Rotation Magnetization Reversal Fluxgate Excited by the Voltage Source

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Abstract – **Fluxgate with rotation magnetization reversal of the isotropic disk core under the harmonic voltage source excitation has been analysed and the model of the response on the measured field components has been developed. When the excitation frequency is a half of the excitation circuit resonance frequency, the fluxgate sensitivity increases quadratically with the frequency and can exceed the sensitivity of the current driven fluxgate.**

Keywords – **Fluxgate, sensitivity, resonance excitation, rotation magnetization reversal.**

I. INTRODUCTION

Fluxgate magnetic field transducers belong to the parametric inductive transducers that can register very weak and slowly changeable magnetic fields [1, 2]. They consist of the core made of the soft magnetic material, excitation coil and the pick-up coil. The fluxgate operation principle is based on the ferromodulation effect that consists in the second harmonic appearance in the EMF induced in the pick-up coil when the measured field is applied. It originates from the core nonlinear susceptibility that additionally modulated by the fast excitation magnetic field. But the problem arises with supplying the current of the given shape into excitation coils due to the core nonlinearity. The problem becomes especially remarkable in fluxgates with rotational magnetization reversal of the disk core. Such fluxgates have some advantages over the traditional ones that consist in lower threshold of the inherent noise and the possibility to measure up to three orthogonal magnetic field components [3, 4]. Magnetic excitation in such fluxgates is provided by the field that rotates in the disk core plane and with magnitude sufficient to saturate it. Rotational magnetic field is created by two coils with orthogonal axes which currents' phases shifted one to another by $\pi/2$. In a given work we analyse such a fluxgate in a regime when the excitation coils are driven by harmonic voltage that is much easier to realize. It is shown that this implementation can have essential advantages.

II. RESPONSE SIGNAL MODEL

The excitation coil is considered as the series-oscillating circuit element in which the harmonic oscillations are provided by the harmonic voltage source with EMF $\varepsilon_e(t)$ = $Ue^{j\omega t}$. The circuit consists of inductance L of the excitation coil and of all wires, active resistance R of all the wires including the voltage source internal resistance, capacitance C that include the part of the coil parasitic capacitance and the capacitance of the capacitor for circuit resonance frequency adjustment, as well as additional nonlinear voltage source component of the inductive EMF induced in the coil at the measured field presence due to ferromodulation effect.

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Excitation circuit current equation will appear as:

$$L\frac{d^2I}{dt^2}+R\frac{dI}{dt}+\frac{1}{C}I = j\omega Ue^{j\omega t}+Kh\left(\left(\frac{dI}{dt}\right)^2+I\frac{d^2I}{dt^2}\right), \quad (1)$$

where U is an excitation voltage amplitude, h is a measured field, K is a coefficient, that depends on the material properties and the transducer construction. The equation (1) is solved analytically by asymptotic method in assumption that measured field is small. As follows from the solution the current in the excitation coil has two resonances: at a circuit natural-vibration frequency ω_0 and at a half-frequency $\omega_0/2$. When the circuit is excited at a $\omega_0/2$ frequency, voltage across the coil is proportional to the measured field with sensitivity that depends quadratically upon the excitation frequency. Thus, increasing the circuit resonance frequency and the excitation frequency correspondingly, the sensitivity of such a fluxgate may exceed the sensitivity of the current driven fluxgate which the second harmonic amplitude of EMF induced in the pick-up coil is proportional to the excitation frequency at fixed value of measured field. Besides, using the voltage driven mode and measuring the signal on the excitation coil, there is no need any more of the pick-up coil that simplifies the fluxgate design.

III. CONCLUSION

The excitation coils voltage supply mode of a given shape is considered in this paper. It was shown that in the case when the excitation frequency is one half of the circuit resonance frequency that is composed by the excitation coil and the capacitor, the fluxgate sensitivity depends on the excitation field frequency quadratically and can exceed the current driven fluxgate sensitivity. The necessity of the pick-up coil disappears in this case that that simplifies the design of fluxgate transducer.

REFERENCES

[1] F. Primdahl, „The fluxgate magnetometer" *J. Phys. E: Sci. Instrum.* Vol. 12, pp. 241-253, 1979.

[2] P. Ripka, „Advances in fluxgate sensors", Sensors and Actuators A, Vol. 106, pp. 8-14, 2003.

[3] P.M. Vetoshko, M.V. Valeiko, P.I. Nikitin, „Epitaxial iron garnet film as an active medium of an even-harmonic magnetic field transducer" *Sensors and Actuators A*, Vol. 106, pp. 270-273, 2003.

[4] S.B. Ubizskii, L.P. Pavlyk, E. Hristophorou, „Rotation magnetization reversal modelling of the single crystalline iron garnet film as a magnetic film transducer", Scientific Notes of Tavrida National University named after V.I. Vernadskii, Series „Physics", Vol. 19 (58), pp. 68-75, 2006.