

Electrodynamics Settings of the Communicator

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Abstract Studied electromagnetic properties of connections between component. The analysis of electromagnetic field components parallel radial highway lanes of the printed and volumetric mounting electronic devices. Found conversion algorithms mutual capacitive, inductive, dielectric and semiconductor parameters of the symmetric and regular communication structures.

Keywords: *between component connections, electromagnetic interference, printed tracks, communicator, electrodynamic parameters, MEMS, NEMS*

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1. Introduction

The theme of this study were between the component connection of computer and other information and communication tools. The current level of technology design and manufacturing of micro and nanotechnology integrated circuits characterized by the use of a variety of physical, chemical and the biological processes. Synergetic approach the study of phenomena and processes of such devices must, first of all, based on the theory and methods of mathematical physics, including electrodynamic [1-8].

Nanotechnology allows the manufacture of monolithic integrated circuits with dividing resolution of 20 nanometers, thereby dramatically raise the frequency of signal processing and increase the integration of elementary components per unit volume.

At the same time, technology design of integrated structures virtually abode at chain theory of electrical circuits, as evidenced by a number of applications of computer simulation: MicroCap, OrCAD, MultiSim more. Some attempts to correct the adequacy models by requiring minimize the total length of highway lanes, such as Altium Designer, do not solve the problem and shaken methods modeling of electrical circuits that are based solely on the classical Kirchhoff's law. However, in [5,6,7,8] expressed reservations that modern monolithic integrated circuit components and means of the relationship between them have acquired properties that can not be accepted mathematical models that incorporated in the software architecture of the above software packages.

2. The Formulation of the Problem

For the first time on the study of electrical circuits as object electrodynamic [1,2], led by Professor O.V. Tozoni started at the Institute of Cybernetics of AS in

Ukraine almost half a century ago. A mathematical model was designed for powerful computing systems - computer type BESM-6. In many cases, individual work brought to the numerical results as of Nikolsky V.V. [3], who studied the chain of high frequency directing devices were only illustrative and had a rather scientific, rather than practical. Lack query, explained the complexity of algorithms, insufficient big at the time integration circuits and weak capacity of computers. A step forward was research of professor A.I. Knyazya in Odessa Electrotechnical Institute of Communications [1,4]. The proposed methods of calculation fields in the quasi-stationary approximation, was based on the analogy of different orthogonal coordinate systems, allowing to simplify the complexity of numerical algorithms. However, a number of unresolved issues, including the problem of space-time distribution of sources of flow vectors induction and selection of idealization the communicator structure of and a number of other poorly formalized tasks are not allowed to bring results to the finished application. To solve the problems set out accounting electromagnetic interference between component connections leading scientists have joined efforts within research areas, which are called micro- and nanoelectronic mechanical systems (MEMS, NEMS) [6]. However, the search for simple algorithmic mapping procedures morphology monolithic integrated circuit design is extremely urgent problem

3. Statement of the Tasks

In generalized models of analysis and synthesis high frequency of electrical [1-9] circles one of the main problems is the calculation of the flow of the electric and magnetic induction in different environments, conductor, dielectric, magnetic, characterized by the relevant material parameters γ , μ , ε . The source of these streams are currents and voltages trees communicator. Under the communicator is to be understood compositional element of the circuit, that transfers energy from one component to another component. The form and value of the energy in

the idealized communicator remains unchanged. In other words, if from the electronic device to remove all are concentrated components, that make information and changing energy, then we get the communicator. First of all - a single-layer or multi-layer boards, for example, Figure 1.

