

**TFD TLM: A NEW COMPUTATIONALLY EFFICIENT FREQUENCY
DOMAIN TLM BASED ON TRANSIENT ANALYSIS TECHNIQUES**

Iman Salama

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Electrical Engineering

Dr. S. Riad, Chair

Dr. I. M. Besieris

Dr. C. Christopoulos

Dr. A. Elshabini Riad

Dr. W. A. Scales

Dr. W. Su

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Iman Salama

(Abstract)

The TLM was initially formulated and developed in the time domain. One key issue in a time domain analysis approach is the computational efficiency, where a single impulsive excitation could yield information over a wide frequency range. Also, it may be more natural and realistic to model non linear and frequency dispersive properties in the time domain rather than in the frequency domain. However, in some circumstances, frequency domain analysis may be more appealing. This might be due to the fact that the traditional teaching of electromagnetics emphasizes frequency domain concepts as frequency dispersive constitutive parameters, complex frequency dependent impedances and reflection coefficients. It might be even easier and more direct to be able to model these parameters in frequency domain rather than trying to synthesize an equivalent time domain model. The only limitation of frequency domain analysis, is that the analysis has to be repeated at every frequency point in the frequency range of interest.

In this work, a new frequency domain TLM (FDTLM) approach is introduced which combines the superior features of both the time domain and the frequency domain TLM. The approach is based on a steady state analysis in the frequency domain using transient analysis techniques and hence is referred to as TFDTLM. In this approach, the link lines impedances are derived in the frequency domain and are chosen to model the frequency dispersive material parameters. The impedances and propagation constants are allowed to be complex and frequency dependant. Consequently, the TFDTLM can provide more accurate modeling for wave propagation in a frequency dispersive medium. The approach was inspired by the concept of bounce diagram in the time domain and the equivalent frequency domain bounce diagram.

To make the TFDTLM approach computationally efficient as compared to other frequency domain TLM approaches, it was critical to maintain some relationship between the mesh response at one frequency point and any other frequency point. The goal was to be able to extract all the frequency domain information in a wide frequency range by performing only one simulation. To achieve this, the transitions between two adjacent cell in all media expressed by ($e^{-\gamma l}$) have to be expressed in terms of the propagation factor of some reference medium chosen to be the medium with the least propagation delay. This was done with the aid of a digital filter approximation that can be implemented iteratively inside the TLM mesh. The filter can be thought of as some type of compensation equivalent to the stubs in a time domain TLM, yet more accurate and more general. An important advantage of the TFDTLM is that it can easily be interfaced with existing time domain TLM schemes as well as absorbing boundary conditions originally developed for time domain TLM with the slightest modifications. The

TFDTLM is implemented a three dimensional mesh and the superior performance of the new approach in modeling lossy inhomogeneous media is demonstrated.

The new approach in addition to being computationally efficient as compared to other frequency domain TLM methods, has proven to have superior dispersion behavior in modeling lossy inhomogeneous media as compared to time domain TLM .

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