Characteristics of New 3D Distributed Node TLM Mesh with Cells of Arbitrary Aspect Ratio

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In traditional TLM schemes, cells are restricted to square or cubic size. This undoubtedly affects the efficiency of the method whenever the transverse resolution requirements in a guiding structure impose an unnecessarily small discretization step in propagation direction. To overcome this problem, Al-Mukhtar and Sitch have proposed modifications to 'conventional TLM' leading to a mesh grading by means of stubs. Recently Hoefer and Sautier [1] have proposed a more general 2D-TLM algorithm which removes the restriction that the cell shape must be square [2], [3]. The basic theory of two-dimensional rectangular TLM meshes of arbitrary aspect ratio was described and the 2D stub free rectangular shunt node was introduced. The difference in the length of the link lines in the two co-ordinate directions is compensated by a corresponding modification of their phase velocities and their characteristic impedances. In this project, this concept is extended to the 3D distributed node TLM mesh with general cuboid cell. Consider the 3D distributed node in Fig. 1 which is a elementary cell of the generalized three-dimensional TLM network. The desired features of this cell are:

1. Impulse Synchronism: The velocities of impulses on the dispersionless link lines must be such that the transit time Δt is the same for all lines. This implies that the line velocities are proportional to the line lengths.

2. Isotropic Wave properties: In the infinitesimal limit (Δx, Δy, $\Delta z << \lambda$), the plane wave network velocity v_n must be the same in all directions.

Using these two properties we can determine the inductances and capacitances as well as the characteristic impedances of the link lines that constitute a 3D cuboid cell. A full dispersion analysis of the cuboid mesh has been performed for the general case, and the results have been compared to the characteristics of the traditional cubic mesh (Fig.2). Numerical results obtained with cuboid meshes have been compared with those obtained with a cubic cell to demonstrate the validity of the algorithm. Based on those comparison, we have demonstrated that the cuboid cell is more flexible and can save memory as well as CPU time [4], [5]. Further research is directed towards the modeling of layered dielectrics without the use of stubs, simply by changing the aspect ratio of cells from one medium to the other.

References

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[2] W.J.R. Hoefer, "The transmission line matrix (TLM) method", in Numerical Techniques for Microwave and Millimeter Wave Passive Structures, T. Itoh, Ed. New York:Wiley, 1989.

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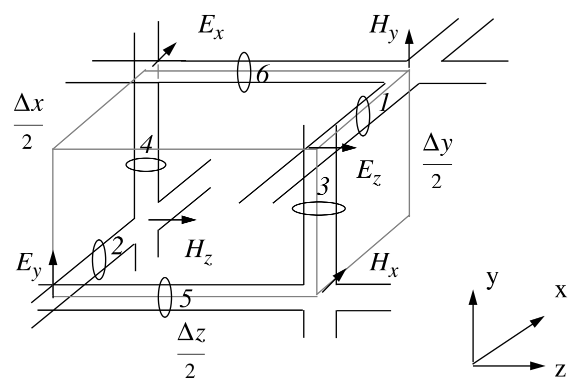

Figure 1. 3D distributed node

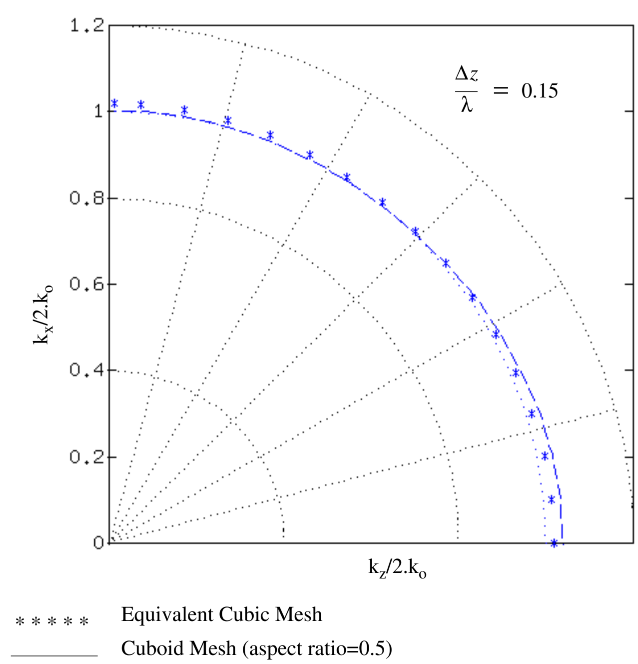

Figure 2. Frequency response of a rectangular waveguide cavity for three different mesh aspect ratios