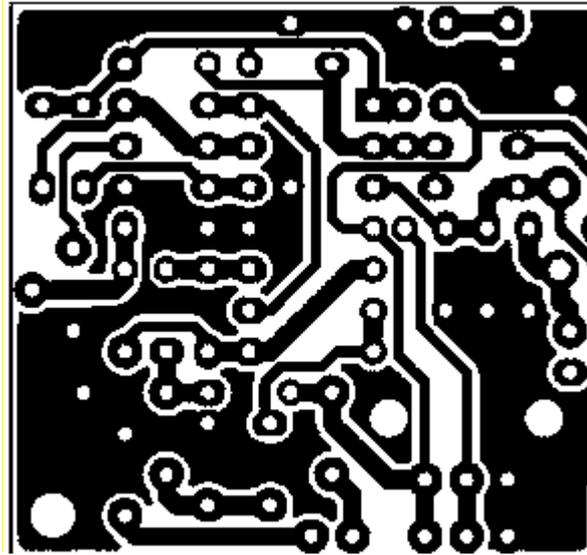


Figure 1. Communicator - a piece of PCB

The source of these streams are currents and voltages trees the communicator. The surfaces through which flows calculated asked morphology device. Depending on the need to identify those or other electromagnetic parameters such surfaces are: lateral surface highway lanes; closed circuit formed highway lanes, or surface tree (node communication highway lanes), as part of the device. Under the trees means a series of parts of the communicator on which it crumbles when removing from the construction the lumped components and their replacement by point equivalents insulated from each other all poles (their geometrical extensions) at this point.

Model the communicator as compositional elements of the electronic device may be formed in a matrix equations that reflect the relationship descriptors (sets of actions and reactions) at its poles. In general, impacts and reactions can be any physical quantities: current, voltage, the flow of the electric and magnetic induction, charges, power and so on. For example, under the influence can be regarded as a set of arc voltage components and reactions - currents poles, or vice versa.

In general, using a variety of natural phenomena and processes in the transfer of energy and information the communicator complexity of calculating matrix elements determined the communicator varying degrees of detail physical, electromagnetic, chemical and biological processes that contribute to its functioning.

Analysis of structures the communicator type electrodynamic restrict the following tasks: preparation system matrix equations that establish the relationship between currents and voltages pole arcs the communicator; formulation of the problem of calculating the parameters of the communicator in the quasi-stationary approximation; determine the potential of the electromagnetic field; calculating the flow of magnetic and electric induction for most common morphological structures the communicator; determine the relationship between the magnetic and

electrostatic settings of communicator; performed numerical calculations to confirm the results.

4. The Main Part

Consider a system of matrix equations, which connects the voltage and current curves pole device. Let the electric circuit consists of k components, the communicator has n poles that combine these components in the electrical circuit. Not narrowing generalization assume that the number of branches of the communicator equals the number of its poles, and the total number of trees - $(r + 1)$. Within quasistationary approach can assume that every tree, like the "topological" node of the circuit has one and the same potential. Thus, the number of independent trees (nodes) will be equal to r , that is one less of the total, and the number - independent paths defined cycloramic number of the graph corresponding electrical circuit

$$q = n - r + 1 - k, \quad (1)$$

4.1. Resistive Communicator Parameters

To form ohmic losses conductors such as contour ξ can be written

$$U_{\xi}^{Rd} = R_{\xi,1}^d * I_1 + R_{\xi,2}^d * I_2 + \dots + R_{\xi,n}^d * I_n \quad (2)$$

where ξ - additional voltage ξ - circuit, caused by the voltage drop across all its areas of conductor, marks on uppercase Rd do not have the numbers, and indicate that the corresponding values are wood communicator (d) and belong to the ohmic losses (R); $\alpha = \overline{1, n}$ - number pole trees (number of poles trees and poles components identical); $R_{\xi,\alpha}^d$ - resistance plot communicator "tied" to the current pole I_{α} .

Keep in mind that the current pole is not always equal currents tree branches and resistant individual conductors may differ from equivalent ohmic values of parameters.

Really $R_{\xi,\alpha}^d$ - is a common aspect ratio between voltage and current at the poles, rather than any conductor within the device.

Defining communicator, fixing ohmic losses $R_{\xi,\alpha}^d$ are problems of electrodynamic, formulation which will be executed later.

