Recent developments on magnetoimpedance sensor

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Sensitive micro magnetic sensors referred to as MI sensors[1] are based on magnetoimpedance (MI) effect in amorphous wires and CMOS IC electronic circuits providing a sharp-pulse excitation. Micro sized mass production MI IC chips for electronic compasses have been supplied since 2002 for mobile phones and since 2010 for smart phones. Making use of ultra-low intrinsic magnetic noise in amorphous wires, pico-Tesla (10^{-8} Oe) resolution had been realized for developed MI sensor, in which several hundred turns pick-up coil was used for signal detection.

For measuring extremely weak magnetic field such as a bio-magnetic field, it is necessary for canceling the background uniform noises such as geomagnetic field. We have developed a gradiometer based on the MI sensor. The gradiometer is composed of a pair of MI elements: a sensing element and a reference element with distance between elements of 3 cm. The gradiometer has a good linearity and a high sensitivity of 1.2×10^5 V/T even for no amplification (Fig.1). The sensitivity difference in two heads is within 1%. As shown in Fig. 2, the noise level of the gradiometer is approximately 2 pT/Hz$^{1/2}$ at 1Hz. We have also demonstrated bio-magnetic field measurement using the high performance MI gradiometer[2)-3)].

Three principal advantageous features of the amorphous wire MI sensor in summarized are follows.

1) Sub-millimeter size sensor head is realized with a high sensitivity of several nT resolution. Utilizing this advantage, 3-axis electronic compass chips having 10 μm diameter amorphous wire heads are in producing; those are compatible with the advanced integrated circuitry for smart phones.
2) Ultra high sensitivity with a resolution of 1 pT without any magnetic shielding in a portable type MI sensor operating at room temperature have been realized.
3) Ultra quick response for magnetic field signal detection will be useful for micro size wireless receiver application.

References

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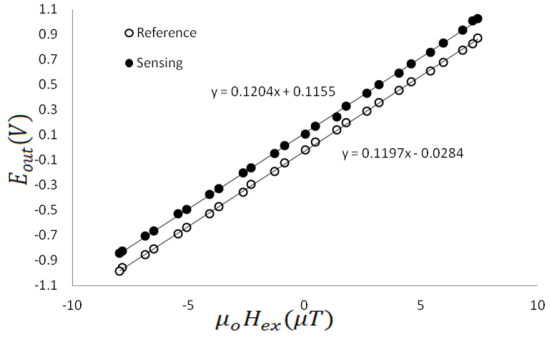

Fig.1 Field detection characteristics of the MI gradiometer. Number of turns of the pick-up coil is 600 and the length of the wire is 1 cm.

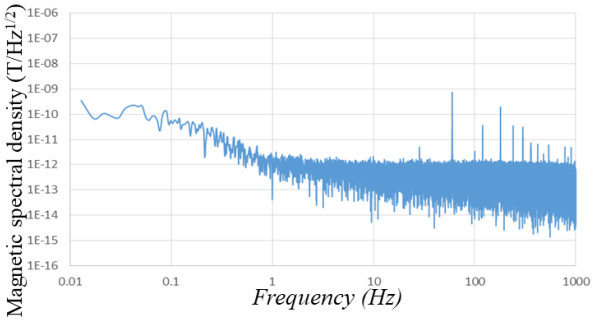

Fig.2 Magnetic noise spectral density of the MI gradiometer.