X-Y Flat Position Sensor with nanocrystalline armature

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2D flat position sensor is based on variable transformer with laminated nanocrystalline flake VITROLAM® armature. Thanks to this material the operation frequency can be increased up to 1 MHz, resulting in sensitivity up to 100 mV/cm for the excitation current of only 5 mA. The nonlinearity error is below 3 % in the ± 15 mm range for any position and movement direction. Liftoff changes and temperature dependencies are compensated by the ratiometric method.

Keywords: Magnetic position sensor; nanocrystalline alloy

1. Introduction

X-y position in a plane can often be measured by two perpendicular single-axis linear position sensors. However, some applications require truly 2-dimensional position sensors, such as aligning printing plates or contactless charging coils. Existing optical [1] and capacitive [2] solutions are sensitive to dirt and humidity. Systems with permanent magnets are industrial standard [3], but they have limited accuracy due to the sensitivity to external DC magnetic fields and magnet inhomogeneity. Existing transformer sensors use moving coils, introducing reliability problems with moving leads [4]. We have developed a two-axial position sensor based on the flat variable position transformer [5]. Our first design used a set of five equal stationary coils and a moving cross-shaped armature. The problem with that solution was a crosstalk between the two axes, large nonlinearity, high power consumption and limited range of only ± 5 mm in the 45° movement direction.

2. Results and discussion

Our new design shown in Fig. 1 is based on a large excitation coil, four smaller pick-up coils, and a 40-mm circular armature made of a VITROLAM® 800R 5L3000 sandwich. The sensor shape and dimensions were optimized using parametric 3-D FEM model including eddy currents. All flat coils are made in PCB technology and have 20 turns. The VITROLAM laminate consists of five isolated layers of 18-µm-thick nanocrystalline VITROPERM 800R tape. The fragile nanocrystalline material is crushed into flakes, reducing eddy currents in the tape plane. The material which was developed for contactless chargers has flat loop and relative permeability of 3 000. We believe that this is the first sensor application of VITROLAM. Thanks to this material the operation frequency can be increased up to 1 MHz, resulting in sensitivity up to 100 mV/cm for the excitation current of only 5 mA, which is a 30-fold reduction of power consumption compared to [3]. The parameters measured on sensor prototype are in a good agreement with FEM model. The nonlinearity error is below 3 % in the ± 15 mm range for any position and movement direction. Fig. 2 shows an example of the measured linearity error for out-of-center movement. We will demonstrate effective compensation for liftoff changes and temperature changes by using ratiometric output. We also show how the quality of this compensation depends on armature diameter. Further increase in sensitivity can be achieved by using a magnetic backplate.

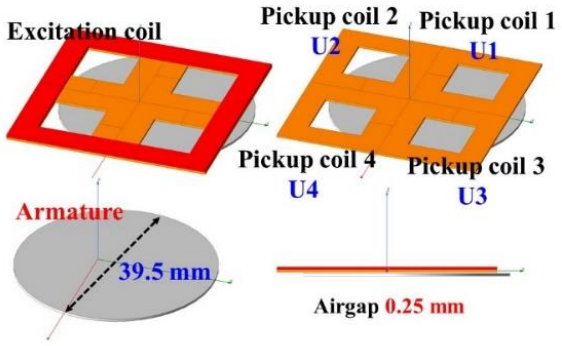

Figure 1: X-Y position sensor consists of large excitation and four small pick-up stationary flat coils and moving armature

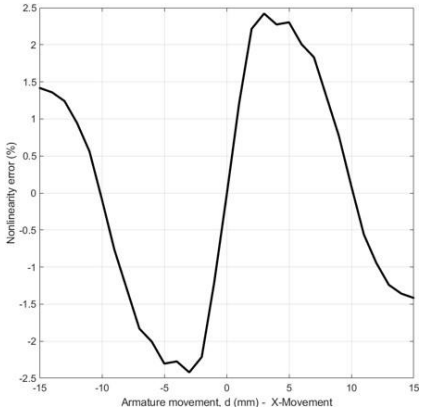

Figure 1: Fig. 2 Non-linearity error for y= 3.75 mm, -15 mm < x < 15 mm

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