Number of independent equations of type (2) in accordance with the second Kirchhoff's Law defined by the formula (1). The matrix form of writing is:

$$\begin{bmatrix} U^R \end{bmatrix}_{q,1} = \begin{bmatrix} R^d \end{bmatrix}_{q,n} \begin{bmatrix} I \end{bmatrix}_{n,1} \quad (3)$$

Model calculation ohmic losses in conductors of communicator represented in the form (3), called current, that is such, a source of additional voltages in which is the current poles components.

4.2. Inductive Communicator Parameters

Consider another type of current models that allows accounting the magnetic flux through the contours of the communicator.

According to Faraday's law of independent circuits are shown in additional voltage due to currents create magnetic flux tree branches of communicator also can be written as (3)

$$[\dot{U}^\Phi]_{q,1} = [Z^d]_{q,n} [i]_{n,1}, \quad (4)$$

where a separate line presented as

$$U_\xi^{d\Phi} = Z_{\xi,1}^d * I_1 + Z_{\xi,2}^d * I_2 + \dots + Z_{\xi,n}^d * I_n, \quad (5)$$

and every element of the matrix $[Z^d]_{q,n}$, which is at the intersection ξ - row and α - column

$$Z_{\xi,\alpha}^d = j\omega L_{\xi,\alpha} \quad (6)$$

Note that the vectors described voltages and currents the poles of trees (4) are in complex form for subsequent formation of a closed system of equations in symbolic analysis method of complex amplitudes. Substituting (6) into (5) and dividing the result by $j\omega$ available

$$\Phi_\xi^d = L_{\xi,1}^d * I_1 + L_{\xi,2}^d * I_2 + \dots + L_{\xi,n}^d * I_n, \quad (7)$$

indicating that each ξ - circuit ($\xi = \overline{1, q}$) currents that flow from the poles generate magnetic fluxes mediated by. The immediate source of these flows are real leaders the currents trees communicator. Equation (7) in a body can also be present in the matrix form

$$[\Phi]_{q,1} = [L^d]_{q,n} [i]_{n,1}, \quad (8)$$

allowing you to add comprehensive induced voltage circuits (4) as

$$[\dot{U}^\Phi]_{q,1} = j\omega[\Phi]_{q,1} = j\omega[L^d]_{q,n} [i]_{n,1}. \quad (9)$$

It should also be borne in mind that it is current only at the point of connection of communicator and component, not the real currents that generate real magnetic fluxes.

The value of induced voltage in the ξ - circuit ($\xi = 1 \dots q$) depends on the currents of all n of poles components. Thus, the voltage that occurs in ξ -th independent circuit is modeled as a dependent voltage source, the value of which is determined by a linear combination of currents poles (5).

4.3. Conductor Device Settings

The loss of communicator due to substandard insulation properties between the trees we model based on equations that establishes the relationship between the leakage current through the insulation of ξ - tree

$$I_\xi^{Gd} = G_{\xi,1}^d * U_1 + G_{\xi,2}^d * U_2 + \dots + G_{\xi,n}^d * U_n, \quad (10)$$

where I_ξ^{Gd} - additional current ξ - tree which caused partial currents $G_{\xi,\alpha}^d * U_\alpha$ from ξ - tree, $\xi = \overline{1, r}$, under voltage U_α arc α of communicator for the remainder of the trees through certain areas of the insulation environment that came under voltages.

Indications on uppercase Gd does not have the numbers, and indicate that the corresponding values are tree communicator (d) and relate to energy losses in insulator (G); $\alpha = \overline{1, n}$ - number of arcs communicator (number of arcs communicator components and the same); $G_{\xi,\alpha}^d$ - equivalent the conductivity of volume of communicator which is tied to α - tree arc voltage U_α , $\alpha = \overline{1, n}$.

It should again be noted, that the arc voltage is not always equal to the voltage between different branches of trees, and some parts of the conductivity of the insulation space may not coincide with equivalent values conductor parameters $G_{\xi,\alpha}^d$.

Defining the parameters of communicator, that fix the energy loss in the insulation environment $G_{\xi,\alpha}^d$ of is the task of electrodynamics in spreading current conduction in the conductive space.

