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Development of planar microfluxgates using FeNi and FeNiCo electrodeposited cores

T. Heimfarth[(1)*] and M. Mulato[(1)]

(1) FFCLRP, Universidade de São Paulo, e-mail: tobiash@pg.ffclrp.usp.br
* Corresponding author.

Abstract – Planar fluxgates using optimized electrodeposited FeNi and FeNiCo alloys and innovative layout have been produced. A new manufacture approach that permits a fast way from sketch to macro scale prototypes has been used allowing systematic studies. A new layout device tested presented good linearity range, much higher than the standard one built and operated in the same conditions. The sensor response keeps linear in magnetic fields up to 500 µT with 75 V/T sensibility.

Fluxgates are vectorial magnetometers with high sensitivity, only lower than SQUIDs, but operating at ambient temperature. Originally these sensors have been developed with size and power consumption incompatible with a lot of technologies, restricting its use. To overcome this fact, several types of microfluxgates have been proposed in literature making use of the thin films technology. But making the sensor smaller brings some inconveniences as the increase of noise [1]. These devices have a poor performance comparing to the big ones but there's still a lot of room for improvement. Also, in a development point of view, the photolithography required in the manufacture process of such device uses expensive masks that, once done cannot be changed anymore, restricting layout tests.

Early works [2] have determined the best current density for FeNi and FeNiCo alloys electrodepositing, both 14 mA/cm². Based on this, we built functional planar sensors in order to test the optimized ferromagnetic material as fluxgate core and also innovative sensor layouts (figure 1). Firstly, only macro scale devices were created using printed circuit board as substrate and a laser printer toner based lithography. This process is very simple and allows a fast way from sketch to macro scale prototypes. Note that, unlike the conventional macrofluxgates, these devices can be directly scalonable. Than with a systematic characterization of each device, only the best in performance will be miniaturized.

Border effects where observed in the electrodepositing process, with oxide formation due the high local current. As the cooper surface where the ferromagnetic material will lay on have the exact geometry of the final core, this could be an issue. An workaround that has shown results was the addiction of an outer cooper ring with an 0,3 mm offset from the core border. This ring attracts to itself the excess of ions, minimizing the effect on working area.

Another observed electrodeposition effect, but not mentioned in [2], was an anisotropy response in parallel directions showed by some core samples. This behavior probably is originated by the solution inhomogeneity in rest state and can be used to reduce the crossfield response present in fluxgates.

The device built with the new layout (figure 1b) presented in our previous tests a good linearity over the range of -500 µT to +500 µT and a 75 V/T sensibility with power consumption of 0.3 W. The standard layout fluxgate (figure 1a) with the same power, substrate area used and ferromagnetic alloy, only reached a linear range over -150 µT to +150 µT with a 91 V/T sensibility. Comparing the standard sensor layout with the proposed fluxgate, the second one shows an expressive gain in linearity range without considerable sensibility lost (figure 2).

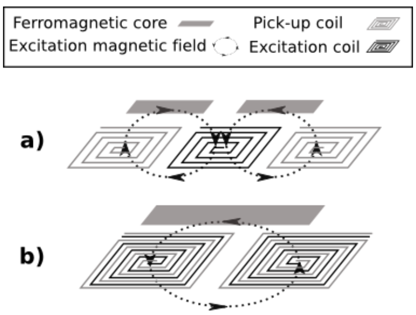

Figure 1: Schematics of the **a)** standard planar fluxgate and the **b)** proposed double coil layout.

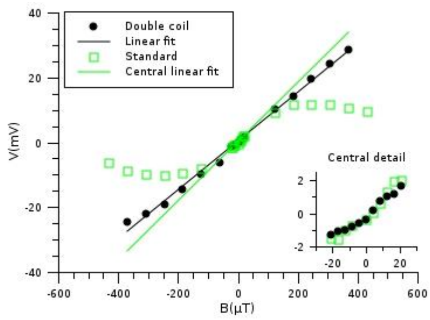

Figure 2: Second harmonic amplitude response of the fluxgates due to a magnetic field in the sensing axis.

[1] P. Ripka, Sensor and Actuators A 106 (2003) 8-14.
[2] Thais Cavalheri dos Santos, Master´s thesis (2007)