Very long-term equivalent magnetic drift observations of PHMR sensors

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We have investigated the very long-term stability (some days) of some Planar Hall MagnetoResistance (PHMR) as magnetic sensor [1]. It was measured in a very quiet environment in terms of temperature and magnetic field. For our samples, the observed drifts have a positive or negative slope less than half nanotesla per second, depending on the Wheatstone PHMR bridge unbalance and bias voltage, mainly. We sought to understand the origin of the phenomenon having a very long time constant. We propose to detail our modelling, which could explain this behavior, which is very little studied considering the experimental constraints. The physics underlying the experimental results appeared consistent with our investigation and clarified some other observations. We will present a method which helps to reduce, notably, this phenomenon.

Keywords: Long-term stability ; Magnetic sensor ; PHMR

1. Introduction

Magnetoresistance as PHMR sensor has been extensively studied in terms of performances: Sensitivity (V/T), Bandwidth (Hz), Equivalent magnetic noise (T/√Hz), Temperature Coefficient of the Offset (TCO - % K^{-1}), Temperature Coefficient of Sensitivity (TCS - % K^{-1}), *etc.* [1, 2]. But they are almost no measurement of very long-term intrinsic stability. Here, we propose to investigate an original approach to quantify more precisely and, independently, to the external temperature, the sensor stability. As, we named Intrinsic Temperature Coefficient of the Offset (ITCO).

2. Results and discussion

To proceed with the measurement of this ITCO, we have made measurements in our magnetically shielded room for a few days. The sensing element consists of a PHMR Wheatstone bridge [1, 2, 3]. The latter output is amplified and filtered by an instrumentation amplifier (× 500). Our ADC have a dynamic range of 24 bits, a sampling frequency of 718 Hz, and is controlled by a laptop. In parallel, we made the acquisition of 3D fluxgate outputs and a temperature sensor. The latter is closed to the magnetometers. An example of acquired data is given in figure 1. We observed a linear drift of around 400 (pT/s). Furthermore, it appears uncorrelated with the room temperature or the sensed residual magnetic field appearing in our magnetically shielded room.

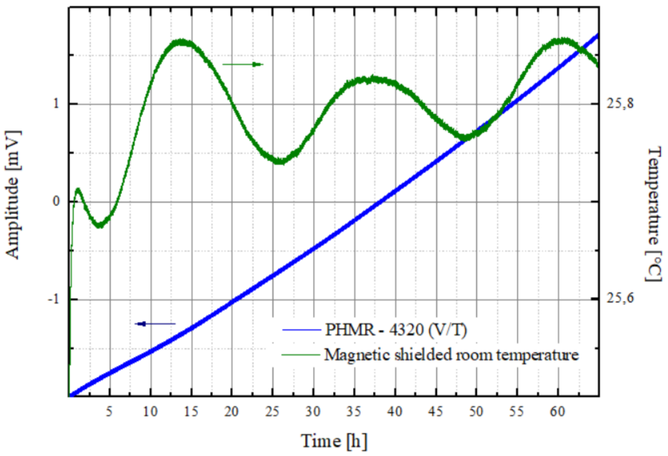

Figure 1: Example of an observed voltage long-term drift (blue curve) and room temperature closed to the sensor (green curve).

We have tested the sample with different conditions of power bias and amplification to ensure that there is no experimental artifact. Results are similar. Based on this observation, we have analyzed the origin of this drift, which is not correlated to temperature, at first glance. We remember that the voltage output of the Wheatstone Bridge is given by

$$V_S(t,T) = \left(\frac{r\,\Delta\rho(t,T)}{2\,w\,t_{fm}}\right) Sin\left(2\,\left(\psi - \theta_r(T,t,B_{app})\right)\right)\,I_{dc}$$

where $\Delta\rho(t,T)$, r, w, t_{fm}, ψ, $\theta_r(T,t)$, B_{app} and I_{dc} are the difference in PHMR anisotropic resistivity, the radius, the width and the thickness of the ferromagnetic layer characterizing the Wheatstone bridge resistance geometry, the specific angles (*cf.* [1]), the sensed magnetic field and the Wheatstone bridge bias current.

Based on this equation and associated assumptions, we can observe that some parameters could depend on the time and on the temperature. To support our modeling, we focused on the anisotropic resistance parameter variation. It yields

$$\Delta\rho(T,t) = \Delta\rho_0 + \alpha\left(T_{PHMR}(t) - T_{RChT}(t)\right)$$

where $\Delta\rho_0$, α , T_{PHMR} and T_{RChT} are, respectively, the nominal anisotropic resistivity, the temperature coefficient of $\Delta\rho$ and the temperatures of one element of the PHMR Wheatstone Bridge and in the room chamber. With this approach, we are able to explain the observed drift.

Furthermore, this modelling opens the way for the development of optimized electronic control, which helps to suppress up to a certain extend this dependence, as we will exemplify.

References

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Acknowledgments: We thank eV-Technologies which provide the sensors.