Phase Characteristics of the Circular Waveguide with an Azimuthally Magnetized Ferrite Cylinder and a Dielectric Toroid

Mariana Nikolova Georgieva-Grosse [(1)], and Georgi Nikolov Georgiev [(2)]
(1) Consulting and Researcher in Physics and Computer Sciences,
D–70839 Gerlingen, Germany
(2) Faculty of Mathematics and Informatics, University of Veliko Tirnovo
"St. St. Cyril and Methodius", BG–5000 Veliko Tirnovo, Bulgaria

It is supposed that the circular waveguide, containing a co-axially positioned ferrite cylinder of azimuthal magnetization, surrounded by an isotropic dielectric toroid that supports normal TE_{0n} modes, might provide an increased value of the differential phase shift, compared to the one, entirely filled with ferrite, if the size of the anisotropic area is suitably chosen. Due to the great number of parameters involved, the study of the phase characteristics of this geometry is a cumbersome task. To facilitate it, the discussion has been confined to the case in that the relative permittivities of both media are equal (G.N. Georgiev and M.N. Georgieva-Grosse, Proc. 2010 IEEE AP–S Int. Symp. Antennas Propagat. & CNC–USNC/URSI Radio Science Meeting, Toronto, ON, Canada, ID 330.9, 2010; G.N. Georgiev and M.N. Georgieva-Grosse, Proc. 6th Europ. Conf. Antennas Propagat. EuCAP, Prague, Czech Republic, 1141-1145, 2012; M.N. Georgieva-Grosse and G.N. Georgiev, Proc. Sixteenth Int. Conf. Electromagn. Adv. Applicat. ICEAA'14, Palm Beach, Aruba, 1290-1293, 2014; G.N. Georgiev and M.N. Georgieva-Grosse, In: L. Rocha and G. Mateus (Eds.), Wave Propagation: Academy Publish, Cheyenne, Wyoming, USA, 161-196, 2014).

Here the aforesaid structure is treated. In contrast to before, it is assumed that the relative permittivity of the dielectric filling is smaller than that of the ferrite. In conformity with this, the problem gets more involved. Like earlier, in the inner area it is integrated by the complex Kummer confluent hypergeometric functions. In the outer one, however, relations between the parameters appear for which ordinary Bessel and Neumann or modified Bessel and McDonald functions should be used. This reflects the fact that the parameter, linking the radial wavenumbers in both strata might become real or purely imaginary. Thus, two forms of the characteristic equation are obtained. A numerical technique for its solution is developed. The roots are found, accepting as parameters the ratio of the two relative permittivities, the one of the ferrite cylinder to waveguide radius, the off-diagonal ferrite permeability tensor element and the imaginary part of the complex first parameter of confluent functions. There is a limiting value of the imaginary part referred to at which the form of the equation is changed. A procedure is suggested for computation of the phase characteristics of geometry in normalized form. The analysis reveals existence of two curves for positive and negative ferrite magnetization, resp. of combinations of the parameters for which phase shift might be afforded. As in the case, already known, the characteristics are finite and end at peculiar envelope lines. The phase picture is too complicated and depends significantly on the ratio between the relative permittivities.