Number of independent equations of the first Kirchhoff's law such as (10) is equal to r . The matrix form of writing is:

$$[i^G]_{r,1} = [G^d]_{r,n} [\dot{U}]_{n,1} \quad (11)$$

Model calculation of energy losses in the conductor's communicator represented in the form (11), called voltage's, that is such a source of additional current which has a voltage arcs device.

Capacitive options communicators. Consider a model that allows accounting of the electric flow from trees communicator, characterized in that form displacement currents between the trees, i.e. currents, the nature of which is not related to polarization or charge transport in space.

The current displacement creates a variable flow of the electric induction, like current between the capacitor plates in a vacuum (with a perfect insulator) between them.

Displacement currents of trees communicator in matrix form is written as

$$[j^N]_{r,1} = [Y^d]_{r,n} [\dot{U}]_{n,1}, \quad (12)$$

which is presented as a separate line

$$I_\xi^{dN} = Y_{\xi,1}^d * U_1 + Y_{\xi,2}^d * U_2 + \dots + Y_{\xi,n}^d * U_n, \quad (13)$$

and every element of the matrix $[Y^d]_{r,n}$, which is at the intersection ξ - row and α - column

$$Y_{\xi,\alpha}^d = j\omega C_{\xi,\alpha}. \quad (14)$$

Vectors induced currents and voltages of arcs trees (12) are in complex form for subsequent formation of a closed system of equations in symbolic form in accordance with the method of complex amplitudes. Substituting (14) into (13) and dividing the result by $j\omega$ can be obtained

$$N_\xi^d = C_{\xi,1}^d * U_1 + C_{\xi,2}^d * U_2 + \dots + C_{\xi,n}^d * U_n, \quad (15)$$

indicating that from each of ξ - tree ($\xi = \overline{1, r}$) currents flowing from the poles indirectly generate electrical flow. The immediate source of electrical flow is a real voltage

between of the trees communicator. Equation (15) can be represented in matrix form

$$[\dot{N}]_{r,1} = [C^d]_{q,n} [\dot{U}]_{n,1}, \quad (16)$$

that allows us to formulate complex matrix form a plurality of displacement currents of trees (12) in the form

$$[\dot{I}^N]_{r,1} = j\omega [N]_{r,1} = j\omega [C^d]_{r,n} [\dot{U}]_{n,1}. \quad (17)$$

It should also be borne in mind that U_α this is a voltage only on the surface of energy component verge of contact arc and arc the communicator, not the real voltage that generates electrical flow within the device. The value of the bias current ξ - tree ($\xi = 1 \dots r$) depends on the voltage of arcs all n components. Thus, the current shift from ξ -independent tree is modeled as dependent energy sources, the value of which can be formed by (13).

Thus, analyzing the results it should be noted, that electrodynamic problem statement, you should first find the real sources of space-time, which create a stream of electrical and magnetic induction. Guided by the values of these indirect sources, ie descriptors model (topological currents of poles and voltage of arcs components), real space-time voltage and current can be determined only by the terms of morphology analysis device. This poorly formalized problem solved only by creating libraries of composite components communicator (of trees and contours).

Second, the need to develop a library of electrodynamic parameters for the standard, the most common form of highway lanes canonical conductor structures. Thirdly, it is necessary to determine how structural disintegration of complex shapes communicator with a view to their possible reproduction of canonical structures based on superposition. These canonical structures should first consider the components of the communicator in a system and parallel or radial conductors.

