Analysis of an Inductive Proximity Sensor

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Introduction: 90 percent of automation sensors are binary proximity detectors. Compared to their mechanical counterparts, inductive proximity sensors offer almost ideal properties as contact-free and wear-free working principle as well as high switching frequency and precision [1,2].

A high frequency magnetic field is provided by a LC-oscillator (cf. Fig. 1). It interacts with the object to be sensed. Two effects can be used for technical detection applications. First, there is a shift in frequency of the LC-resonator. Second, the oscillation amplitude changes. In this work, model-based insight is provided to the effects referring to the example of the sensor shown in Fig. 2.

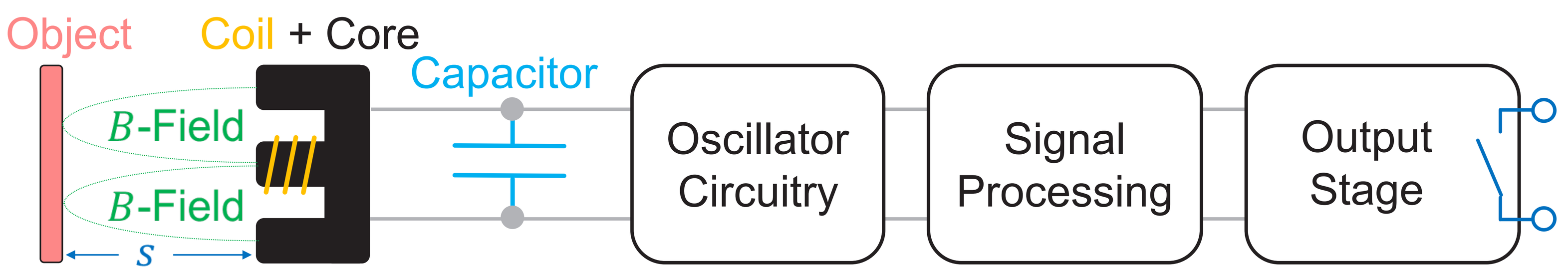

Figure 1. Block diagram of a inductive proximity sensor.

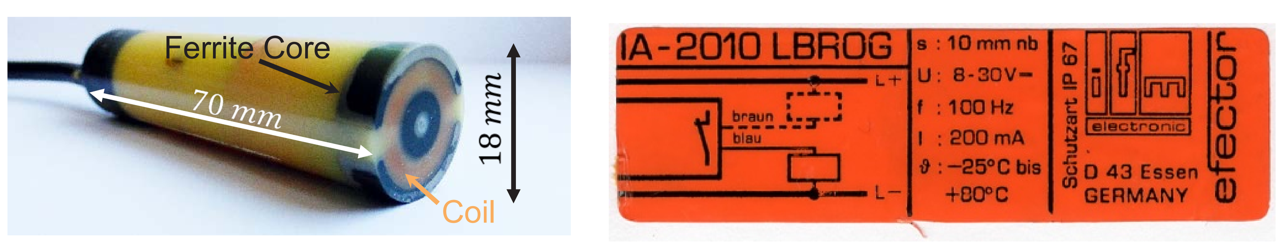

Figure 2. Analyzed inductive proximity sensor.

Computational Methods: The model is setup with the *Magnetic Fields* and the *Electrical Circuit* physics interfaces. 2D *Axial Symmetry* and *Infinite Element Domains* are used. The configured boundary conditions are shown in Fig. 3. To investigate the transient behavior of the LC-resonator a *Capacitor* and an *External I Vs. U* node are inserted to the *Electrical Circuit* physics interfaces.

Fig. 4 reveals some details of the mesh. In particular *Boundary Layers* on the surface of the detection object (skin effect) and the mesh in the *Infinite Element Domain* regions can be observed.

