NEW 3D TLM CONDENSED NODE STRUCTURES FOR IMPROVED SIMULATION OF CONDUCTOR STRIPS

John S. Nielsen* and Wolfgang J. R. Hoefer**

*** Lockheed Canada Inc., 1 Iber Rd. Stittsville Ont. Canada K2S-1E6**
**** University of Ottawa, Dept. Elec. Eng. Ottawa, Ont., Canada K1N-6N5**

ABSTRACT

This paper presents a set of modified condensed node TLM structures, compatible with the 3D TLM condensed node, that improve the modelling of conductor strips and provide a means of directly embedding lumped devices into the mesh. The improvement in accuracy is demonstrated by evaluating the propagation constant of a simulated microstrip line.

INTRODUCTION

In the condensed TLM node formulation, initially developed by Johns[1], conductor strips are simulated by truncated Dirichlet boundary walls located halfway between the nodes.[2] When this method is used in simulating transmission line structures such as microstrip or stripline, it is observed that the simulated propagation constant is always too low.[3] For moderately coarse mesh densities, the error is typically around 3 to 5 percent.

To explain this error, consider the example in Fig.1 showing a cross-section of two coupled strips with a 2-port lumped element connected between the strips. The strips are simulated by truncated Dirichlet walls and the device is simulated by a localized reflection point also halfway between the nodes. Nodes 1 and 2, immediately adjacent to the left conductor edge, share a corner which is coincident with the conductor edge and should therefore couple strongly with the resultant edge current. However, as observed in Fig.1, the coupling is not direct, but has to pass through nodes 3 and 4. This results in a weaker, delayed interaction that effectively reduces the propagation velocity.

Similarly, the direct physical connection between the lumped device and the conductor strip is poorly represented. As observed in Fig.1, the current flow through the device does not couple directly with the current flow in the conduction strips. The interaction must pass through 2 condensed nodes resulting in a delayed, weaker interaction. This effects the input impedance as seen by the device.

CONDUCTOR STRIP NODES

To counter these problems, a set of new nodes has been developed such that the conductor strip is embedded directly into the node structure to achieve higher coupling. These nodes are sketched in Fig.2 with "d" representing the dimension of the condensed node cell. The "half node", sketched in Fig.2a is a condensed node bisected by a conductor plane. The "edge node", Fig.2b, is similar to the half node except that the conductor sheet edge lies within the node. The edge current flowing in this node couples directly with the

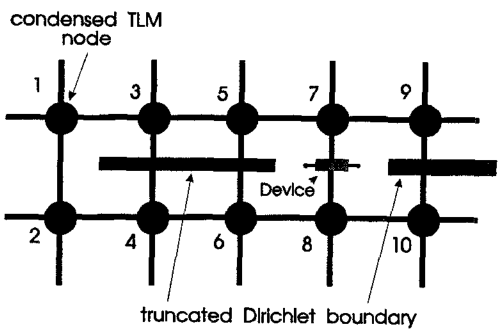


Fig.1 TLM Condensed node model of a pair of conductor strips with a connected 2 port device

adjacent E and H fields. The corner node in Fig.2c is necessary for simulating discontinuities in planar transmission lines. Finally the 90° wedge node in Fig.2d is useful in simulating ribbon bonds to devices and wrap-around conductor planes. The nodes have 12 independent state variables consistent with the conventional condensed node. A portion of these field components relate directly to the physical current flow on the conductor surface. Hence these new nodes form an direct interface between the fields and the current flow on the conductor. The conductor node set is modelled after the condensed node and therefore retains the energy and current conservation properties as well as the dispersion characteristics. A description of the derivation of the scattering matrix for the half and edge nodes is found in [3]. Scattering matrices for the other node types are developed in a similar fashion.

When modelling planar transmission line devices, the conductor nodes must also model the interface between two dielectrics at the conductor strip plane. This is done by adding capacitive stubs to the node ports representing the increased capacitance due to the presence of the dielectric medium. Finally transmission losses due to conductor resistivity is modelled by adding a series resistor each node port connected to the conductor sheet.

