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Selection of Parameters of the Ferrite Element for Pulse UWB Receiving Antenna

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Abstract—The theoretical model of pulse ultrawideband (UWB) receiving antenna consisting of a ferrite element surrounded by a coil of conductor is investigated. The magnetodielectric cylinder of infinite length is selected as the ferrite element. The excitation UWB signal represents a pulse of electromagnetic field with the envelope in the form of a Gaussian function with high-frequency filling signal. The peculiarities of amplitude-time dependence have been considered for the pulse of induction electromotive force occurring in the closed conducting loop, which surrounds the cylinder, under the assumption of absence of its influence on the scattered fields inside and outside the cylinder. The connection between the electromagnetic parameters of the ferrite element and the frequency-time parameters of the excitation pulse electromagnetic field, which are optimal from the point of view of effective undistorted signal reception, has been determined.

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INTRODUCTION

Enhancement of capabilities of traditional radiolocation in order to identify and recover the form of an object based on the characteristics of the scattered field, investigation of fields, that occur in the case of electromagnetic signals influence on various objects, are associated with the utilization of time and spatially confined fields (pulses) with different types of the envelope and the width of the frequency spectrum [1–5]. In particular, such pulses are widely applied to solve the problems of subsurface sounding. In this branch of radiolocation the problem of development of a compact pulse ultrawideband (UWB) receiving antenna, which provides high sensitivity and does not distort the form of the received signal, remains relevant.

Ferrite loop antennas can be utilized as such kind of antennas. The introduction of a ferrite core into the loop antenna allows one to improve its sensitivity and to reduce the sizes significantly. There are a large number of publications aimed at solving the problems of broadening of the operation frequency band of the ferrite antennas and at their sensitivity increasing [4, 6–11].

The operating principle of the ferrite antenna consisting of a conductive loop, inside of which the rod of the low-frequency ferrite is located, is similar to the operating principle of the wideband pulse transformer and it allows one to use simultaneously two conversion mechanisms of the detected field intensity into the output signal of the receiving antenna. Fast field variations are detected by the loop, and the registration of slow variations is provided by the processes of ferrite reversal magnetization.

Since the characteristics of a pulse UWB receiving ferrite antenna depend on the electromagnetic parameters of the ferrite rod (magnetic permeability of the ferrite, the geometric dimensions of the cylinder), then in order to develop practical designs one needs to select their optimal set. The theoretical analysis of amplitude-time dependences of UWB pulse fields, which are induced inside the ferrite rods with different electromagnetic parameters, will greatly simplify this process.

A rigorous solution of the arising boundary problem with the formulation of boundary conditions, which take into account the finiteness of ferrite element's length and connected with it circular conductor of limited sizes, is a complex mathematical problem, the solution of which has not been obtained yet. However, in the case of small loop size compared with the spatial length of the incident pulse and large ratios of length of the ferrite rod to its diameter one can neglect their influence on the diffraction fields inside and outside the cylinder. These conditions determine the further formulation of the problem, in which the characteristics of the impulse of electromotive force (EMF) of the induction within a loop are the investigation subject. In order to perform undistorted reception of UWB signal the amplitude-time dependence of the induction EMF

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