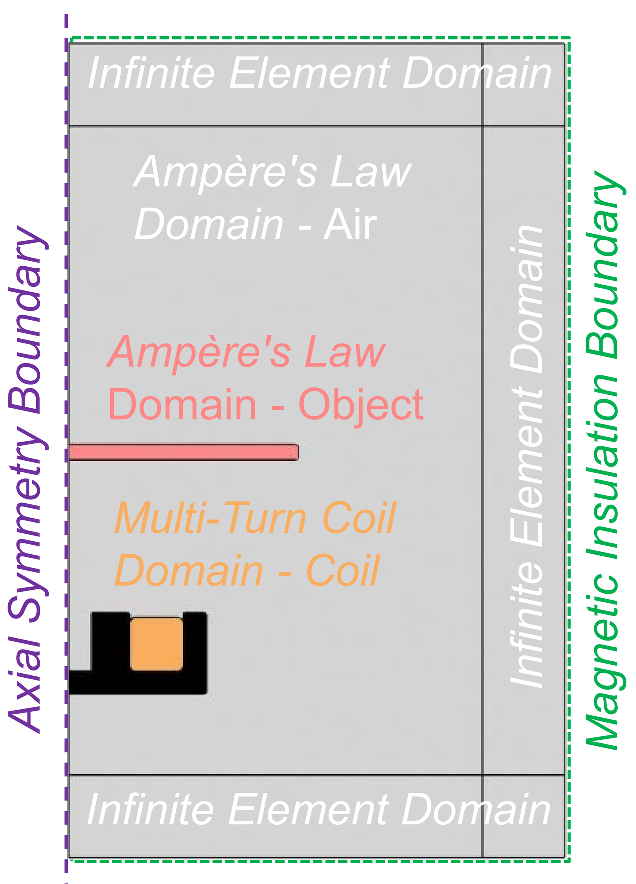

Figure 3. Model setup.

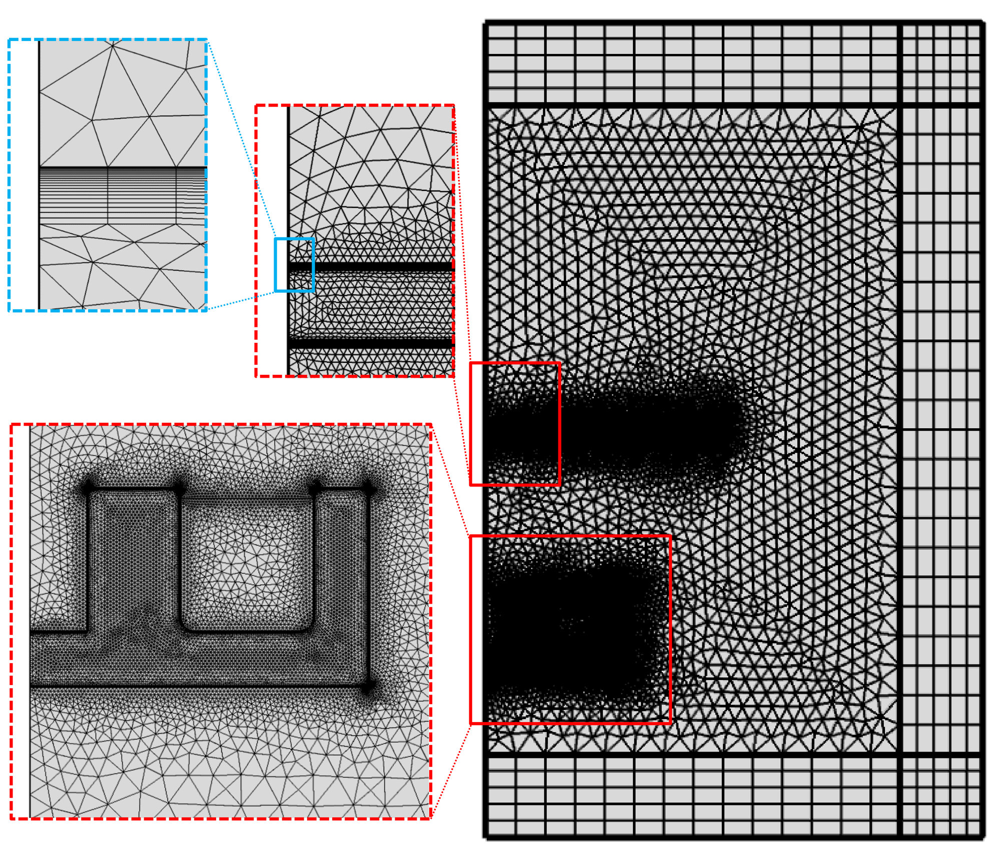

Figure 4. Mesh.

