Passive Microsensor Based on LC Resonators for Substance Identification

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Abstract

A scheme for inductive wireless powering and readout of passive LC sensor is presented. The sensor's inductor is designed as a planar square coil and is used as the power-receiving component. The capacitor is connected directly to the inductor and was designed as an interdigital capacitor (IDC). With an external transmitting coil (coupling antenna), an electromagnetic field is generated which couples with the sensor, affecting the impedance of the coupling antenna. This work studies the effects of permittivity variations in a capacitive transducer induced by different solutions (Figure 1). The LC sensor used was fabricated under glass with copper metallization of 63 µm, with a total size of 1 cm X 1 cm. All the fabrication and characterization processes were carried out at the clean room of the Universidad de los Andes. The design and the simulation of the wireless passive micro sensor based on LC resonators were made using the RF Module of COMSOL 4.2a. With COMSOL, it was possible to verify the theoretical design made to assure that the sensor was sensible over a wide range of different values of dielectric constants. The software was also used to optimize the dimensions of the coupling antenna, in order to obtain the best coupling between the sensor and the antenna. On the other hand, the variations in the sensor's resonant frequency were determined by measuring the real part of the input impedance seen by the coupling antenna. This behavior could be checked with the COMSOL simulations. All the designs were simulated with full 3D analysis to consider the effects caused by the sensor's complete geometry and the interconnection elements (Figure 2). The whole system was simulated at a fixed distance of 5 mm between the sensor and the coupling antenna for different values of number of turns and radius of the antenna. The chosen parameters of number of turns and radius of the antenna, were the ones that maximized the Q-factor (Figure 3). All the system was simulated and resistance graphics were obtained in the frequency domain as presented in Figure 4. The changes in permittivity represent changes in the resonance frequency of the sensor, resulting in different solutions identification.
The sensor was fabricated with the following dimensions: 1 cm^2 area, 120 µm wide copper lines with a separation between them of 75 µm and the experimental results were similar to the obtained with COMSOL simulations. A wireless powering and readout scheme by means of a second LC resonator was presented. The system was fabricated and tested experimentally with results predicted by equations and COMSOL simulations. The optimization of the system coupling was possible with the use of COMSOL. The sensor was fabricated in the clean room of the Universidad de los Andes and tested with an Vector Network Analyzer (VNA) Master (Anritsu, Japan). Results were similar with the ones obtained with simulations in COMSOL.

Figures used in the abstract

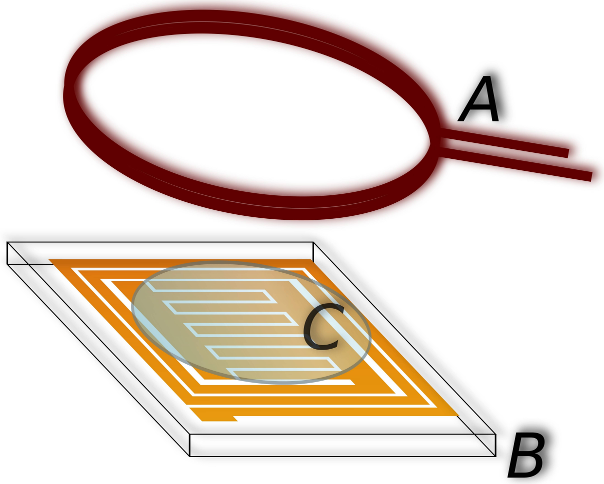

Figure 1: Model of the designed and simulated system. A is the coupling antenna, B is the designed sensor and C is the tested substance.

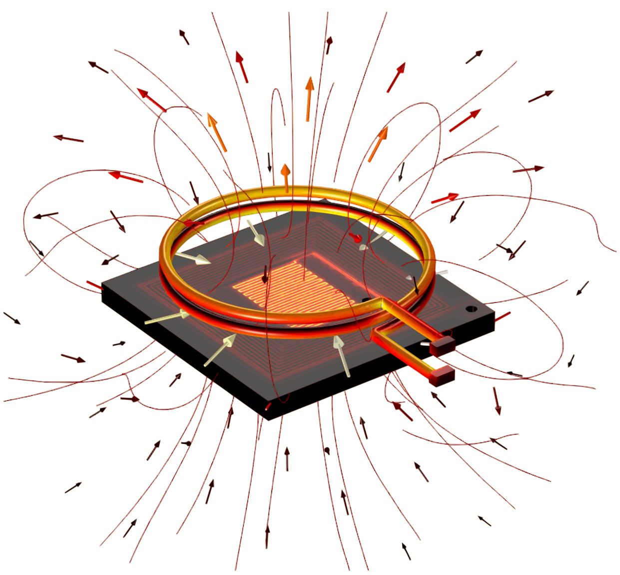

Figure 2: RF 3D simulation of the whole system showing the electromagnetic fields. Magnetic fields are shown with line curves and arrows, while the electric field magnitude is shown on the sensor's surface.

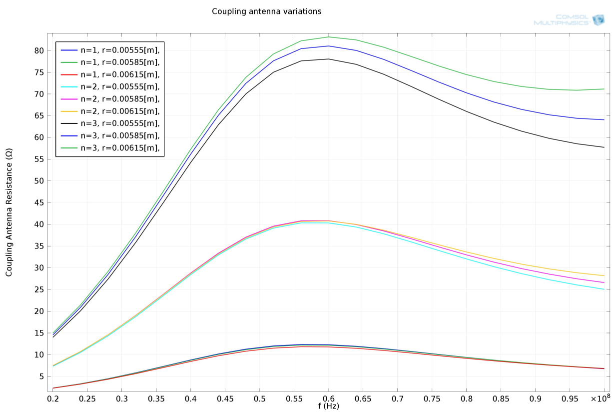

Figure 3: Resistance curves showing the resonance of the sensor. Only some of the simulated parameters are shown. The Q factor is appreciated for each case. The parameters studied where the number of turns of the antenna (n) and its radius (r). The chosen parameters were n=2 and r=5.85 mm.

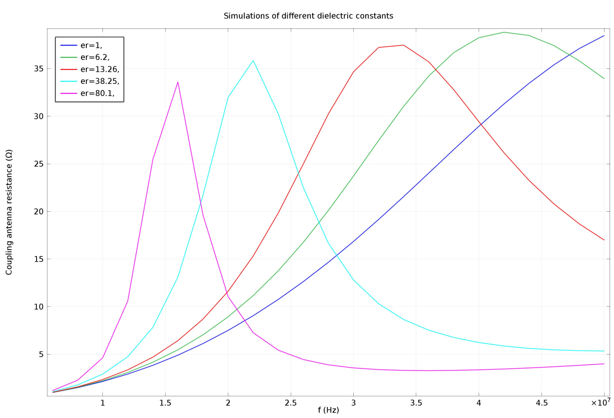

Figure 4: Simulation results of the system with different values dielectric constant covering the IDC. The substances correspond to air (er=1), acetic acid (er=6.2), pyridine (er=13.26), DMF (er=38.25) and Milli-Q water (er=80.1).