Finite-Element Solutions with Complimentary Bases Applied to Waveguides

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This paper describes a new method of obtaining solutions to the modes of propagating electric and magnetic fields of arbitrarily shaped wave-guides loaded with multiple dielectrics. Currently, a large number of solutions to waveguide problems via the finite element method use the vector Helmholtz equation to obtain the modes as well as the electric and magnetic fields. The vector Helmholtz equation is used to obtain either the electric or magnetic field. A new approach to this problem is presented in this paper using a dual equation approach that provides solutions to both the electric and magnetic fields simultaneously as well as the modes.

The required equations for the finite element method are obtained directly from Maxwell's equations using variational principles. Basis functions that are complimentary in nature similar to the complimentary nature of Maxwell's equations are applied to these equations to develop the finite element solution. The vector Helmholtz equation is compared to the complementary variational approach. The variational solution is obtained using the complementary bases to solve for both the fields simultaneously. Several combinations of the complementary basis functions are possible and this paper provides results using different sets of complementary basis functions. A comparison with the solution via the vector Helmholtz equation for the electric field is provided for a circular waveguide. The eigenvectors obtained in the solution represent the fields, with the field patterns shown for several modes.

Previous articles by the authors introduced the complementary bases and its application to magnetostatics. This article provides the extension into dynamics. Specific information regarding the advantages and disadvantages of using the complimentary bases are not covered as it is left to future publications by the same authors.