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PERMING EFFECT IN RESIDENCE TIMES DIFFERENCE FLUXGATE MAGNETOMETERS

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Abstract

The aim of this paper is to present experimental results on the estimation of perming effect in an experimental prototype of fluxgate magnetometer that uses the Residence Times Difference (RTD) readout strategy. This approach is based on the time domain characterization of the transitions between the stable steady states of the hysteresis loop whose features are related to the external magnetic field to be measured [1-5].

The perming effect can affect the output signal of the device (by an offset) after the magnetic shock. It is similar to hysteresis, but the applied field may be much higher than the full-scale range. All the sensors containing ferromagnetic material are susceptible to perming. The only solution is periodical re-magnetization of the sensor, which ensures the defined magnetic state. In the case of Fluxgate sensors, the re-magnetization is performed through the excitation current. Anyway, it must be considered that no significant perming is observed if the device is polarized by a high current value [6].

To suppress the offset, it might be useful to employ the same technique used by the AMR sensor [7], consisting in the application of a high current pulse to the core to stabilize its the magnetic status before the normal operation of the sensor.

The obtained experimental results allow for the definition of guidelines for the optimal re-magnetization strategy of the ferromagnetic core in the particular case of RTD fluxgate magnetometers.

The preliminary results that we are going to show are about a PCB FR4 RTD fluxgate [5]. The particular geometry of the sensor, shown in Fig. 1a, is eligible for an incomplete saturation of the ferromagnetic core in some areas that are thus susceptible to perming during normal operating conditions.

In order to produce the external reference target magnetic field necessary for the sensor characterization, the solenoid in Fig. 1b has been used. The knowledge of its geometrical parameters, allows for the exploitation of the well known relations between the applied current and magnetic field inside a solenoid to control the reference magnetic field value by suitable driving currents. The solenoid and the prototype have been placed inside a magnetic shield, as shown in Fig. 1b.

The experimental characterization procedure is shown in Fig.2; it consists of six consecutive steps:

A-(0-5)s. In the first step the magnetic state of the core must be reset. To such aim a one period (T = 5s), triangular shaped magnetic field is forced through the external solenoid. The amplitude of the applied field must be high enough to ensure a sufficient saturation of the core (in the case considered the peak-to-peak amplitude is 800μT). During this phase the magnetometer is not driven by any excitation current as it could vary its magnetic state.

B-(6-35)s. The magnetometer is driven with a periodic current and 30 seconds of the output signal (RTD) with nominal zero applied field are acquired.

C-(36-65)s. A high DC magnetic field is applied through the external solenoid for 30 seconds.

D-(66-95)s. The applied field is turned off and a RTD shot of 30 seconds is acquired. As it cab observed an offset appears in the output signal as respect to the same signal analized in phase (B). This quantity can be considered as the perming offset.

E-(96-100)s. Same as step A.

F-(101-130)s. Same as step B, to simply test if the reset signal works properly.

It must be noted that the output signal of the sensor is not acquired during phases A, C and E (grayed areas in Fig.2).

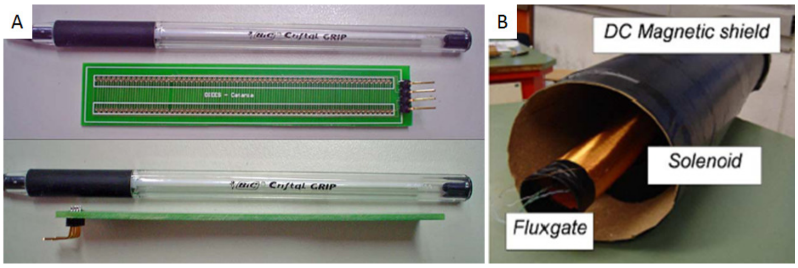

Figure 1 – (a) RTD fluxgate, PCB FR4 prototype. (2) Experimental setup: the sensor is placed inside the solenoid that produces a controllable magnetic field. The solenoid is hosted inside the magnetic shield.

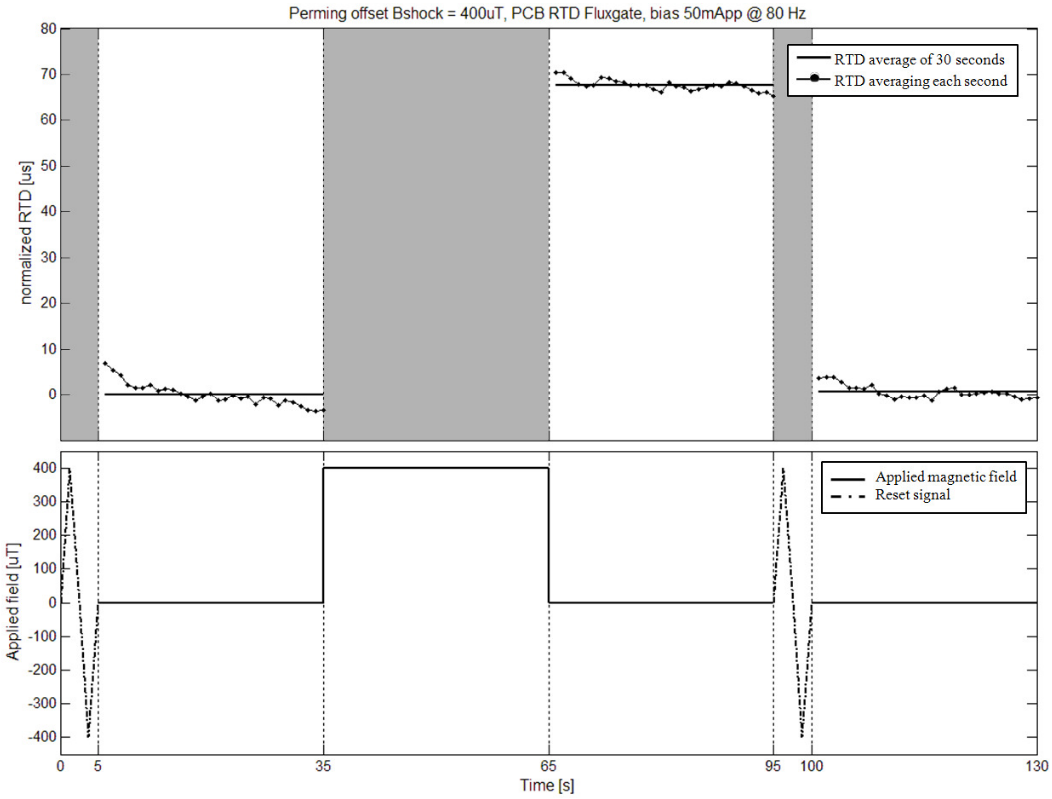

Figure 2 – Experimental characterization procedure to estimate the perming effect in RTD Fluxgates magnetometers. This example refers to a PCB FR4 prototype with excitation current of 50mApp @ 80 Hz. The magnetic shock applied here is 400 µT (step C)

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