Miniature Induction Sensors for Scientific Research and Objects Diagnostics

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Abstract - **This paper presents the design peculiarities of induction sensors for magnetic fields study: the first, for the use in space conditions and the second, for the study of anomalous magnetic fields arising from rails flaws. For both cases the problem of their size minimization while ensuring minimum level of magnetic noise and the required spatial resolution is discussed.**

Keywords – **miniature induction sensor, magnetic field, noise level, flux concentrators, defects in rails.**

I. INTRODUCTION

Induction magnetometers (IM) are widely used for natural and man-made magnetic fields variations study. They are probably the most widespread devices used for minerals and hydrocarbons exploration, study of the Earth's magnetic field structure, detection of hidden metal objects, non-destructive test and technical diagnostics of the objects and constructions, electromagnetic compatibility problems solution, information security providing in the telecommunication systems, research of the effects of electromagnetic radiation influence on the environment and others. They have relatively high sensitivity and wide band of received signals, ability to measure the components of the variable magnetic field vector what allows obtaining full information about the field structure, high reliability, relatively low cost and maintenance and use convenience.

Certainly, different application areas impose different requirements to the main IM parameters. For example, systems for objects electromagnetic diagnostic require IMs that may have relatively low sensitivity but provide a good spatial resolution to detect local or point-like magnetic field perturbations over defects [1]. If to such IMs the rigid requirements as to low level of own magnetic noise are not imposed, for the IMs for space research, to the requirements of weight and power consumption minimization, necessary to have as low as possible noise level. IM for field exploration geophysics must have as low as possible magnetic noise level and such its parameters as length, weight and power consumption have secondary importance.

This report is devoted to the induction sensors (IS) intended for first two applications mentioned above: the first, for magnetic fields study in space conditions and the second, for the detection of anomalous magnetic fields arising from rails flaws.

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II. MINIATURE INDUCTION SENSOR FOR SPACE RESEARCH

To raise the sensitivity of the miniature IS for magnetic fields study in space conditions the magnetic flux concentrators at the ends of the IS core are applied as proposed in [2]. The features of this approach are discussed and it is shown that the efficiency of these concentrators use depends not only on the ratio of concentrator diameter to the core diameter, but also on the ratio of core length to concentrator diameter. Based on these results the miniature ($19x19x19$ mm^3) three-components IS was designed and manufactured. Its experimental studies have confirmed the sensitivity threshold increasing in 2.2 times compared with the IS having the core without concentrators. Based on such an IS the IM LEMI-139 (operating frequency band 40 - 10,000 Hz) with intrinsic magnetic noise level $9 \cdot 10^{-2}$ pT / $\sqrt{}$ Hz at 7 kHz was created.

III. LOCAL INDUCTION SENSORS FOR THE RAILS DIAGNOSTICS

For local and point-like defects in rails diagnostics the corresponding ISs for high-speed magnetodynamic flaw detection method were created. The necessity of multi-channel system usage is discussed. The models of local ferromagnetic induction sensor (FIS) and point frame type sensor (PFS) were designed for such task solution. The main parameters of the FIS and PFS are presented. The possibility of their use for multi-component and multi-channel recording of the magnetic field perturbations arising over the defects of rails is shown.

IV. CONCLUSION

For both cases the problem of minimizing ISs geometric sizes while ensuring minimum level of magnetic noise and the required spatial resolution is discussed. The models of the miniature sensors were designed and high level of their parameters is experimentally verified.

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