COAXIAL MICROWIRE WITH THE BIMETALLIC SHEATH

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Abstract. The bimetallic sheath of a coaxial microwire have an influence on its parame-ters. Thickness and properties of a magnetic covering of the sheath influence on value of line-ar inductance and wave resistance, attenuation and phase factors, that allows regulating of these parameters. Theoretical definition of primary parameters of a coaxial microwire with a bimetallic sheath is realized. The received expressions allow calculating of initial parameters of a coaxial microwire and parameters of models of radio-electronic elements on its basis.

Key words: coaxial, microwire, bimetallic, sheath.

Introduction. The coaxial microwire is a perspective element for creation on its basis of various radio-frequency filters and delay lines. Technological process of manufacturing of a microwire in glass isolation has restrictions in an opportunity of significant variations of the isolation thickness of its dielectric permeability. It limits a range of the possible values of the linier parameters of the inductance, capacities and resistance. With the purpose of expansion of an opportunity of regulation of the initial parameters it is possible to apply the bimetallic covering containing a magnetic component to the decision of the specified problem. By regulation of the thickness and the value of its magnetic permeability of this component it is possible to change in significant limits the value of linear inductance and dielectric permeability. The thickness of a covering is also affecting the value of linear capacity. Theoretical consideration of coaxial microwire model is important for the subsequent description of the models of the electronic elements on its basis.

The mathematical model. The research of parameters of a coaxial microwire we shall carry out according to the following model. The contour of cross section of a coaxial microwire will consist of two circles which it is accepted located in the center of cylindrical system of coordinates r, α and the axis of a wire is directed along an axis z, as shown in fig. 1.

Let's enter for the material medium constants the following designations:

1) for the internal conductor (thread) at при $0 < r < r_0$ we shall designate σ_i, ε_i, μ_i,

2) for the external conductor (the first layer of the cable sheath) at $r_a < r < r_b$ we shall designate σ_a, ε_a, μ_a, where r_b - external radius the first layer of the cable sheath.

3) for the external conductor (the second layer of the cable sheath) at $r_b < r < r_c$ we shall designate σ_b, ε_b, μ_b, where r_c - external radius of a coaxial microwire.

4) for the dielectric, which is filling space between an internal and external conductor at $r_0 < r < r_a$ we shall designate σ_g, ε_g, μ_g.

These indexes - 0, a, b, c - are used also for indexing constants and variables of the corresponding medium.

Accepting a condition, that electric and magnetic fields do not depend on coordinate z, i.e., $\partial / \partial z = 0$, and also, in cylindrical system of coordinates components of vectors $\vec{E}$ and $\vec{H}$ do not depend on a corner α, i.e. $\partial / \partial \alpha = 0$, for electric and a magnetic field strength field in the thread, isolation and cable sheath the following expressions [1,2] can be received for an internal conductor (thread) of a microwire:

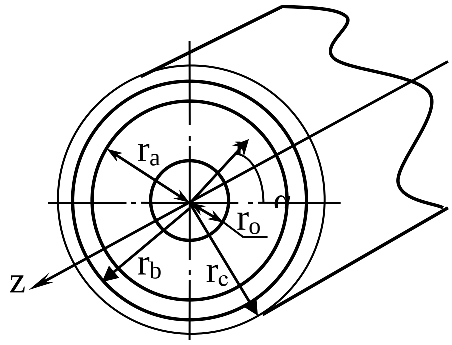

Fig.1. Cross section and sizes designation of a coaxial microwire

$$\dot{E}_{zi} = \frac{k_i \dot{I}_z}{2\pi\sigma_i r_0} \frac{J_0(k_i r)}{J_1(k_i r_0)} \qquad (1)$$

$$\dot{H}_{\alpha i} = \frac{\dot{I}_z}{2\pi r_0} \frac{J_1(k_i r)}{J_1(k_i r_0)} \qquad (2)$$

For the first layer of the sheath:

$$\dot{E}_{za} = \frac{k_a I_z}{2\pi \cdot \sigma_a r_a r_b} \cdot \frac{(Y_1(k_a r_a) r_a - Y(k_a r_b) r_b) J_0(k_a r) - (J_1(k_a r_a) r_a - J_1(k_a r_b) r_b) Y_0(k_a r)}{Y_1(k_a r_a) \cdot J_1(k_a r_b) - Y_1(k_a r_b) \cdot J_1(k_a r_a)} \qquad (3)$$

For the second layer of the sheath:

$$\dot{E}_{zb} = -\frac{k_b \dot{I}_z}{2\pi\sigma_b r_b} \frac{Y_1(k_b r_c) \cdot J_0(k_b r) - Y_0(k_b r) \cdot J_1(k_b r_c)}{Y_1(k_b r_b) \cdot J_1(k_b r_c) - Y_1(k_b r_c) \cdot J_1(k_b r_b)} \qquad (4)$$

where $k^2 = -j\omega\mu\sigma$ - a medium distribution constant,

$J_0(kr), J_1(kr)$ - Bessel functions of the zero and first order of a first sort,

$Y_0(kr), Y_1(kr)$ - Bessel functions of the zero and first order of the second sort or Neumann functions,

σ - conductivity, ω - circular frequency, ε - electric permittivity,

μ - magnetic permeability of the corresponding examined medium.

