive Area Trimming on the Read Range of Inkjet Printed Epidermal RFID Tags

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***Abstract*— The effect of reducing the volume of conductive ink used in the fabrication of Epidermal RFID tags on the read range of the tag is investigated in this paper. The ink usage reduction is achieved by trimming the conductive parts of the designed tag.**

***Index Terms*—epidermal antenna, Inkjet printing, RFID Tag.**

I. INTRODUCTION

This work presents an RFID tag which is in the form of a tattoo. The transfer tattoo paper in [1] was used to fabricate this skin mounted (Epidermal) RFID tag. The pattern of the RFID antenna was printed on the tattoo paper using an Inkjet printer [2]. The pattern was then transferred onto the skin using a thin adhesive film Fig. 1.

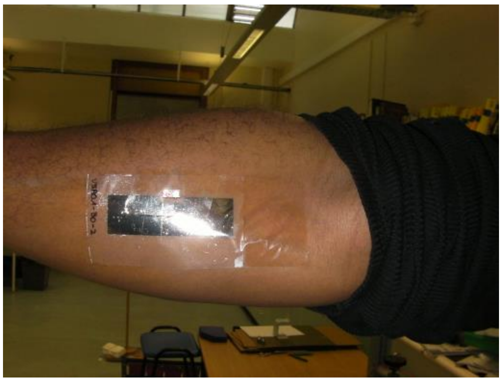


Fig. 1. Inkjet printed Tattoo paper

Epidermal RFID tags can be used for temporary tracking and identification of personnel in places and scenarios where cheap and disposable RDIF tags are desired for safety and security purposes. These tags can find some use where they can replace the conventional physical forms of RFID tags.

Owing to the additive nature of inject printing, the process has less fabrication stages compared to the subtractive and multi-stage conventional etching. Due to this, inkjet printing has the potential to provide a cheaper means of tag fabrication, especially for small scale or bespoke production. There is however need to be conservative with the volume of conductive ink used in order to fully utilize the cheap option inkjet printing provides. Work has been done to demonstrate the reduction of ink volume by varying the number of deposited conductive ink layers on an antenna design and also by deposition of ink on specific areas of the tag as seen in [3] In this work, the obtainable read range from an epidermal RFID tag that had its area trimmed in order to reduce the volume of conductive ink used for its fabrication is examined.

II. INKJET PRINTING

Various authors have reported on the Inkjet Printing fabrication of RFID tags and Antennas. These tags may have different applications beyond simple asset tracking [4]. There has also been work on the inkjet printing of tags on porous materials (paper, cardboard, leather and wood), [5] - [11].

For this work, the objective is to fabricate skin mounted RFID tags with the minimum conductive ink volume. This is to be done while maintaining read range. The conductive ink used in this work is Sigma-Aldrich, SunTronic U5603 from Sun Chemicals [12]. The ink was deposited with 20µm dot spacing. To ensure maximum obtainable conductivity, each tag was made with three layers of conductive ink. This implies that after the completion of print, the deposited conductive ink was allowed to dry then another layer was printed above it. The cycle was repeated twice. Each tag was thermally sintered for 30 minutes at 135 °C. Ink layer thickness varies according to formulation, substrate and surface preparation.

III. TAG DESIGN

The schematic of the initial RFID design used in this work is shown in Fig 2.

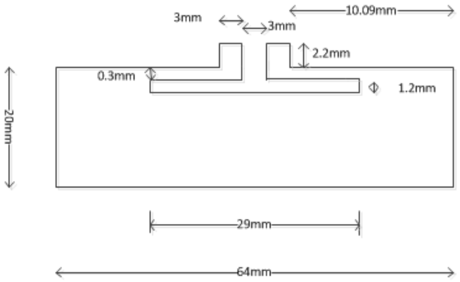


Fig. 2. Schematic of Epidermal RFID tag

The tag shown in the schematic was simulated on a phantom using CST [illegible] phantom was designed in such a way that it represents the layers of the human body namely: the skin, fat, muscle and bone Fig 3.

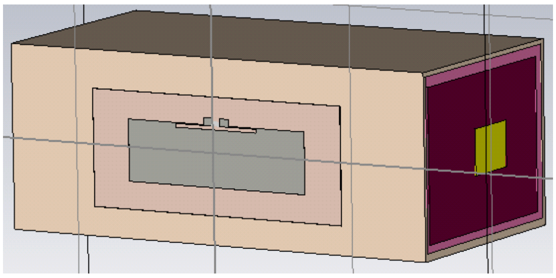


Fig. 3. Layered Phantom

An NXP transponder chip (input impedance 15 – j128 Ω) was attached to the tag. The Same chip was used for the inkjet printed tags. The tag was designed to simulate at the EU UHF RFID frequency range of 865 – 868MHz Fig. 4.

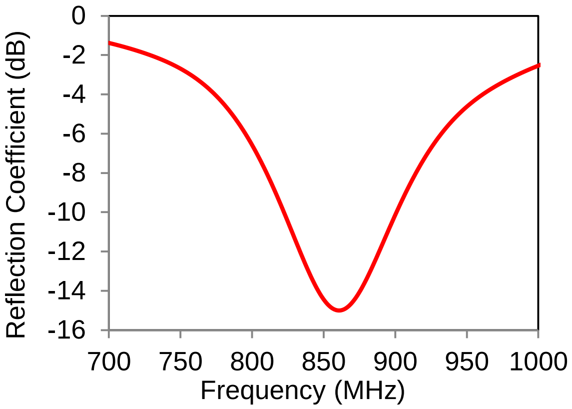


Fig. 4. Simulated tag reflection coefficient

For this tag design, simulation has shown that the highest current density for this tag design is located around the slot region and on the feedline. This is shown in Fig 4. Going by this indication, parts of the tag with lower current density can be trimmed off reducing the surface area of the tag hence resulting in lower volume of conductive ink used.

