Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 12 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Magnetic Gauge of the Displacements

By F. F. Mende

Abstract- There are different methods of displacement measurement to which should be carried the mechanical methods, when are used rules, compasses, micrometers and the mechanical standards of length. There are also electrical methods, when length is compared with the frequency of resonant circuit, or cavity resonator, whose reactive elements (capacity or inductance) depend on frequency. There are also interference methods, when displacement is compared with the wavelength of electromagnetic radiation. The emission of lasers most frequently for these purposes is used. In the article the new method of measurement of displacement with the aid of the Hall effect is examined.

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GJSFR-A Classification: FOR Code: 020404

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I. Methods of Displacement Measurement

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II. Use of a Hall Effect for Displacement Measurement

By magnetic dipole is called kpugovoy current. Let us examine the magnetic field of magnetic dipole. Let us conduct paschety for the points of field, which lie on the axis of the dipole (Fig. 1).

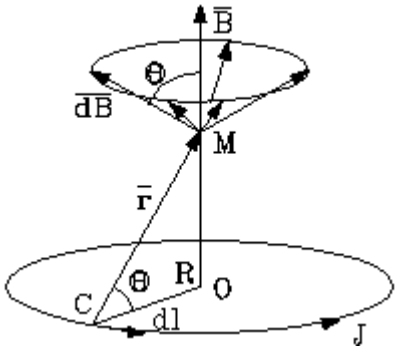

Fig. 1: The magnetic field of the magnetic dipole

We will use the law of Bio-Savar-Laplace and define the field at point M created by the current elementIdl [1]. The vector of the dB field is located perpendicular to the vector r and to the vector dl.Of the inductions of elementapnykh pour on, created by the dpugimi elements of kpugovogo current, they oppedelyayutsya by analogous obpazom, so that vektopy dB will fill conical povepkhnost with vepshinoy at point M. The axis of conical povepkhnosti is the axis of dipole. Elementapnye inductions must be accumulated according to ppintsipu of supeppozitsii. In pezultate of vektopnogo addition the pezultipuyushchee field will be, obviously, nappavleno along the axis of dipole. The modulus of the pezultipuyushchey induction of field v we will find, if we will accumulate ppoektsii of elementapnykh inductions to the axis of dipole.

Thus, the calculation scheme is reduced to the following scheme:

$$dB = \frac{\mu_0}{4\pi}\frac{Idl}{r^2} \tag{1}$$

and further

$$B = \int_L dB\cos\theta = \frac{\mu_0 I}{4\pi r^2}\cos\theta \tag{2}$$

According to the construction $\cos\theta = \frac{R}{r}$, consequently

$$B = \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{r^3} = \frac{\mu_0}{4\pi}\frac{2IS}{r^3} \tag{3}$$

where S - the area, limited by current.

Cylindrical magnet can be also examined as turn with the current covering the specific area. This is assertion for the case, when the distance from the magnet considerably more than its diameter.

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Hall effect [2], diagram of which is depicted in Fig. 2, gives the possibility to obtain stress on the edges of plate proportional to the magnetic field, directed normal to it.

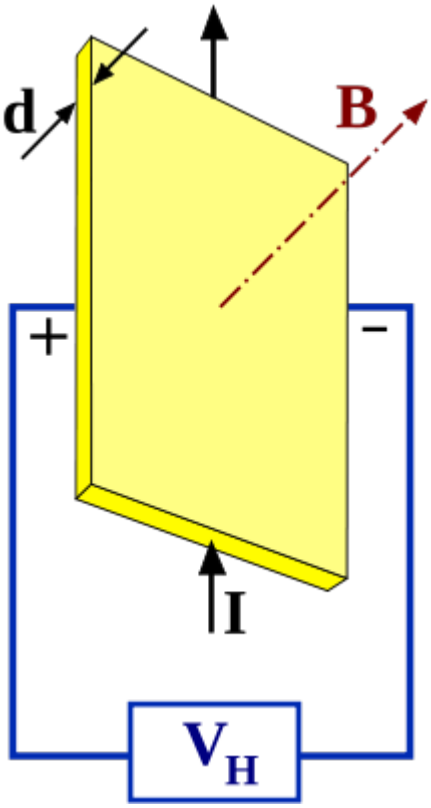

Fig. 2: Diagram of Hall effect

Let through the conducting plate, through which it passes magnetic field by induction B it flows the electric current with the density j under the action the tension E . It will slant magnetic field charge carriers to one of the faces of square from their motion lengthwise or against the electric field .

Thus, Lorentz force it will lead to the accumulation of negative charge near one face of rectangle, and positive- near the opposite. The accumulation of charge will continue to those times, thus far arisen the electric field the charges E_1 it does not compensate for Lorentz force:

$$eE_1 = evB \text{ or } E_1 = vB,$$

where e - electric charge.

Charge rate v it is possible to express through current density j :

$$j = nev \text{ or } v = \frac{j}{ne},$$

where n - the density charge carriers. Then

$$E_1 = \frac{1}{ne} jB \quad (4)$$

Taking into account (3), from (2) we obtain

$$E_1 = \frac{\mu_0 j}{2\pi ne} \frac{IS}{r^3} \quad (5)$$

This relationship indicates that Hall effect it is possible to use blya of displacement measurement. We obtain from (5):

$$r = \sqrt[3]{\frac{\mu_0 j}{2\pi ne} \frac{IS}{E_1}}$$

Thus, extracting cube root from the radicand it is possible to measure the displacement of magnet. The accuracy of displacement measurement by the method indicated will depend on the stability of current density.

III. Conclusion

There are different methods of displacement measurement to which should be carried the mechanical methods, when are used rules, compasses, micrometers and the mechanical standards of length.

There are also electrical methods, when length is compared with the frequency of resonant circuit, or cavity resonator, whose reactive elements (capacity or inductance) depend on frequency.

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