

Development of high-sensitive and wide-range linear magnetic field sensor

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Recently, there are increasing interests in high sensitive magnetic sensors from a view point of application to biomagnetic sensing and non-destructive analysis. For example, pT level or smaller value of magnetic detectivity is required for the detection of electrical activities in brain and heart. Spin-valve TMR sensor is one of the candidates to realize such high performance at room temperature without complicated equipment. High sensitive spin-valve TMR with bottom free layer structure has been reported^{1,2}. Nevertheless, in general, there are technical tradeoff between the magnetic sensitivity and the input range of the magnetic field.

In our study, an improved magnetic sensor structure with highly enhanced magnetic sensitivity has been developed by incorporating an optimally designed magnetic flux concentrators (MFC) with bottom free structured TMR. Also excellent linearity with wide input range has been successfully obtained by using magnetically balanced closed-loop system.

Figure 1 shows transfer functions of the magnetic sensor with MFC and that without MFC. The magnetic sensitivity is enhanced over 87 times larger than that without MFC. In order to make such high sensitivity compatible with wide input range, we utilized magnetically balanced closed loop system. The linearity of the closed loop sensor is better than $\pm 0.1\%$ F.S. (Fig.2) in the range as much as $\pm 100\ \mu\text{T}$, which is larger than the earth magnetic field. Figure 3 shows a sensor output signal spectrum in which an input sine wave signal of 354 pT rms at 10 Hz is detected with sufficient SNR.

This sensor device structure explained above is envisioned to become a key technology in realizing the magnetic sensing of pT level.

- 1) K. Fujiwara et al, Journal of Applied Physics, 111 (2012) 07C710
- 2) K. Fujiwara et al, Japanese Journal of Applied Physics, 52 (2013) 04CM07

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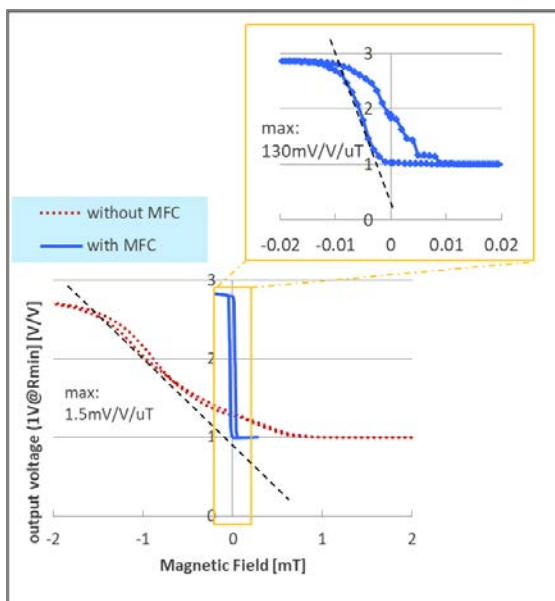


Fig. 1 transfer functions of the magnetic sensor

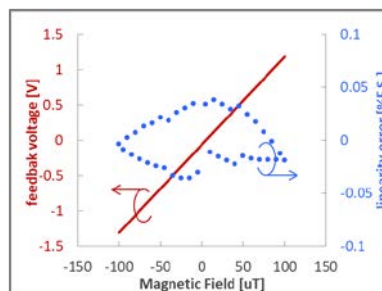


Fig. 2 Feedback voltage and linearity error

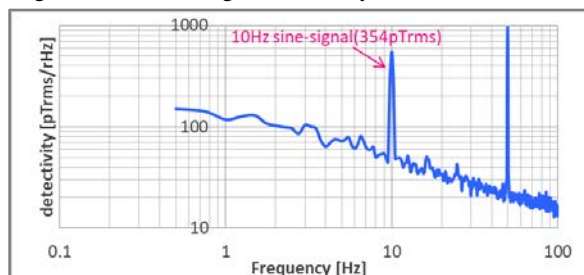


Fig. 3 Spectrum of the sensor output signal with 10Hz sine wave input