RFID-Enabled Temperature Sensor

Ibrahim M. Abdel-Motaleb and K. Allen
Department of Electrical Engineering, Northern Illinois University, DeKalb, IL 60115

Introduction: A small temperature sensor is designed to be placed on patients' teeth to monitor the progression of dental diseases and study the reliability of dental materials. The sensor is made of titanium and powered and read using a Radio Frequency Identification Device (RFID) reader.

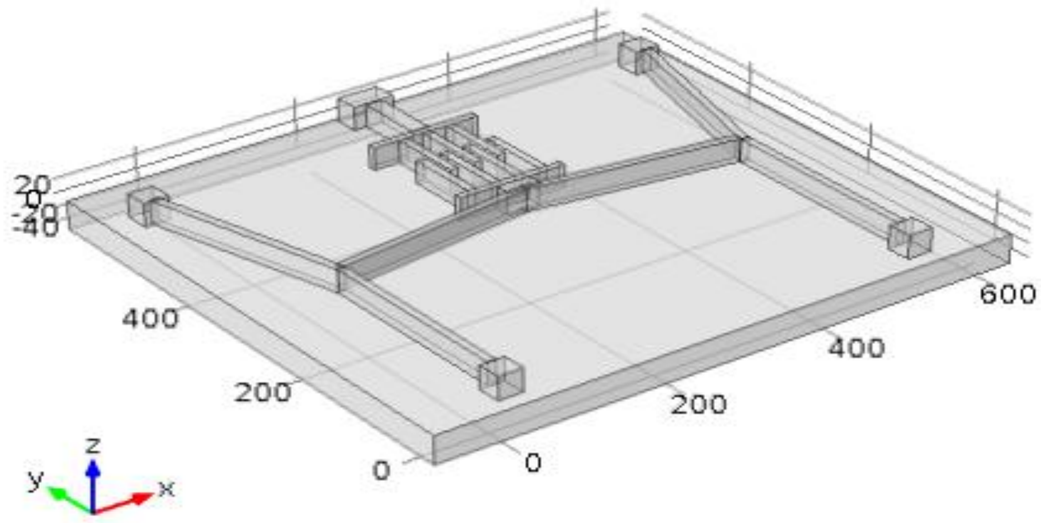

Figure 1. Bent Beam Temperature Sensor

Sensor Operation:

1. The capacitor of the sensor is coupled to a LC resonant network of a passive RFID tag.
2. This makes the tag's resonance frequency dependent on the value of the sensor's capacitance.
3. Hence, by measuring the shift in the resonance frequency, one can measure the change in temperature.

Results: The Joule Heating and Thermal Expansion module was used to determine the displacement of the lower movable comb with temperature. Figure 2 shows this displacement at the expected operating temperature extremes of the sensor.