5. Vector Potential of the System of Parallel Conductors with Currents

The conductors of communicator usually are laid on the a parallel track and on the track with radial structure in the places of their joining to the electrical components. Field of $(n + 1)$ parallel conductor simply calculated, for example, is known to vector potential in the space between parallel conductors, that directed along the axis z , is independent of the coordinate z and has only one non-zero component. Under these conditions both in Cartesian (x, y, z) , and in polar coordinates it satisfies the Laplace equation

$$\frac{\partial^2 A(x, y)}{\partial x^2} + \frac{\partial^2 A(x, y)}{\partial y^2} = 0, \quad (18)$$

solution which is a function that in polar coordinates

$$\rho = \sqrt{x^2 + y^2}, \quad \alpha = \arctg \frac{y}{x}. \quad (19)$$

takes the form

$$A(\rho, \alpha) = \frac{\mu \sum_{k=1}^{n+1} I_k \ln \sqrt{\rho_k^2 + \rho^2 - 2\rho\rho_k \cos(\alpha - \alpha_k)}}{-2\pi} \quad (20)$$

where ρ_k, α_k - polar coordinate axis of k -th conductor, μ - magnetic permeability of environment in which there are conductors, I_k - current of k -th conductor positive direction which coincides with the direction of the vector potential.

By placing observation point on the surface of the m -th wire by laying

$$\rho = \rho_m \pm a_m \quad \alpha = \alpha_m \quad (21)$$

where m - number a_m - radius m -th conductor, that is, after substituting (21) into (20) we obtain the vector potential of the surface of the m -th wire

$$A_m = \mu \sum_{k=1}^{n+1} I_k P_{mk} \quad (22)$$

where

$$P_{m,k} = \frac{\ln(\rho_k^2 + (\rho_m \pm a_m)^2 - 2(\rho_m \pm a_m)\rho_k \cos(\alpha_m - \alpha_k))}{-4\pi} \quad (23)$$

If the result of calculations by (23) does not depend on what the sign (+ or -) stayed in (21), (23), it allows to justify the assumption coincidence of fields generated strings with fields thin wires. According to the first Kirchhoff's equation total current autonomous system of conductors is zero.

$$I_{n+1} = - \sum_{k=1}^n I_k \quad (24)$$

After substituting (24) in (22) can be folded n equations, each of which determines the value of the vector potential at the m -th wire

$$A_m = \mu \sum_{k=1}^n I_k (P_{mk} - P_{m,n+1}) \quad (25)$$

The magnetic flux Φ_{mk} through the area between the wires m and q with length l , is:

$$\Phi_{mq} = l(A_m - A_q) = l\mu \sum_{k=1}^n I_k \begin{pmatrix} P_{mk} - P_{m,n+1} \\ -P_{qk} + P_{q,n+1} \end{pmatrix}. \quad (26)$$

Volume flow in wires neglected. As the only independent threads n , then without limiting generalization, organize sequence independent review areas in (26) by changing the index $q = m+1$; $m = 1, 2, \dots, n$. Subject to then (26) can be rewritten as:

$$\Phi_{m,m+1} = l\mu \sum_{k=1}^n I_k B_{mk} \quad (27)$$

where

$$B_{m,k} = P_{m,k} - P_{m+1,k} - P_{m,n+1} + P_{m+1,n+1} \quad (28)$$

In (27) double indexes flow of magnetic induction through area $(m, m + 1)$ length l can also be replaced by a

single index m without reducing the information content and submit (27) in matrix form

$$\begin{bmatrix} \Phi_1 \\ \dots \\ \Phi_m \\ \dots \\ \Phi_n \end{bmatrix} = l\mu \begin{bmatrix} B_{11} & \dots & B_{1k} & \dots & B_{1n} \\ \dots & \dots & \dots & \dots & \dots \\ B_{m1} & \dots & B_{mk} & \dots & B_{mn} \\ \dots & \dots & \dots & \dots & \dots \\ B_{n1} & \dots & B_{nk} & \dots & B_{nn} \end{bmatrix} \begin{bmatrix} I_1 \\ \dots \\ I_k \\ \dots \\ I_n \end{bmatrix} \quad (29)$$

The form (29) corresponds to the matrix equation (8), in accordance with which the matrix of magnetic parameters of the parallel wires can be represented as

$$[L]_{n,n} = l\mu [B]_{n,n}, \quad (30)$$

where

$$[B]_{n,n} = \begin{bmatrix} B_{11} & \dots & B_{1k} & \dots & B_{1n} \\ \dots & \dots & \dots & \dots & \dots \\ B_{m1} & \dots & B_{mk} & \dots & B_{mn} \\ \dots & \dots & \dots & \dots & \dots \\ B_{n1} & \dots & B_{nk} & \dots & B_{nn} \end{bmatrix}, \quad (31)$$

Algorithm for computing, for example, L_{mk} each element of this matrix is calculated based on the geometric characteristics of the sequence using formulas (21) and (23), (28) in the cyclic procedures. The number of cycles in each procedure is determined by the number of conductors.

