

ABSTRACT

Title : Multiple-harmonic detection circuits for GMR and fluxgate magnetometers

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Researcher : Ting-Yu Hsu

Advisor : Jen-Tzong Jeng

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The field modulation and harmonic detection methods for the giant-magnetoresistance (GMR) and fluxgate magnetometers are proposed in this work. Under a sinusoidal modulation field, the voltage-field characteristics of a GMR sensor are hysteretic V-shape curves. For a fluxgate, the induced signal sensitive to the external dc field is a voltage wave at the double frequency of excitation. According to Fourier analysis, it can be found that these signals are formed by specific components at harmonic frequencies of excitation. For GMR, the field sensitive components are the first, third, fifth, and other higher-order odd harmonics. For fluxgate, they are the second, fourth, sixth, and other higher-order even harmonics. To detect the harmonic signals of GMR and fluxgate, we built a signal generator which can generate the excitation current as well as its even and odd frequency reference square waves. The harmonic component in the sensor output was extracted by a lock-in amplifier with the reference square wave at a specific harmonic frequency of excitation. It is found that the minimum noise of $2.5 \text{ nT}/\sqrt{\text{Hz}}$ was achieved at 3rd harmonic for the GMR magnetometer with the excitation current of 44.2 mA. For the fluxgate, the minimum noise was $2.5 \text{ nT}/\sqrt{\text{Hz}}$ with the excitation current of 75 mA. The result of this work is valuable in improving the performance of GMR and fluxgate for applications in low-frequency magnetic field measurement.