# Reduction of fluxgate gradiometer susceptibility to uniform magnetic fields using permalloy shielding disk

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A new method for constructing fluxgate gradiometer has been previously introduced[1]. The developed gradiometer uses a pair of fluxgate sensor heads connected in counter series in order to detect the difference in magnetic field. The sensor heads are operated in the fundamental mode orthogonal fluxgate (FM-OFG) mechanism which provides very low noise measurement capability. The developed gradiometer has been proven to be efficient in detection of tiny magnetic particle contaminations down to the size of 50 μm[2]. The parasitic susceptibility of the FM-OFG gradiometer to the uniform magnetic field is, however, in need of reduction when the gradiometer is used in magnetically noisy environments. In this work, in order to reduce the parasitic susceptibility of the gradiometer to the uniform magnetic field, the efficiency of a small permalloy disk plate placed underneath the gradiometer sensor heads is investigated. The efficiency of the method is estimated numerically and confirmed experimentally.

Figure 1 shows an illustration of the sensor configuration with the shielding desk. The two heads of the FM-OFG gradiometer are configured parallel to each other with a baseline separation distance between the centers of the two heads. The sensor heads are centered above the shielding disk with a separation distance of 5 mm. Experiments were conducted using two permalloy disks of thickness 1 mm having diameters of 10 cm and 12 cm. To evaluate the shielding disk effectiveness; a quasi-static uniform field is applied parallel to the sensor heads axis. It is noted that, the effect of adding the shielding disk to the sensor on the amplitude of the sensor output signal has been evaluated and found to be of minor relevance (less than 10 % reduction). The recorded experimental results are shown in Fig. 2, for the measured gradiometer susceptibility to uniform field vs. the separation baseline between the sensor heads. From the graph, we can see the gradiometer uniform field susceptibility with the shielding disk is reduced to around a fifth of its value for the individual sensor. The shielding performance is improved as the baseline separation is reduced, where the sensor heads grow closer to the center of the shielding disk.

The proposed sensor configuration achieved a significant reduction to the FM-OFG gradiometer susceptibility to uniform fields. The improved configuration has several prospective applications to be used in, such as; magnetic contaminant detection in lithium ion battery manufacturing, and magnetic nanoparticles detection for biomedical applications.

**References**

[1] I. Sasada and S. Harada, "Fundamental mode orthogonal fluxgate gradiometer," IEEE Trans. On Magn., Vol. 50, 4007404 (2014).
[2] A. L. Elrefai and I. Sasada, "Magnetic particle detection in unshielded environment using orthogonal fluxgate gradiometer," Journal of Applied Physics., 117, 17C114 (2015).

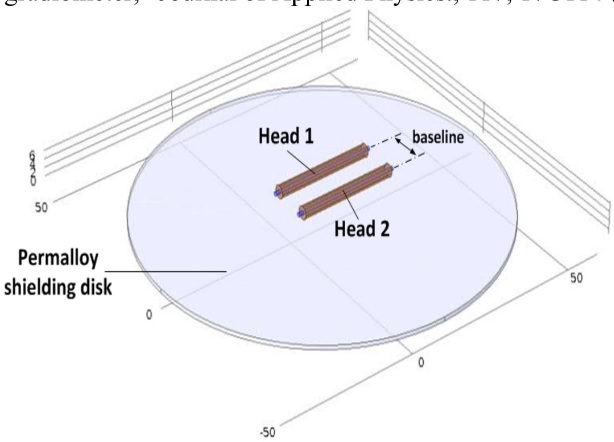


**Fig. 1:** Illustration of the sensor placement over the shielding disk. The sensor heads plane is 5 mm above the shielding disk plane.

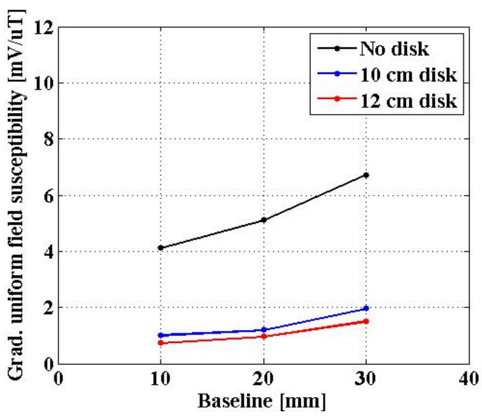


**Fig. 2:** gradiometer uniform field susceptibility [mV/μT] vs. baseline separation distance [mm] without shielding disk and with shielding disk of diameters 10 and 12 cm.