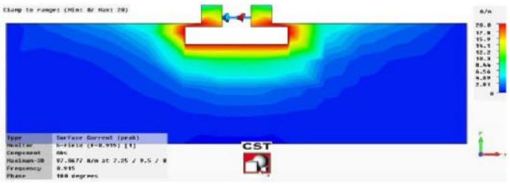
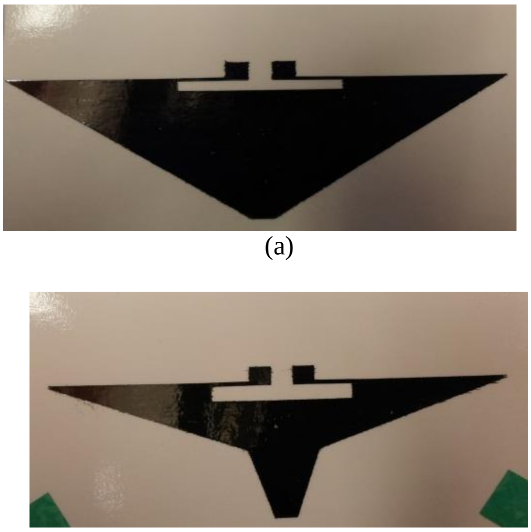


Fig. 4. Simulated surface current distributed

Two different trimmed designs were obtained from this tag. The first is a design with 48% of its surface area trimmed off and the other tag has 65% of its surface area trimmed off Fig. 5.



(a)

(b)

Fig. 5. (a) 48% reduction in surface area. (b) 65% reduction in surface area

IV. MEASUREMENT SETUP

The measurement equipment used for this experiment was the Voyantic Tagformance lite Kit [14]. The measurements were taken in a lab environment. The equipment was calibrated at a distance of 45cm following manufacturer's specification. Up to 2 meters gap was given between the equipment and lab furniture in order to prevent interference and reflections.

To provide benchmark comparison, the tag design in Fig 2. was fabricated from a copper clad Mylar sheet measuring 0.066mm. Both the inkjet printed tags in Fig. 3a and 3b and the copper tag of Fig. 2 were placed on the arm. The copper tag was held in place on the skin with the aid of a double sided tape. In the case of the inkjet printed tag, because of the nature of the transfer tattoo paper on which it was printed, it was able to be transferred and attached to the skin using a thin adhesive film. Both printed tags were measured at 30 minutes intervals. To assess whether the tags were affected by inkjet fabrication or simply patch shape, copper versions of the 2 tags shown in Fig. 3(a) and (b) were also fabricated and tested.

V. RESULTS

From the graphs in Fig. 4, it is observed that both inkjet printed tags have reduced read range, however this is not severely diminished and so a reader can still send and receive signals from the tags. The graphs also show that some of the loss in read range is because of the modification made on the tag design as seen from the etched samples of the tags. Additionally, it can be observed that the tags maintained functionality three hours after the commencement of the measurements. Further experiments prove that these Epidermal tags continued to function for up to 8 hours.

http://www.fujifilmusa.com/press/news/display_news?newsID=880140. [Accessed: 14-Oct-2014].

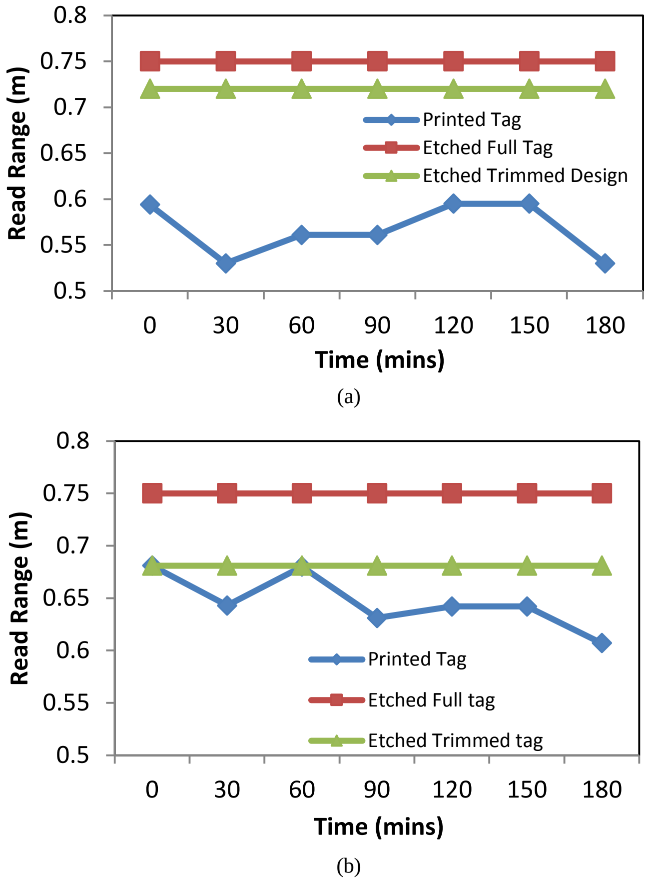


Fig. 4. (a) Read Range of tag with 48% reduction in surface area Read (b) Read Range of tag with 48% reduction in surface area Designs

VI. CONCLUSION

This work has proved that it is possible to reduce the volume of conductive ink used for the fabrication of inkjet printed epidermal RFID tags without severely compromising the obtainable read range of the tag. Further work would be to establish the influence of increase dot spacing of deposited ink on the tags.

VII. ACKNOWLEDGEMENT

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