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On the TE/sub n0/ Modes of a Ferrite Slab Loaded Rectangular Waveguide and the Associated Thermodynamic Paradox

A.D. Bresler. "On the TE/sub n0/ Modes of a Ferrite Slab Loaded Rectangular Waveguide and the Associated Thermodynamic Paradox." 1960 Transactions on Microwave Theory and Techniques 8.1 (Jan. 1960 [T-MTT]): 81-95.

It has been known for some time that the secular equation for the TE/sub n0/ modes of a perfectly conducting rectangular waveguide loaded with a transversely magnetized dissipationless full height ferrite slab located against one of the narrow walls of the waveguide admits the possibility of the existence of only a single propagating mode (transporting energy in one direction only). In this paper, it is established that if we admit the existence of a passive dissipationless uniform waveguide supporting only a single propagating mode we are led inescapably to a thermodynamic paradox. A uniqueness theorem is cited to establish that, for the waveguide described above, the paradox is associated with the TE/sub n0/ mode set alone. This conclusion motivates a thorough study of the secular equation for the TE/sub n0/ modes of this waveguide. This study is initiated by an investigation into the properties of the TE/sub n0/ surface waves guided along a plane interface separating a transversely magnetized dissipationless ferrite from free space. It is shown that two oppositely directed surface waves are guided along this interface. These two surface waves are admitted in different finite ranges of the parameter values which never coincide and which may or may not overlap. Each of the two surface waves has both a high- and a low-frequency cutoff and, in general, both a high and a low dc magnetic field cutoff. The propagation constant of one of the surface waves becomes infinite at the low field (high-frequency) cutoff. The next step in the analysis consists of an examination of the behavior of these surface waves on finite thickness ferrite slabs located in different environments. It is shown that when one of the two interfaces bounding the slab approaches a short circuit the infinite propagation constant noted above behaves in a peculiar discontinuous fashion. Next, the TE/sub n0/ mode secular equation of the slab loaded rectangular waveguide is analyzed and information is developed leading to a description of the behavior of the propagation constants of all the propagating TE/sub n0/ modes. This analysis reveals that the possibility of the existence of only a single propagating mode is associated only

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with the surface wave mode of this waveguide. A resolution for the thermodynamic paradox is proposed based on the discontinuous behavior of one of the infinite propagation constants associated with this surface wave mode. It is shown that with a properly chosen secular equation for the waveguide under consideration there are always an even number of TE/sub n0/ propagating modes, half of which transport energy in one direction, half in the other. This demonstration is based, in part, on an analysis leading to relations between the direction of the power flow associated with a propagating mode and the derivative of its propagation constant with respect to the dc magnetic field.

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