Results: Fig. 5 displays calculated magnetic fields [3]. The field magnitudes within the region of the object and the coil core are significantly higher than in the rest of the model domains. This relates to the respective values of the permeability's. The skin effect is observed for the measurement object. Fig. 6 shows the normalized sensor impedance over distance [3]. These results provide direct insight to the sensor sensitivity. For very small distance, the imaginary part of the impedance (impact on resonance frequency) provides a detection effect. For larger distance, only the real part of the impedance (impact on oscillation amplitude) provides a reasonable sensitivity.

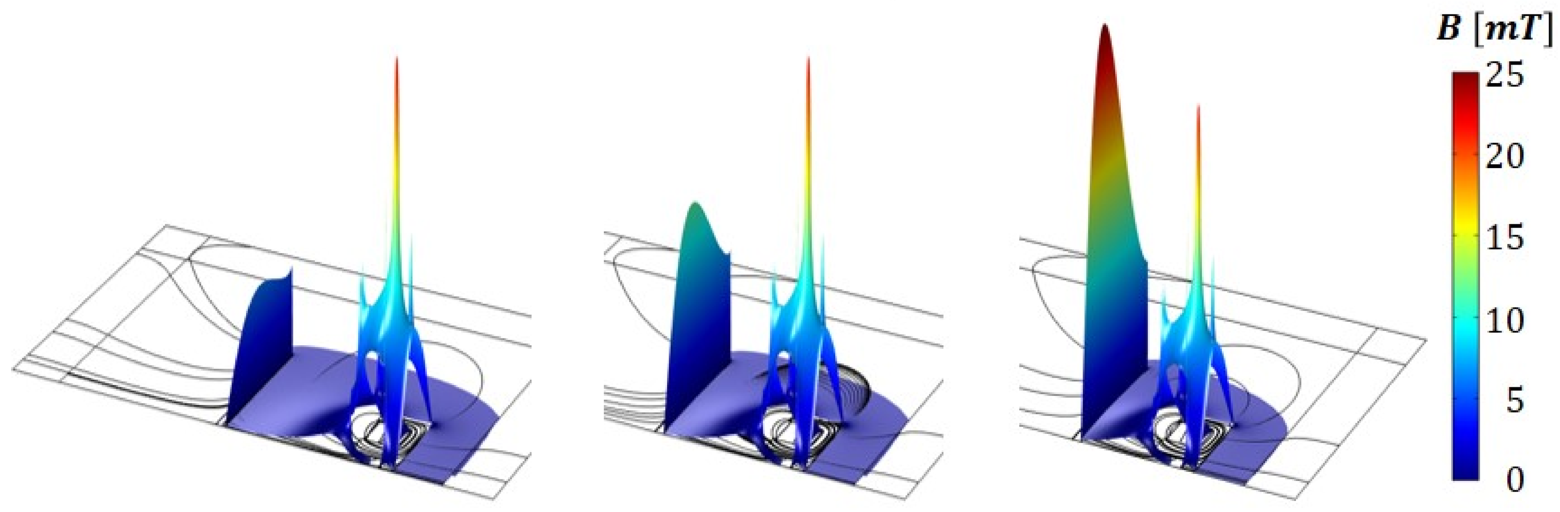

Figure 5. Magnetic field for f_{res} = 1 *MHz* and sensor-object distances *s* = 13 *mm*, 10 *mm*, 7 *mm*.