Being based on expressions (1,3,4), it is possible to receive expressions for the loss resistance and accordingly for the linear resistance and inductance.

For the internal conductor (thread):

$$Z_i = R_i + j\omega L_i = \frac{\dot{E}_{zi}(r = r_0)}{\dot{I}_z} = \frac{k_i}{2\pi\sigma_i r_0} \frac{J_0(k_i r_0)}{J_1(k_i r_0)} \tag{5}$$

where R_i - active resistance, $j\omega L_i$ - reactance, L_i - inductance of an internal conductor, ω - circular frequency of a signal.

Similarly, for the first and the second layer of the cable sheath:

$$Z_a = R_a + j\omega L_a =$$

$$= \frac{k_a}{2\pi \cdot r_a r_b \sigma_a} \cdot \frac{(Y_1(k_a r_a) r_a - Y(k_a r_b) r_b)(J_0(k_a r_b) - J_0(k_a r_a)) - (J_1(k_a r_a) r_a - J(k_a r_b) r_b)(Y_0(k_a r_b) - Y_0(k_a r_a))}{Y_1(k_a r_a) \cdot J_1(k_a r_b) - Y_1(k_a r_b) \cdot J_1(k_a r_{ba})} \tag{6}$$

$$Z_b = R_b + j\omega L_b = -\frac{k_b}{2\pi\sigma_b r_b} \frac{Y_1(k_b r_c) \cdot J_0(k_b r_b) - Y_0(k_b r_b) \cdot J_1(k_b r_c)}{Y_1(k_b r_b) \cdot J_1(k_b r_c) - Y_1(k_b r_c) \cdot J_1(k_b r_b)} \tag{7}$$

Thus, the common longitudinal linear resistance of a coaxial microwire:

$$Z = Z_i + Z_a + Z_b + j\omega L_g \tag{8}$$

where Lg - so-called external inductance [1]:

$$L_g = \frac{\mu_g}{2\pi} \ln \frac{r_a}{r_b} \tag{9}$$

Presence at the formula (8) composed Z_a means, that the total impedance of linear resistance has increased for the value of introduced resistance R_a and the value of the reactance $j\omega La$, determined by value of introduced linear inductance. The introduced inductance can exceed essentially the inductance of the internal conductor, that allows making adjustment of linear parameters of a coaxial microwire.

The linear resistance of a coaxial microwire will be defined as the real part of complex resistance Z (10), and the linear inductance as an imaginary part of complex resistance Z referred to the frequency of the signal (11):

$$R = \mathrm{Re}(Z_i + Z_a + Z_b + j\omega L_g) \tag{10}$$

$$L = \frac{1}{\omega} \mathrm{Im}(Z_i + Z_a + Z_b + j\omega L_g) \tag{11}$$

For the value of the cross conductivity it is possible to write down [1, 2]:

$$Y = G + j\omega C = \frac{2\pi\sigma_{gb}}{\ln\frac{r_b}{r_i}} + j\omega\frac{2\pi\varepsilon_{gb}}{\ln\frac{r_b}{r_i}} \qquad (12)$$

where C - linear capacity of the coaxial microwire., σ_{gb} and ε_{gb} - the equivalent conductivity and dielectric permeability of the isolation and the first layer of the sheath.

The attenuation and the phase factor of will be defined as real and imaginary parts of complex factor of distribution:

$$\gamma = \sqrt{Z \cdot Y} = \sqrt{(Z_i + Z_a + Z_b + j\omega L_g)\cdot(G + j\omega C)} \qquad (13)$$

The wave resistance of a coaxial microwire with a bimetallic environment:

$$\rho = \sqrt{Z / Y} = \sqrt{(Z_i + Z_a + Z_b + j\omega L_g)/(G + j\omega C)} \qquad (14)$$

Conclusions

The received expressions allow to define parameters of coaxial microwires with the bimetallic sheath, taking into account properties of materials of a microwire.

Expressions for calculation of frequency depended values can form a basis for calculation of more exact and reliable linear parameters of a coaxial microwire, attenuation and a phase factors, wave resistance and form a basis for mathematical models of elements on the basis of a coaxial microwire, such as radio-frequency filters and delay lines.

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This work is support by Civilian Research and Development Foundation for the Independent States of the Former Soviet Union (CRDF) No MOE2-5022-CH-04.