Conductive Ink Usage Optimization Using Grid Designs for Inkjet Printed Epidermal RFID Tags

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Abstract — Techniques to reduce the amount of conductive inks used for the inkjet printing of body mounted RFID tattoo tags are presented in this work. Different grid thicknesses and separation distances are investigated. The performances of the different tags are evaluated based on measured read range.

Keywords — epidermal antenna, Tattoo, RFID tag.

I. INTRODUCTION

RFID tags have long been used for asset and personnel tracking, in retail stores, warehouses and for access control in secure buildings [1]. It has also found use in hospitals where it can be used to enhance patient safety and improve the efficiency of the medical personnel [2].

When RFID are used on humans, they are usually in the form of ID badges and wristbands. While this set up may be sufficient for tracking, it may not be suitable for access control in high security environments because these badges and wristbands could easily be transferred from one person to another. An alternative could be skin embedded RFID capsules but this is invasive and will not be suitable in cases where the use is temporary. Because of this there is a need for temporary, skin mounted RFID tags that cannot easily be transferred from one person to another without its functionality being lost [3].

Inkjet printing of RFID tags represents a viable alternative to conventional etching. This is because of the advantages it provides some of which includes flexibility during fabrication which enables conductive ink to be deposited on parts of the structure being fabricated as needed. For instance more ink could be deposited on parts of the tag where there is higher current density. There is also the case for less wastage of fabrication materials due to inkjet printing being an additive process as opposed to etching where the unneeded copper parts are removed. However, if the amount of conductive ink used for the fabrication of a structure is not minimized, the cost of the conductive ink could cancel out these benefits [4], [5]. This work demonstrates the reduction of ink usage for inkjet printed RFID tags using gridded designs.

The practice of using gridded antennas has been reported in various literature where it can be used for the concept of antenna transparency [6]–[8]. However the use of these antennas directly mounted on skin is not widely reported. This idea would be used in this work to exploit the possibility of reducing the volume of conductive ink used for the fabrication of inkjet printed epidermal RFID tags. The Epidermal RFID Tag presented in this work was fabricated using a Mylar sheet of 0.043mm thickness with a 0.023mm thick copper layer. It is used to show proof of concept and the actual inkjet printing of the epidermal tags is ongoing.

II. GRIDDED ON-BODY RFID TAGS

The tag design used for this work is the design used in a previous work [3]. This is a slot based design with the highest current density around the slot as shown in Fig. 1. This concentration of current around the slot is also seen in the gridded designs as shown in Fig. 2. The dimensions are shown in Fig. 3. The tags were designed to operate at the EU UHF RFID band (865-868MHz) but also have a 10dB point bandwidth wide enough to operate at the lower frequencies of the US UHF RFID band which goes from 902-928MHz. The ASIC used for the RFID tag is an NXP transponder chip (input impedance 15 – j128 $\Omega$) [9].

![Fig 1. Surface current distribution on tag](image)

![Fig 2. Surface current distribution on gridded tag](image)
The effect of the skin on the tag was simulated using a phantom block to represent the human arm. The electrical properties of the human body used are as obtained in [10]. The on body tag simulation was done with CST microwave studio.

For this study, different grid designs were tested. With these the grid spacing and width were varied in order to obtain the optimum results. Initially grids with only vertical lines were tested. These tags had a grid thickness of 0.5mm and were separated by 5mm and 2 mm. In a bid to improve the current distribution on the tag and hence performance, a single horizontal line was introduced and this was increased to three for evaluation purposes. Fig. 4 shows the grid designs considered in this work.

III. PERFORMANCE ANALYSIS

The performance of the tags was measured using Voyant’s Tagformance lite RFID calibrated measurement system [11]. The measurement was made with the tag on the arm. The obtained read ranges at the EU and US UHF RFID bands are show in Fig. 5.

The peak read range in the EU UHF RFID band was 1.5m at 865MHz. There is a general decrease in read range for the gridded designs as can be seen from the graph. However, it is observed that as the gridded lines became closer the read range reduces. A further decrease in read range is brought about by the introduction of horizontal grids. This could be linked to the detuning of the match between the tag and the ASIC as a result of an increase in capacitance.

In addition to the observed reduction in read range, there was also a downward shift in frequency. This is due to the longer current path introduced to this tag by the grid as opposed to that obtainable with a full tag.
IV. SUMMARY

This work demonstrates the possibility of conductive ink volume reduction in the fabrication of epidermal RFID tags. Etched copper tag tests indicate that there was some reduction in read range when compared with a full tag. However, this reduction does not diminish the usability of this tag. The observed reduction in operating frequency can be compensated for by retuning the tag to the right frequency after the introduction of the grids.

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REFERENCES


