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Flux-Gate vs. Anisotropic Magneto Resistance Magnetic Sensors Characteristics in Closed-Loop Operation

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Abstract : The increasing demand for accurate and reliable magnetic measurements over the past decades has paved the way for the development of different types of magnetic sensing systems as well as of more advanced measurement techniques. Anisotropic Magneto Resistance (AMR) sensors have emerged as a promising solution for applications requiring high resolution, providing an ideal balance between performance and cost. However, certain issues of AMR sensors such as non-linear response and measurement noise are rarely discussed in the relevant literature. In this work, an analog closed loop compensation system is proposed, developed and tested as a means to eliminate the non-linearity of AMR response, reduce the 1/f noise and enhance the sensitivity of magnetic sensor. Additional performance aspects, such as cross-axis and hysteresis effects are also examined. This system was analyzed using an analytical model and a P-Spice model, considering both the sensor itself as well as the accompanying electronic circuitry. In addition, a commercial closed loop architecture Flux-Gate sensor (calibrated and certified), has been used for comparison purposes. Three different experimental setups have been constructed for the purposes of this work, each one utilized for DC magnetic field measurements, AC magnetic field measurements and Noise density measurements respectively. The DC magnetic field measurements have been conducted in laboratory environment employing a cubic Helmholtz coil setup in order to calibrate and characterize the system under consideration. A high-accuracy DC power supply has been used for providing the operating current to the Helmholtz coils. The results were recorded by a multichannel voltmeter The AC magnetic field measurements have been conducted in laboratory environment employing a cubic Helmholtz coil setup in order to examine the effective bandwidth not only of the proposed system but also for the Flux-Gate sensor. A voltage controlled current source driven by a function generator has been utilized for the Helmholtz coil excitation. The result was observed by the oscilloscope. The third experimental apparatus incorporated an AC magnetic shielding construction composed of several layers of electric steel that had been demagnetized prior to the experimental process. Each sensor was placed alone and the response was captured by the oscilloscope. The preliminary experimental results indicate that closed loop AMR response presented a maximum deviation of 0.36% with respect to the ideal linear response, while the corresponding values for the open loop AMR system and the Fluxgate sensor reached 2% and 0.01% respectively. Moreover, the noise density of the proposed close loop AMR sensor system remained almost as low as the noise density of the AMR sensor itself, yet considerably higher than that of the Flux-Gate sensor. All relevant numerical data are presented in the paper.

Keywords : AMR sensor, chopper, closed loop, electronic noise, magnetic noise, memory effects, flux-gate sensor, linearity improvement, sensitivity improvement
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