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A low-cost inductive proximity sensor for industrial applications

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Abstract

In this paper, we present an inductive proximity sensor with fully integrated electronics. The sensor with the compact hybrid configuration is composed of a sensing flat coil and an integrated electronic interface. We focused during the development on the temperature stability and robustness of the sensor by keeping its low-fabrication cost. The sensor exhibits a longitudinal resolution of 120 nm for an aluminum target position up to 500 μm from the sensing coil with the side size of 3.5 mm. The temperature drift of the sensor is less than 700 ppm/°C for the same range of the target position. The total working range is from 100 to 1500 μm. The sensor power consumption is 100 mW and the active sensor dimensions are 3.5 mm × 3.5 mm × 1.2 mm. We also showed the facility of the sensor packaging. This kind of integrated sensor has the potential for even more industrial applications.
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1. Introduction

Inductive proximity sensors are widely used for the contactless measurement of object or target displacement and position [1] in numerous technical products and systems. They are found in various industrial applications in market segments [2] like graphics industry, handing and robotics, semiconductors, automotive industry or profile imagery [3]. In all this market segments, there are various application, which cannot be solved yet because of physical dimensions or cost. A suitable hybrid microsensor can be obtained by combining of an inductive coil made of thick electroplated layers and a silicon chip with electronics made in a standard CMOS process. The challenge of our work was to develop such a sensor stable in temperature by using new technologies for microsystem integrations.

2. Principle and realization

A new hybrid proximity sensor is based on a relaxation oscillator in differential configuration recently developed for an integrated proximity sensor [4] and a flat sensing copper coil developed by LC-LiGA process [5].

The output signal of this electronic interface is a squared alternative signal where the frequency depends on the proximity of the coil to a conductive (usually aluminum) target. A suitable electroplated sensing copper coil with the side length of 3.5 mm, pitch of 25 μm (20/5) and Cu-height of 25 μm developed by the company Applied MicroSwiss has the coil inductance of 4.29 μH and the coil resistance of 18 Ω. The approach of a conducting target will have an effect on the magnetic field distribution and on the dissipation, and consequently on the coil time constant $\tau = L/R$ (where L is the inductance, and R is the resistance), which determines the output frequency of the sensor. However the temperature influences the time constant τ as well. The error caused by the temperature variation of 100 °C is of the same order of magnitude as the total output change due to the approach of the target, and is strongly non-linear depending on target position. An existing simple temperature compensation method [6] for this kind of proximity sensor is based on a negative temperature coefficient (NTC) resistor. This method requires one external SMD component with adjustable temperature coefficient, what is not suitable for batch production of the sensor. For this reason, a new approach of fully integrated temperature compensation was studied.

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