UHF Printed Sensor for Force Detection

Almudena Rivadeneyra
Pervasive Electronics Advanced Research Laboratory (PEARL)
Department of Electronics and Computer Technology
University of Granada, 18071
Granada, Spain
email:arivadeneyra@ugr.es

Andreas Albrecht
Institute for Nanoelectronics
Technical University of Munich, 80333
Munich, Spain
email:andreas.albrecht@tum.de

Paolo Lugli
Faculty of Science
Free University of Bozen-Bolzano, 39100
Bozen-Bolzano, Italy
email: paolo.lugli@unibz.it

Markus Becherer
Institute for Nanoelectronics
Technical University of Munich, 80333
Munich, Spain
email: markus.becherer@tum.de

José F. Salmerón
Pervasive Electronics Advanced Research Laboratory (PEARL)
Department of Electronics and Computer Technology
University of Granada, 18071
Granada, Spain
email: jfsalmeron@ugr.es

***Abstract*— In this contribution, we show the advances in the direction of designing Radiofrequency Identification (RFID) antennas with sensing capabilities. In this particular case, we have integrated a force/pressure sensor made of a silicon-based organic polymer in one of the arms of a dipole antenna made of silver paste. The sensor response to external forces modifies the resonance frequency of the dipole antenna that can be detected by an external RFID reader, building up a wireless force sensor system.**

Keywords*— *flexible; force sensor; pressure; printed electronics; Ultra-High Frequency band.

I. INTRODUCTION

In this paper, we focus on the Ultra-High Frequency (UHF) band (860 MHz) that is commonly used for Radiofrequency Identification (RFID) tags and communications. In particular, lots of effort has been made in the past decades to develop antennas operating in this frequency band with the so-called printed electronics [1]-[3]. The reasons behind this are the attractive features that such technology offers with respect to conventional ones, like the feasibility of creating electronics in virtually any substrate, its cost-effectiveness and large-scale manufacturing, among others [4]. There are many examples in the literature where printed UHF antennas are embedded in RFID tags with sensing capabilities [5]-[7]. However, these tags require the utilization of silicon chips to transmit the information, leading to hybrid electronics, which slows the fabrication process and makes more difficult their industrialisation [8]. An alternative that has arisen interest in the last years is the implementation of wireless chipless sensors. The characteristic of these sensor tags is the design of sensors whose information is associated with their electromagnetic properties, such as the resonance frequency or the threshold power magnitude [9].

What we describe in this paper is precisely an UHF chipless sensor for pressure detection. The sensor is fabricated by screen printing of silver and poly(dimethylsiloxane) (PDMS) and its working principle is the variation in the resonance frequency when a certain pressure is applied in the UHF antenna.

The rest of the paper is structured as follows. In Section 2, the fabrication of the sensor and its characterization are presented. The results of the sensor' characterization are shown in Section 3, together with the discussion. Finally, the main conclusions are drawn in Section 4.

II. MATERIALS AND METHODS

The silver (Ag) screen printing paste employed in this work to print the antenna was LOCTITE ECI 1010 0.2KG E&C by Henkel (Germany) used without modifications. An array of pillar was made of polydimethylsiloxane (PDMS) formulated as in [10], but deposited with screen printing. All pastes were printed onto thermally pre-heated (100°C for 30 min) polyethylene terephthalate (PET) Melinex 506 of DuPont of a thickness of 100 µm. A manual screen printer (Nino from Coruna, Switzerland) was used to print with a screen with 120 threads/cm of mesh density. After printing, the pastes were dried at 100°C for 30 min in an Memmert oven before printing the next type of paste.

The E5061B ENA Vector Network Analyzer of Keyight was utilized for the S_{11} parameter measurements, as described in [11]. Similar capacitive pressure sensors were already studied in [12].

III. RESULTS AND DISCUSSION

We investigated the use of our thin pressure sensors without a dielectric, as these are shorted at a certain pressure. Figure 1 shows the patterned area that acts as the sensor. The dielectric is structured in pillars and the contact area corresponds precisely to the areas between pillars when certain pressure is applied in the patterned area. At UHF frequency, the sensor device behaves as a capacitor in series with one of the antenna dipole arms. When pressure is applied, the sensor device behaves as a series resistor, ideally a short-circuit, leading to a change in both the resonance frequency and the magnitude, as shown in Figure 2.

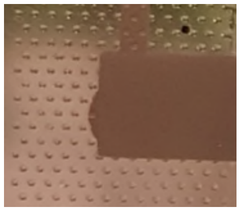

Figure 1. Pressure-sensing area.

We studied the frequency response, represented in Figure 2, by pressing and releasing several times with a plastic clamp (button area) over the sensor area.

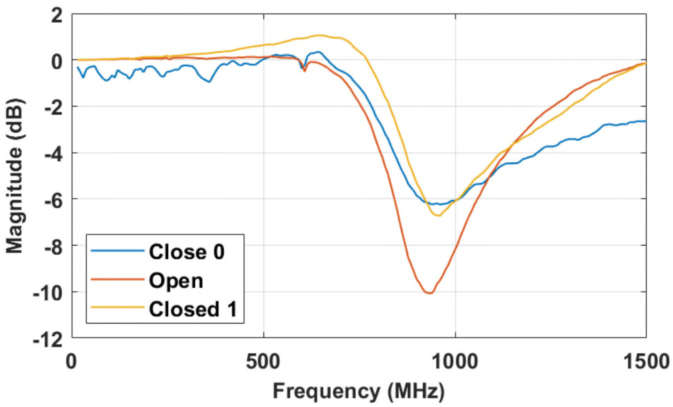

Figure 2. S_{11} magnitude for open and close states. Close 0 corresponds to the first attemp of closing the button, followed by Open when the button is released and finally Close 1 when the button is pressed again.

The dipole antenna that can be modelled as RLC series circuit was designed to resonate at 868 MHz when the sensor is pressed. When the sensor is released, a small series capacitance is added to the dipole series capacitance causing a shift of the resonance frequency upwards. This detuning of the resonance frequency is enough to be discriminated by an RFID reader, but it is not enough to inhibit the wireless link between the reader and the sensor tag.

IV. Conclusions

In this contribution, we present the possibility of designing a printed UHF sensor for force detection based on PDMS and silver on a flexible substrate. In particular, there is a shift in the resonance frequency as well as a change in its magnitude when the force is applied in the area where the structured PDMS has been deposited. When pressing the mentioned area, the resonance frequency is increased and its magnitude decreases. This solution paves the way for including sensor information in printed RFID antennas. In the future, we will study in depth the influence of the force applied on the resonance frequency together with the analysis of the area where the structured PDMS is located.

Acknowledgment

This work has been partially supported by the fellowship H2020-MSCA-IF-2017-794885-SELFSENS and the TUM Graduate School.

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