Fig. 4 that both the active and reactive components of the load approach zero, with the natural field of the spherical antenna exerting the predominant influence on the shaping of the radiation pattern. This means that, by appropriately choosing the parameters $ka$, $kb$, $\theta_0$, $\varphi_0$, $\varphi_1$ (and, through them, the load values $Y_L$ and $Y_R$) we can achieve a mode of operation of the spherical antenna such that the effect of the dipole source can be ignored, i.e., achieve control of the radiation of the "dipole+loaded sphere" system, with maximum radiation power ensured in each specific instance.

LITERATURE CITED


METHOD OF MODIFIED DIRICHLET PROBLEM FOR CALCULATING PARAMETERS OF MULTICONDUCTOR LINES

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A method is proposed for calculating the parameters of multiconductor lines whose cross section is filled with a piecewise-homogeneous magnetodielectric. It is assumed that a TEM mode propagates in the line. The thickness of the conductors is finite, and the interfaces between regions with different magnetodielectrics are arbitrary. The line may be closed or open. The method makes it possible to compute line parameters when the potentials or charges are arbitrarily specified on the sources. Calculations involve the solution of a singular integral equation whose kernel can be set up in elementary fashion. An example of numerical implementation of the method is given. An accuracy estimate for the numerical results is given.

Introduction

As we know [1], multiconductor transmission lines are extensively used in microwave engineering (strip lines in particular). In this paper we investigate a multiconductor line whose cross section is shown in Fig. 1. As a particular case, the line may be open, i.e., without a screen with contour $L_0$. All of our study will be made for TEM modes. The losses in the metal and magnetodielectric are disregarded.

If we formulate the electrodynamic problem exactly, then no TEM wave can exist in a line filled with piecewise-homogeneous magnetodielectric, and hence the calculations cannot be reduced to the solution of a Laplace equation. The basis for using the "TEM approximation" is provided both by the results of numerous experiments over a fairly wide range of frequencies, and by theoretical studies of the dispersion in individual lines. For example, for asymmetrical strip lines (which have been investigated most completely), it has been established that allowance for the dispersion yields a correction of 2.8% as compared to the TEM approximation for a ratio of the greatest characteristic dimension of the line to the wavelength of 0.1 [2]. We can anticipate that the error will be of the same order of magnitude for an arbitrary line if the ratio of the greatest characteristic geometrical dimension of the line to the wavelength is on the order of 0.1 or less. For microstrip techniques this means that the "TEM approximation" is valid up to centimeter wavelengths. As the theoretical and experimental evidence given in [3] suggests, the parameters of many microwave devices whose basic element is a multiconductor line can be determined with an accuracy of a few percent. Therefore, the line characteristics as computed in the TEM approximation are entirely suitable for calculating the parameters of such devices.

The electrodynamic properties of multiconductor lines with TEM modes can be described if we know the running capacitance and inductance matrices [4]. In this study we will consider only how to calculate the running capacitances. The inductances can always be obtained in the same way, using the principle of duality [5]. Therefore, without loss of generality, we will assume in what follows that $\mu_1 = \ldots = \mu_4 = \ldots = \mu_p = \mu_0$. 

Frequently it is not necessary to know the entire matrix of running capacitances, but rather it is sufficient
to calculate the parameters of a line with preset excitation conditions. For example, it has recently been dis-
covered that strip lines with strips having a free potential are quite promising [6, 7]. As regards such strips
(conductors), it is known in advance that the running charge density on them is zero. Therefore it is necessary
to have a method which would make it possible to calculate the parameters for a line of arbitrary configuration
relatively simply, independently of what is known on the conductors (the value of the potential or charge). Here
and henceforth, potential will be understood to mean the potential function of the TEM mode, as defined in [8],
while charge and capacitance will be understood to mean the running charge density and running capacitance.

The problem which we will deal with in this paper can be formulated as follows: For the line shown in
Fig. 1, there are specified potentials \( V_0, V_1, \ldots, V_m \) of conductors with contours \( L_0, L_1, \ldots, L_m \) (\( m \leq n \)), while
on the remaining \((n - m)\) conductors the charges \( Q_{m+1}, \ldots, Q_n \) are known. We are to determine the potential
in the entire region, the charges on the conductors \( L_1, L_2, \ldots, L_m \), and the potentials of the conductors \( L_{m+1}, \ldots, L_n \). For an open line it is additionally specified that the over-all charge \( Q = \sum_{i=1}^{n} Q_i \) is zero, or, equivalently,
the potential at infinity is bounded. After the problem in question has been solved, the calculation of any elec-
drodynamic parameters of the line becomes obvious.

To solve the problem we will employ the method of singular integral equations [9], which was used in
[10] for approximate investigation of strip lines with a piecewise-homogeneous ferrite filler. In accordance
with [10], the integral equations can be obtained directly by using the boundary conditions for the fields, rather
than the potentials. The need for computing the fields in explicit form leads to the fact that a direct relation-
ship between the physical parameters of the line and the solution of the integral equations disappears. Numeri-
cal complications also arise, since the fields (and, together with them, the kernels of the integral equations)
tend to infinity at the corner points in accordance with the boundary conditions on the edge [11]. For lines
with a ferrite filler the direct use of the potentials is rendered difficult by the fact that the permeability tensor
has nondiagonal elements, and this leads to mixing of the real and imaginary parts of the complex potential.
This means that the kernels of the corresponding integral equations will be multivalued functions, and this is
a serious complication in the problem. For lines with isotropic dielectric filler, difficulties associated with
multivaluedness do not arise, and hence it is more convenient to work with a potential that remains bounded
everywhere. Moreover, it will be shown that, by using integral representations different from those in [10],
we can obtain direct relationships between the charge (or potential) of the conductors and the solution of the
singular integral equation. This fact can considerably simplify the problem from both the analytic and the
computational standpoints. Therefore the aim of this paper is to indicate the simplest and most general way
of determining the parameters of multiconductor lines from the solution of the corresponding regular integral
equations, without explicitly computing the electromagnetic fields.

Before proceeding to solve our problem, we should note that if the line is filled with a homogeneous me-
dium, then our problem is simply an electrodynamic reformulation of the modified Dirichlet problem, whose
solution is given in [9]. Hence the name of the proposed method.

**Representation of Potential and Integral Equations**

For the reasons given above, we will give the integral representation of the electric-induction potential,
rather than the electric field potential. We will seek this potential \( \varphi(x, y) \) in the following form: