ISSN 0735-2727, Radioelectronics and Communications Systems, 2020, Vol. 63, No. 5, pp. 235–247. © Allerton Press, Inc., 2020.
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Hankel Transform Application for Calculation of Ring Coils Inductance. Part 1

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Received March 13, 2019
Revised March 9, 2020
Accepted April 29, 2020

Abstract—Electro-acoustic transducers of electromagnetic type are mainly use in modern non-destructive monitoring and technical diagnostics devices of metal products. The influence of a measuring device on parameters of recorded signals, i.e. on the measurement results, can be eliminated if the influence of dimensions of emitters and receivers of alternating magnetic field on the efficiency of generation and reception of elastic waves by the electromagnetic-acoustic method is known in advance.
The article is devoted to the development and testing of a method for calculating the inductance of the electrical circuit of ring coils, which are used in electro-acoustic transducers of electromagnetic type. Improvement of computer technology allowed us to apply the methods of integral transformations, which are still considered unsuitable for practical calculations.
The new method for calculating the inductance of an electrical circuit located near a conductive ferrimagnet is presented. The solution for the case of a ring coil in vacuum is shown. The reliability of the proposed method is confirmed by the results obtained, which fully correspond to the well-known statement of electromagnetic field in a conductive ferrimagnet.

DOI: 10.3103/S0735272720050027

1. INTRODUCTION

Electro-acoustic transducers of electromagnetic type are designed for exciting and receiving ultrasonic waves in metal products under non-destructive testing [1]. They consist of a source of alternating magnetic field, corresponding receiver, a source of constant bias field, and a certain volume of metal located in the immediate vicinity of a source (receiver) of an alternating magnetic field. The processes of interconversion of the energy of electromagnetic field into energy of elastic vibrations of material particles of a metal occur in one, and vice versa.

The elements of an electromagnetic transducer that excites ultrasonic waves in a thick metal plate of a ferromagnetic group are schematically shown in Fig. 1. Position *1* (Fig. 1) indicates the source of an alternating magnetic field (inductor)—a ring coil of turns of wire through which an alternating electric current flows harmoniously time-varying $I(t) = I_0 e^{i\omega t}$, where I_0 is the current amplitude, $i = \sqrt{-1}$ is the imaginary unit, ω is the circular frequency of sign change (flow direction) of alternating current, *t* is the time. The dimensions of the coil *R* are shown in Fig. 1.

Position *2* (Fig. 1) shows a volume element of a ferromagnetic thick plate. The electric properties of the metal are determined by electrical conductivity *r*, which can be considered as an element of the second rank tensor with a spherical index surface. The magnetic properties of a ferrimagnet are determined by a diagonal matrix with elements μ_{11}, μ_{22}, and μ_{33} of a permeability tensor. A source of a constant bias field (solenoid), which forms element values with its field μ_{ij} magnetic permeability matrix of a ferrimagnet, is not shown in Fig. 1.

In the practical use of electro-acoustic transducers of the electromagnetic type, oscillations of the non-magnetic gap between the coil and the sheet metal surface inevitably occur. This gap is often called non-contact. In Fig. 1 a non-contact is indicates as δ. When δ changing, the intensity of the alternating

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

The initial version of this paper in Russian is published in the journal "Izvestiya Vysshikh Uchebnykh Zavedenii. Radioelektronika," ISSN 2307-6011 (Online), ISSN 0021-3470 (Print) on the link http://radio.kpi.ua/article/view/S0021347020050027 with DOI: 10.20535/S0021347020050027.

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