Field current round conductors using conformal mappings can be counted in the field almost parallel conductors of arbitrary cross section, and therefore the results can be generalized to more complex forms of intersections of parallel conductors.

When placing the conductors in the same plane ($y_m = y_k = 0$), or on the surface of a circular cylinder ($\rho = R$) P_{mk} coefficients calculated by the simplified equations, respectively:

$$P_{mk} = \frac{-1}{2\pi} \ln |x_m - x_k + a_m| \quad (32)$$

$$P_{mk} = \frac{\ln[R^2 + (R + a_m)^2 - 2R(R + a_m)\cos(\alpha_{mk})]}{-4\pi} \quad (33)$$

6. Vector Potential System of Radial Conductors

To determine the flows in the system wires crossed appropriate to apply the theory of spherical parallel fields. In spherical coordinates (r, θ, α) coordinate surfaces are: $r = C$ - concentric spheres, $\theta = C$ - circular cones, $\alpha = C$ - half-plane. Instead θ , we will consider the variable β :

$$\beta = \ln \gamma = \lg \operatorname{tg} \frac{\theta}{2} = \lg \frac{\sqrt{x^2 + y^2}}{r + z}, \quad (34)$$

which together with the coordinates

$$\alpha = \operatorname{arctg} \frac{y}{x}, \quad r = \sqrt{x^2 + y^2 + z^2} \quad (35)$$

specifies the location of points in space.

Spherical parallel magnetic field is called the field vector potential which is independent of the coordinates r:

$$\bar{A}_r = A_r \bar{r}^0 = A \bar{r}^0, \quad \frac{\partial A_r}{\partial r} = \frac{\partial A}{\partial r} 0, \quad (36)$$

An important property of spherical parallel field is that imposed coordinates β, α (34), (35) vector potential (36), two-coordinate satisfies the Laplace equation similar to (18):

$$\frac{\partial^2 A(\alpha, \beta)}{\partial \alpha^2} + \frac{\partial^2 A(\alpha, \beta)}{\partial \beta^2} = 0. \quad (37)$$

This means that the field system of parallel filaments with the currents corresponding to spherical field parallel thread-rays system of with current. Potential $A(\gamma, \alpha)$ fields filaments-rays system of with the currents invention similar to (20):

$$\begin{aligned} A(\gamma, \alpha) &= \\ &= \frac{-\mu}{2\pi} \sum_{k=1}^{n+1} I_k \ln \sqrt{\gamma_k^2 + \gamma^2 - 2\gamma\gamma_k \cos(\alpha - \alpha_k)}. \end{aligned} \quad (38)$$

With the potential of spherical- parallel magnetic field can find flows without conducting operations integration. We illustrate this for the flow of magnetic induction. Consider a filled circular sector 1234, Figure 2.

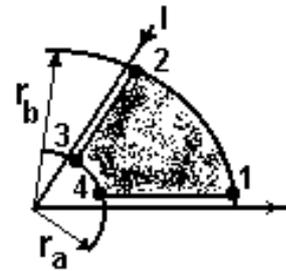


Figure 2. Definition of magnetic flux ring sector

The flow through the sector is

$$\begin{aligned} \int_S \bar{B} d\bar{S} &= \oint_l \bar{A} d\bar{l} = \int_{23} A dl + \int_{41} A dl = \\ &= - \int_{r_a}^{r_b} A_2 dr + \int_{r_a}^{r_b} A_1 dr = (r_b - r_a)(A_1 - A_2) \end{aligned} \quad (39)$$

When taking the integral (39) took into account equality

$$\int_{12} \bar{A} d\bar{l} = 0, \quad \int_{34} \bar{A} d\bar{l} = 0 \quad (40)$$

performed because of orthogonality radial vector (36) and by integrating passing through the area. At intervals - rays 23 and 14 values of the vector potential A is a constant, so he carried under the integral sign. Thus, the flux of magnetic induction, which accounts for unit length in the direction of the radius r is equal to the potential difference in the points through which the rays that create the boundaries of the annular sector.