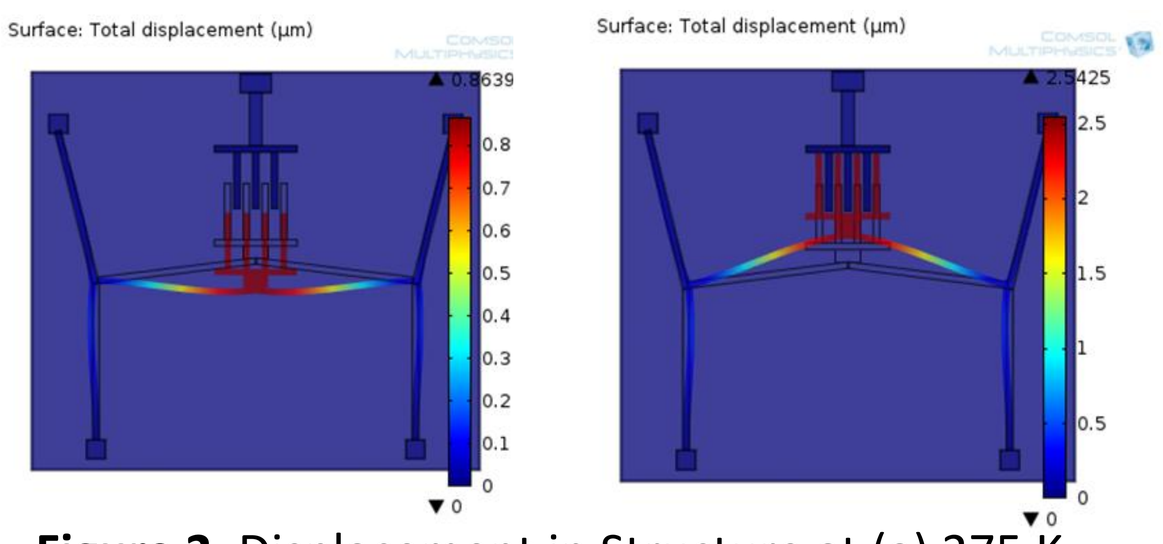

Figure 2. Displacement in Structure at (a) 275 K and (b) 345 K

1. Fig 3 shows the Displacement vs. Temperature relationship over the entire operating range.
2. Using the equation below, the resonance frequency of the RFID tag vs. Temperature can be obtained. See in Figure 4:

$$f_{res} = \frac{1}{2\pi\sqrt{LC_{total}}}$$

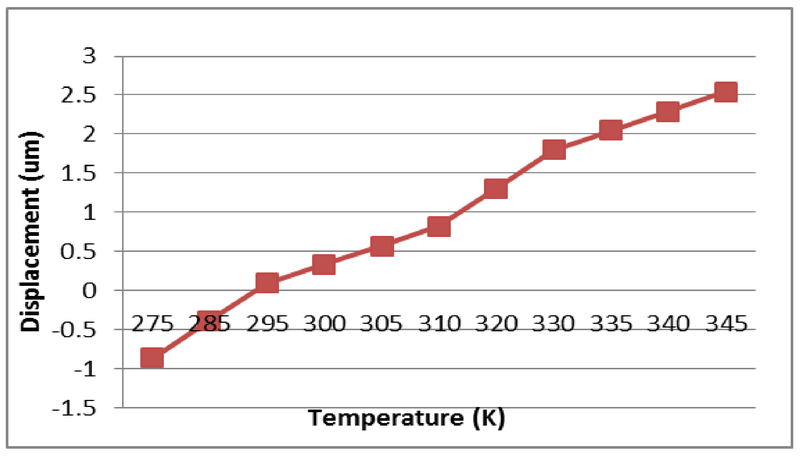

Figure 3. Displacement vs. Temp

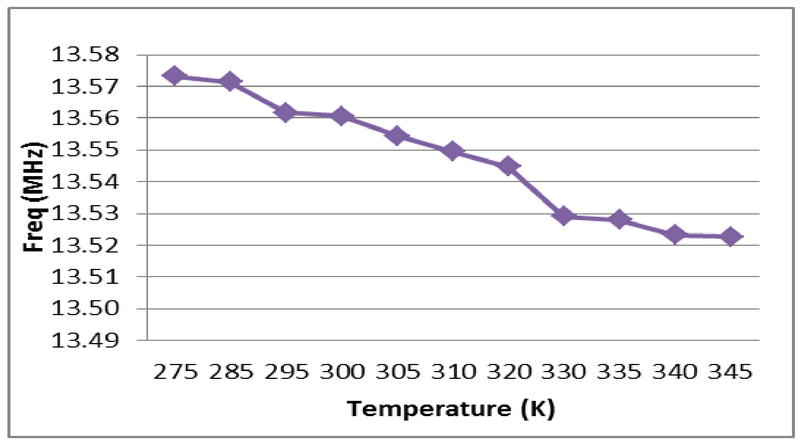

Figure 4. Frequency vs. Temperature

Conclusions:

1. A temperature sensor was designed to be attached to a tooth or a dental implant to monitor their exposure to temperature.
2. COMSOL was used to design the sensor physical structure and to simulation its performance.
3. The sensor capacitance is coupled with the capacitance of a RFID tag LC network.
4. This coupling allowed for measuring the temperature using the frequency shift of the LC resonance frequency.
5. External readers can be used to detect the change in the resonance frequency, and in turn determine the measured temperature.
6. The results indicate that the device will have a very high resolution of about 0.0014°C/Hz.