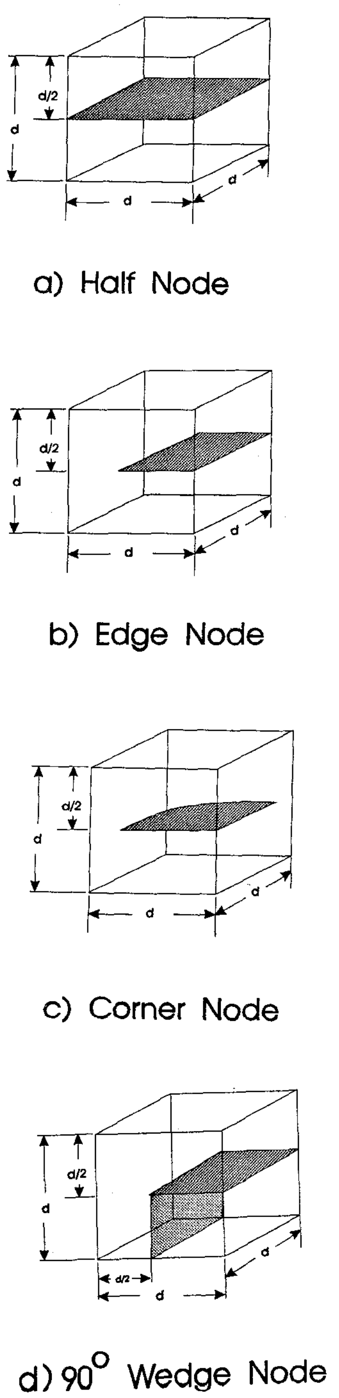
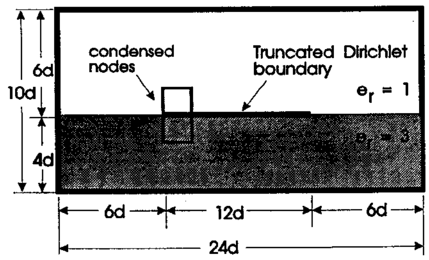


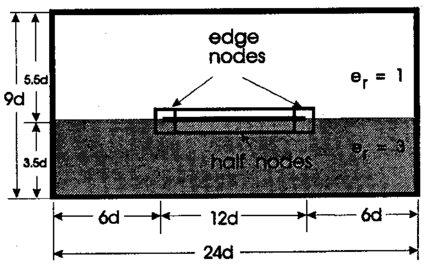
Fig.2 Conductor strip node types (The scattering center of the nodes is situated at the center of the cells)

SIMULATION OF MICROSTRIP LINE

Simulation results of an enclosed microstrip line are presented as a demonstration of the improved accuracy possible by using the half nodes. Two TLM configurations are considered. The first, shown in Fig.3a consists of conventional condensed nodes with the strip modelled by a truncated Dirichlet boundary. In the second simulation, in Fig.3b, conductor strip nodes are employed. Two microstrip geometries are necessary as the conductor strips in each simulation cannot be placed at exactly the same height. Fig.4a and 4b show the effective dielectric constant of the simulated microstrip lines as compared to the empirical equation by Hammerstad and Jensen[4]. As observed in Fig.4, the effective dielectric constant based on the simulation using the conventional nodes is consistently high, indicating that the propagation is too slow which is consistent with the discussion in section 1. The results for the conductor node simulation is consistent with the calculation of Hammerstad and Jensen.



a) Conventional simulation with truncated Dirichlet boundary



b) Simulation using conductor strip nodes

Fig.3 TLM mesh model for microstrip simulation

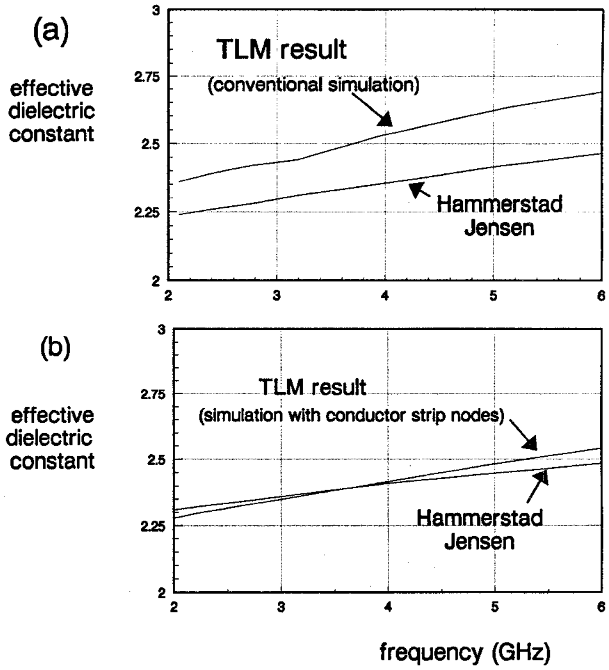


Fig.4 Comparison of TLM simulation of microstrip with Hammerstad-Jensen calculation. a) TLM simulation using truncated Dirichlet boundary
b) Simulation using conductor strip nodes

CONCLUSION

In this paper, new node types are introduced that facilitate the simulation of conductor strips. The nodes significantly improve simulation accuracy of conductor strips. Also the nodes interface directly to lumped devices connected to the conductor strips facilitating microstrip circuit simulation.

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