RFID-Enabled Temperature Sensor

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Abstract

To monitor the progression of dental diseases and study the reliability of dental materials, temperature sensors, along with other sensors, need to be placed on the patients' teeth. For this sensor to be used in the mouth, it should have a small size to fit on the surface of a tooth, have technique to power it inside the mouth, and be made of biocompatible materials. In this paper, we report on a temperature sensor that is has a millimeter-size, made of biocompatible materials, and operate without connection to a power source. The sensor is powered and read using a Radio Frequency Identification Device (RFID) reader, without the need for a power source. The structure of the sensor is shown in Figure 1. As can be seen from Figure 1, the sensor is a comb capacitor with an overlapping area that is changed with temperature. This change results in the change of the effective capacitance. The sensor capacitance is added in parallel to the capacitance of the resonance circuit of RFID. The value of the added sensor capacitance changes the resonance frequency of the tag. By reading the change in the resonance frequency, once can determine the temperature. Using COMSOL, the change in the overlapping areas for the two extreme temperatures of 275K and 345K were simulated. The simulation results are shown in Figure 2. COMSOL was also used to simulate the performance analysis of the device. The Joule Heating and Thermal Expansion module was used to determine the deformation of the movable comb with temperature over the expected operating range. The results shown in Figure 3 indicate that the sensor is linear. Next, the Electrostatics module is used to determine the capacitance value associated with the deformation of the comb capacitor at a function of temperature. The capacitance values obtained from the Electrostatic model were used to determine the shift of the RFID frequency from the original value of 13.6 MHz, as shown in Figure 4. The results show that the device will have a sensitivity of about 1.666 kHz/degree or 6x10-4 degree/Hz. We designed an RFID-enabled temperature sensor. The sensor size is very small and can be embedded in the mouth of a human or an animal. The device can also be used with invasive devices in the body to monitor the temperature. In addition to its small size, the device does not need any power source. Therefore, using a portable RFID reader, the sensor can provide continuous monitoring of the temperature, even during chewing, where data can be stored and sent to the health provider for further analysis.

Figures used in the abstract

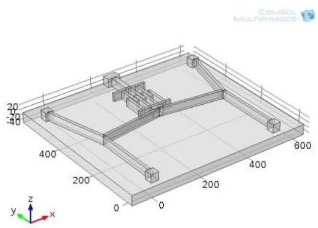

Figure 1: MEMS temperature sensor using interdigitated Comb structure.

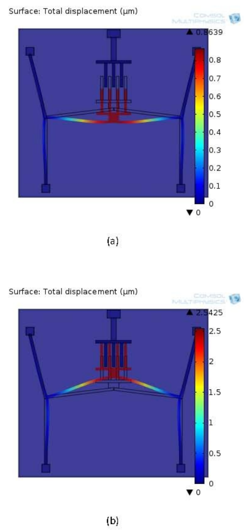

Figure 2: (a) Simulation of displacement of comb capacitor at 275 K b) displacement of comb capacitor at 345 K using COMSOL Multiphysics package.

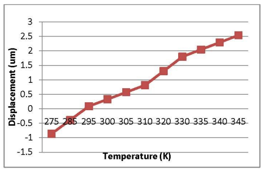

Figure 3: Displacement vs. Temperature relationship for the comb capacitor design. Determined from the Joule Heating and Thermal Expansion COMSOL module.

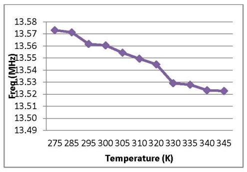

Figure 4: Frequency vs. Temperature relationship for the LC resonant network of the RFID tag after adding the sensor capacitor to the original capacitor of the tag.