

Further Studies of Helicoidal Modes in a Rectangular Coaxial Line with DNG Deflectors

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The propagation inside coaxial waveguides of rectangular cross-section has been the subject of extensive studies (see, e.g., H.E. Green, “The characteristic impedance of square coaxial line”, *IEEE Trans. Microwave Theory Tech.*, vol. 11, pp. 554-555, Nov. 1963, and references therein). Some field components present singularities at the edges of the inner conductor, which may lead to dielectric breakdown. It was shown (P.L.E. Uslenghi, “Helicoidal plane-wave modes in a rectangular coaxial cable containing DNG deflectors”, *Proc. 2025 EMTS*, Bologna, Italy, June 2025) how this complication can be avoided by inserting anti-isorefractive DNG metamaterial prisms of triangular cross-section at the sharp corners of the line, resulting in the propagation of helicoidal plane-wave modes along the line.

In the present work, that original study is extended to the insertion of DNG prisms of quadrilateral cross-section at the sharp corners of the line. The cross-sections of such DNG wave deflectors may be designed to control the pitch angle and number of helicoidal modes. The quadrilateral cross-sections of the deflectors are obtained by joining DNG rectangular prisms to the triangular prisms of the previous work. The dimensions of the added DNG cross-sections lead to the definition of an “effective perimeter” of the rectangular coaxial line, that is the critical length determining the number and propagation angles of the plane-wave helicoidal modes. It is proven that the effective perimeter is equal to the perimeter of the rectangular cross section of the inner metallic conductor, minus twice the portion of such perimeter that is occupied by DNG material. A full-wave analysis of the boundary-value problem is performed in the phasor domain, with a time-dependence factor $\exp(+j\omega t)$ omitted throughout.