Cut-off Characteristics of the Normal TE_{0n} Modes in the Circular Waveguide with a Dielectric Cylinder and an Azimuthally Magnetized Ferrite Toroid

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The azimuthally magnetized circular ferrite and ferrite-dielectric waveguides could find application in various microwave devices: digital phase shifters, cut-off switches and isolators, operating in the normal TE_{01} mode (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). The development of these devices requires a detailed knowledge of the phase behaviour of guiding lines mentioned and in particular of their cut-off frequencies. The information for the latter, however, is still insufficient (W. Che, E.K. Yung and J. Wen, J. Electromagn. Waves Applicat., 16 (8), 1103–1118, 2002, M.N. Georgieva-Grosse and G.N. Georgiev, in Proc. Fourteenth Int. Conf. Electromagn. Adv. Applicat. ICEAA'12, Cape Town, South Africa, 1194-1197, Sept. 2–7, 2012).

The aim of this investigation is to figure up the cut-off characteristics of the normal TE_{0n} modes in a two-layered structure of the aforesaid class in which the isotropic load takes in the inner and the anisotropic one – the outer area and to examine the impact of its parameters on them. For the purpose a special numerical technique, harnessing certain roots of characteristic equation of the geometry, written in terms of complex Kummer and Tricomi confluent hypergeometric functions and real Bessel ones, is elaborated.

It is found out that the configuration possesses two kinds of cut-off frequencies. The first (conventional) ones do not depend on the direction of ferrite magnetization and serve as bifurcation points of the phase curves for its both signs. This is not the case with the second (unconventional) ones. They are connected with the endpoints of the phase characteristics, corresponding to positive (counter-clockwise) and negative (clockwise) magnetization of the ferrite and split in two families.

The dependence of the cut-off frequencies on the dielectric cylinder to waveguide radius ratio and on the off-diagonal ferrite permeability tensor element is presented graphically. A very complicated picture is observed. For certain combinations of parameters of the transmission line the conventional cut-off frequencies are lower than the unconventional ones. In some cases, however, the opposite holds. Further, the second kind of frequencies for positive magnetization might be larger or smaller than those for the negative one.

In addition, based on the results obtained, the condition for phase shifter operation of the waveguide is derived, too and is presented by the cut-off frequencies.