In determining the flow field plane parallel threads used by potential field and limit the flow calculation was selected at a short distance from the a thread (21). This

distance equal to the radius of the wire. The same procedure for the sphere parallel field consists in choosing the boundary beam - limits conductive sector, which is located near the beam-a thread with the current. To determine the potential value of A on the surface of the conical conductor Figure 3a, it is necessary to put in (38)

$$\gamma = \gamma_1 \pm \gamma_0, a = a_0, \quad (41)$$

where

$$\gamma_1 = tg \frac{\theta_1}{2}, \quad \gamma_0 = tg \frac{\theta_0}{2} \quad (42)$$

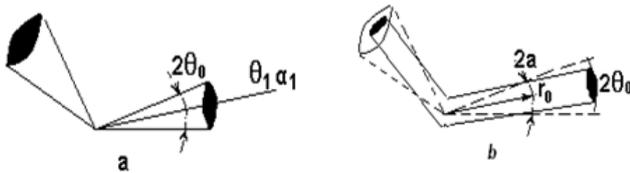


Figure 3. Replacement conical - a cylindrical - b conductor wire

To practice case where the wire has two sharp cones, Figure 3a, less interesting, than the design of wires as thin curved cylinder, Figure 3b. The flow between the cone surface of the conductor, Figure 3a, there will be little different from the stream you want to find, for curved cylinder, Figure 3b, at small angles θ_0 , when executed ratio

$$\theta_0 \approx \frac{a(r_0)}{r_0}, \quad \gamma_0 = tg \frac{\theta_0}{2} \approx \frac{\theta_0}{2} \approx \frac{a}{2r_0} = \frac{a}{l} \quad (43)$$

where, for construction, Figure 3b, a cylindrical wire length

$l = 2r_0$, $a(r_0)$ - radius conical wire at a distance r_0 . Choice of size r_0 at a given radius of a cylindrical wire "a" is related to issues such replacement cylinder cone to flow in finding the place would not have a significant error. Under these conditions, the coordinates of the observation point on the surface of any m-th cone $m = 1 \dots n$ according to (41) can set as

$$\gamma = \gamma_m \pm \gamma_{0m}, \alpha = \alpha_m, \quad (44)$$

Thus, the calculation of magnetic flux in the system of cylindrical radial wires with a common beginning can also be calculated by formulas (27) and (28), provided that the coefficients (23) are calculated by the formula

$$P_{mk} = \frac{\ln[\gamma_k^2 + (\gamma_m + \gamma_{0m})^2 - 2(\gamma_m + \gamma_{0m})\gamma_k \cos(\alpha_m - \alpha_k)]}{-4\pi} \quad (45)$$

It should also be recalled that the results should not depend on the choice of sign in (44), in other words the length of conductors must exceed in order of their radius.

The practical interest is the location of all rays incident on the plane $z = 0$. In this case $\theta_k = \pi/2$ and

$$\gamma_k = \gamma_m = tg \frac{\pi}{4} = 1, \quad (46)$$

which simplifies the expression (45):

$$P_{mk} = \frac{-\ln[1 + (1 + \gamma_{0m})^2 - 2(1 + \gamma_{0m})\cos(\alpha_m - \alpha_k)]}{4\pi} \quad (47)$$

7. Electrostatic Settings of the Communicator

Electrostatic field system of parallel and radial conductors as described by scalar potential $\phi(\rho, \alpha)$ and $\phi(\gamma, \alpha)$. Analytical expressions for them to within a constant factor coincide with (20) and (38) respectively. As algorithmic of procedure consistent with the above-mentioned, give only the final results.