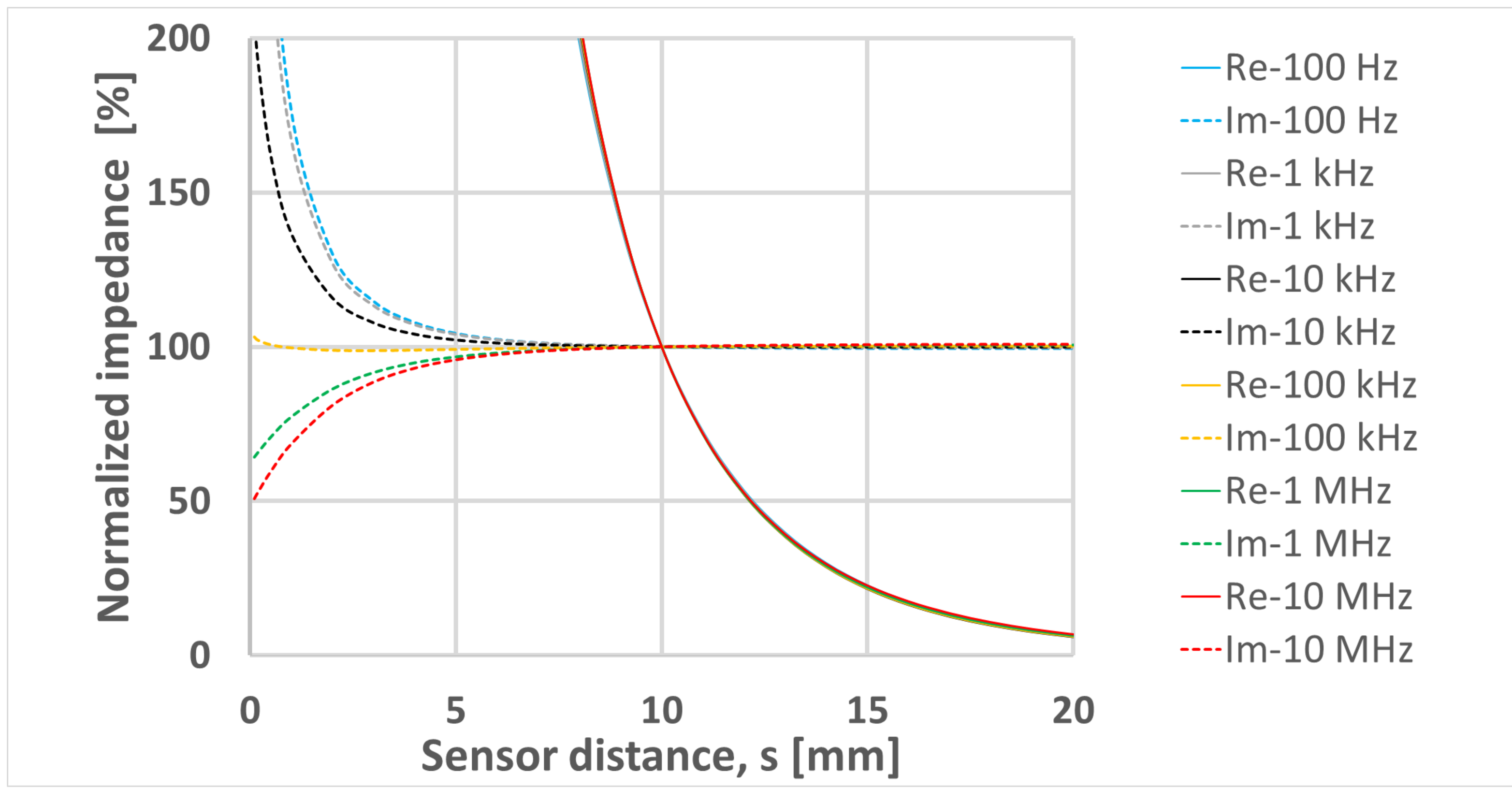

Figure 6. Real and imaginary part of the normalized sensor impedance over distance.

Conclusions: A model was setup to analyze an inductive proximity sensor. The obtained results provide insight on how the sensor should be operated to maximize sensitivity.

References:

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