A semi-analytical model of a closed-core planar fluxgate structure

Michael Ortner[1] and Martin Lenzhofer[1]

[1]CTR – Carinthian Tech Research AG, Villach, Austria

Fluxgates have been around since before 1950. But it was only around the beginning of this century, with modern fabrication processes and electronics, that efficient miniaturization became possible [1]. Today miniaturized fluxgates on PCB- or CMOS-basis are used for multiple applications in bio-medical, as compass, for space exploration and whenever a magnetic field in the nano- and microtesla range should be detected. Such devises benefit from a high level of signal stability and robustness that is due to the simplicity of this sensing principle.

The physical theory behind fluxgates is understood in a macroscopic sense where the demagnetization of the core plays a key role. A lot of analytical work has been done to calculate the demagnetization factor for specific, simple core geometries and for simple hysteresis models [2].

Modern planar layouts aiming at miniaturization, however, use planar spiral coil structures and ferromagnetic ribbons as cores. While the underlying physical principle is the same, magnetic field propagation within the planar setups differs from their '3D' counterparts. It was shown in previous works that only a small fraction of the core ribbon reaches the desired deep saturation when the system is in operation [3].

In this work, a semi-analytical model is developed to describe more complex hysteresis models and to take local saturation effects into account. The model extends the approach by *Perez* [2] to deal with different possible saturation models and FEM simulation to include local saturation effects. We aim to improve the understanding of previous measurements of a multi-layered PCB-based closed core system [3] and planar fluxgate technology in general.

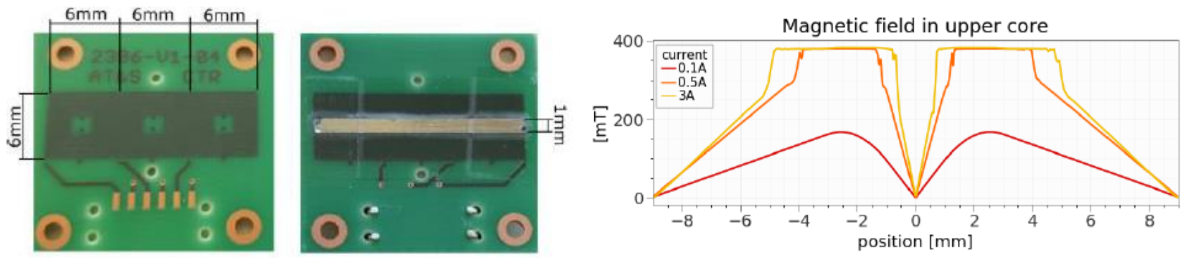

Figure 1. Left to right: The PCB-based planar fluxgate structure developed at CTR with and without a VITROVAC ribbon core of 23um thickness. The graph shows the magnetic induction within and along the core for different excitation currents. The slow spread of the saturation along the core is clearly visible.

[1] P. Ripka, *Advances in fluxgate sensors*, Sensors and Actuators A 106 (2003) 8-14

[2] L. Perez et al, *Analytical model for the sensitivity of a toroidal fluxgate sensor*, Sensors and Actuators A 130-131 (2006) 142-146

[3] M. Lenzhofer et al, *A New Approach For a Planar Miniaturized PCB Based High Sensitivity Fluxgate Sensor Design*, Conf. Proc. Sensor + Test 2017, Nürnberg