Streams vector electrostatic induction between $n + 1$ parallel or radial wires characterized by autonomy determined through electrostatic voltage between the wires as

$$[N]_{n,1} = [C]_{n,n} [U]_{n,1}, \quad (48)$$

where the matrix of proportionality

$$[C]_{n,n} = \varepsilon l [B]_{n,n}^{-1} \quad (49)$$

between the flow of the electric induction and arc voltage is the matrix of electrostatic the communicator settings and ε - permittivity of environment. The elements of the matrix [B], as such that are formed geometry device also calculated by formulas (28), (23) and (45).

Analyzing the electrostatic matrix (49) and magnetic (30) parameters should be noted the close relationship between their computation algorithms. Doing multiple reciprocal matrix of can get

$$[L]_{n,n} [C]_{n,n} = l^2 \varepsilon \mu [E]_{n,n} \quad (50)$$

where [E] - identity matrix. Equation (50) allows to obtain a matrix of electrostatic parameters through a matrix of magnetic parameters and vice versa.

$$[L]_{n,n} = l^2 \varepsilon \mu [C]_{n,n}^{-1}; \quad [C]_{n,n} = l^2 \varepsilon \mu [L]_{n,n}^{-1} \quad (51)$$

Given the analogy of electrostatic fields and field conduction currents between the wires can be calculated in the same way conductor matrix of parameters (10), (11).

To do this in the formula for the scalar potential of electrostatic task replace the value ε in conductivity environment σ , or use the known results for the conversion formula [[10], (3.27)], which is easy to be represented as a matrix equality

$$[G]_{n,n} = \frac{\sigma l^2}{\varepsilon} [C]_{n,n} \quad (52)$$

where σ - conductivity conductor. As for the calculation resisting parameters of, (2), (3), their calculation can be performed similarly to the calculation parameters of conductor (52), which is equivalent to solving problems of electrodynamics in spreading current of conduction environment. But the easiest way to do it knowing the resistivity of the conductive tracks their square, autopsy and length using the formula

$$R = \frac{l}{\sigma S}$$

where S - cross-sectional area of the conductor.

Examples calculation of the parameters communicator. The algorithms were tested in the

software environment MathCad and compared to the simplest forms of communicator with other algorithms [11,12]. Give the results of solving specific problems for the elements of communicator, Figure 1.

Variant 1. Given a 2 wire one millimeter in diameter, length and distance between the axes - 10mm. The results of calculating $C = 0.1158$ nF, and in [11] - 0.1206 nF. The difference is 2%.

Variant 2: Two wires with a diameter of 1 mm and a length of 1m located at a distance of 10 mm. Inductance $L = 2,031$ was uH. Moreover 100% match results are in three algorithms, proposed in this article (30), the algorithm in [[2] p. 139 (3.28)], and by recalculation the result of some other communicator's parameters (51) according to [10].

8. Conclusion

In this paper made a systematic study between componental connections (communicator) for high-frequency, including nanotechnology, electronics. Synergetic effect of creating modern monolithic integrated schemes with the dividing ability to 20nm requires the construction of mathematical models that take into account the interaction of all composite components that form their characteristics. Such models must take into account not only the classic circuit engineering as well design and, in particular electromagnetic interaction and compatibility between componental connections.

Components and communicator have different descriptor. Concentrated components described by time descriptors, and for the communicator - space-time. The relationship between them is represented as a linear combination of (2), (7), (10), (15). They allow to formulate the task of electrodynamics to determine the influence electromagnetic field of communicator. Such influence is modeled in the form of magnetic, electrostatic, resisting and conductor parameters between which, as shown in the numerical examples, there is a close relationship (51), (52).

Determining the flow of magnetic and electric induction through certain fragments surfaces make

possible algorithms for calculating matrix elements electrodynamic parameters (30), (49), (52) for composite components of communicator, presented in a system of parallel and radial wires (highway tracks) that come together to focused component.

Thus, our study allows to raise adequate modeling of electronic products.

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